Losses Strategy

Reducing network energy losses & greenhouse gas emissions

Our Vision

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

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This annex describes SP Energy Networks' strategy for managing energy losses that occur on electricity distribution networks. This strategy applies throughout the 2015-2022 regulatory period and will be subject to regular reviews and updates.

1 Executive Summary

1.1 Context

International climate change agreements have resulted in 2015 proposals that all countries limit emissions by binding targets. The objective is to limit the rise in global temperatures to below 2 degrees centigrade.

The EU vision is to reduce global emissions by 60% (below 2010 levels) by 2050 and 40% by 2030. The EU has created legislation to work towards these targets, including DIRECTIVE 2009/125/EC [Establishing a framework for the setting of ecodesign requirements for energy-related products].

The transport and electricity industries are major contributors to the emissions. Against this background, the UK Government and the electricity regulator (Ofgem) seek continuous improvement in emissions from the electricity industry.

Low carbon generation and efficient dispatch will make by far the major industry contribution to carbon reduction, but each part of the industry chain must play its part in the process of changing culture to reduce pollution which threatens the well-being and prosperity of so many people worldwide.

Electricity losses exist in electricity systems due to the laws of physics and can be managed but not eliminated, with the main driver being customer consumption and time of use.

This baseline strategy is anticipated to reduce losses between 2015 and 2023 by £7.73m, this will, over time, translate to a reduction in our customer bills.

The Scottish and Welsh governments have made higher targets for carbon reduction and we are the only DNO to operate in England, Wales and Scotland.

The largest contribution which DNO's can make is to reduce the losses on their networks which account for about 6% of the energy transported. This is not simple, because much of the network design, equipment and associated operational practice was set before such concerns emerged.

Condition 49 of the DNOs' Licence requires:

- Each DNO to publish a Strategy showing how it will "ensure that Distribution Losses from its Distribution System are **as low as reasonably practicable**, and [the DNO is then] to maintain and act in accordance with its Distribution Losses Strategy";
- Changes and updates to the Strategy to be published and that the changes are justified.

Ofgem, in its advice to DNO's during the RIIO-ED1 determination for an eight year period, has interpreted the **Reasonably Practical** test as investment justified on a standardised cost-benefit analysis. We support this view because our fundamental driver is to provide value and network performance for customers. Network Loss reduction is therefore part of that management, rather than being separate from it.

Our Losses Strategic Vision is to: "Consider all reasonable measures which can be applied to reduce losses and adopt those measures which provide benefit for customers."

We believe that we are aligned with our Regulator in this view.

Assessing improvement or even the present position on losses is not yet an exact science anywhere in the world. One important step in supporting our vision is to improve our understanding of the "losses value" of certain actions. The difficulty with accurate measurement is compounded by the changing demands placed upon our networks over the eight year period of RIIO-ED1. To maintain the best price and service level for customers, we continually innovate to make our networks work harder in the face of load growth and increased distribution connected generation. Our target therefore cannot be set to reduce the losses in absolute terms over to-day's values, but rather to improve them over what would have been the case had we not adopted a proactive strategy.

For us therefore, the approach has to be to develop a strong culture of considering losses in every decision we take. Any cost effective losses reduction activities will have a direct benefit to our customers in reducing energy bills and over the longer term should contribute toward lower costs of energy supplied to customers.

1.2 Present Practice and Strategy for ED1

1.2.1 Losses Assessment

Our present practice in quantifying losses is to measure and record energy entering and leaving the distribution network. Energy entering the distribution network at transmission GSPs is measured with high accuracy metering and is readily quantified. However, the quantification of energy exiting the distribution network is currently dependent on aggregating all customer metered consumption. The difference between the aggregated meter consumption data, provided from the settlement system, and the GSP metered energy represents overall network losses.

The current approach to determining distribution network losses has several shortcomings:

- It is not possible to distinguish between technical network losses and non-technical losses;
- The process is very sensitive to data quality and accuracy;
- Estimated energy consumption is used to determine energy use from unmetered supplies; and
- Apportionment of losses across customers is reliant on educated estimates.

Ofgem recognised these shortcomings and withdrew the previous losses incentive mechanism at the start of DPCR5 due to the challenge of obtaining accurate data needed to provide meaningful and consistent quantification of technical and non-technical losses.

In this context our strategic objective will be to improve accurate information. There are two issues which need to be addressed and, acting alone, we can only address one.

The first issue is development of:

- Methods of measurement within our networks;
- Evaluation techniques for assessing potential savings in technical losses on our LV networks; and
- Evaluation techniques for assessing the losses impacts of developments in complex parts of our HV network.

The second issue is to achieve consistency of approach, or at least of accuracy, across all UK DNO's so that Ofgem can report properly to Government on the contribution which the distribution part of the industry is making towards climate change targets. This also supports the Ofgem proposal for assessing and incentivising DNO's relative performance on losses. We stand willing to support Ofgem, in developing such an initiative and strongly encourage a co-ordinated approach.

1.2.2 Network Design and Operation

Our approach for considering network design has been captured in our technical design documents. These set out how to assess losses quantities and the value of losses in circuits and transformers. As an action under our strategy, we will review both the content and use of these guidelines and will publish our findings by January 2016. We will have particular regard to checking compliance with present and emerging EU legislation. In particular, our design guidelines and approvals process guidelines will be updated to ensure that all technical assessment and approval decisions take full account of our losses Vision and the detail of this strategy.

In the meantime, we publish here a plan with a list of investments which we will undertake to support our Vision in respect of Technical Losses and a list of actions designed to support the Vision in the case of non-technical losses. Our plan for Technical Loss reduction (Section 7) is based upon calculated benefits and our actions for Non-technical loss reduction (Section 8) are based upon our experience. We summarise these plans below in Sections 1.3 (Summary of activities) and 1.4 (Outputs). We do not yet claim to have capability to accurately measure either the baseline or the results of action, but the benefit of our transformer actions is based only upon the fixed losses in our transformers and is therefore guaranteed because these losses are present every hour that the transformer is connected to our network and independent of load so they will be realised no matter what the future holds.

1.3 Summary of activities

Area	Activities	
Processes		
Design Policy Review	• Design and operational Policy review	Proactive
Methods of working	• Vision statement driving a cultural change with a mandate that losses are to be considered as part of all investment appraisals	Proactive
Technical Losses		
Grid Transformers	• (SPM only). Our procurement designs already meet/exceed EU EcoDesign Tier 2. Where we are required to replace or install new 132/33kV transformers, we will aim to do so with modern lower loss transformers.	Opportunistic
Primary Transformers	• Our procurement designs already meet/exceed EU EcoDesign Tier 1 in SPM and Tier 2 in SPD. Where we are required to replace or install new 33/11kV transformers, we will aim to do so with these modern lower loss transformers. • In SPM this activity will replace 35 particularly high loss transformers.	Opportunistic
Distribution Transformers (Ground Mounted)	• We will proactively bring forward the replacement of older (pre-1962) high loss units to cost effectively reduce losses. • Our procurement designs already meet/exceed EU EcoDesign Tier 1 and where we are required to replace or install new HV/LV transformers, we will aim to do so with these modern lower loss transformers.	Proactive
Distribution Transformers (Pole Mounted)	• Project specific evaluation of early replacement of high loss units during planned activities such as OHL refurbishment and rebuild.	Opportunistic
Overhead Lines	• HV main line new builds and offline rebuilds throughout the RIIO-ED1 period will be constructed using larger than usual (100mm^2)conductor.	Proactive
Cables (All voltage levels)	• Project specific evaluation of installing larger cross-section cables on new circuits. • Ongoing studies to inform any policy revisions.	Opportunistic & ongoing assessment
LV Service Cables	• We have been considering our LV service cable policy. The case for change in cable size is not yet clear. We will continue to work to determine whether there is justification for an increase in service conductor sizes.	Proactive ongoing assessment
Substation energy consumption	• We will consider energy efficiency aspects of our house load. • We are reviewing our substation civil specifications with a view to improving energy efficiency.	Proactive
Non-technical Losses		
Revenue Protection	• Increasing our revenue protection team by 22% in 2016 • Working with Merseyside Police, Police Scotland by supplying technicians; • Proactively engaged in delivery of Theft Risk Assessment Service (2016) • Liaison and best practice sharing with UK RPA and International (incl. Iberdrola Fraud Group)	Proactive
Transactional theft	• We will continue to work alongside suppliers to help reduce transactional theft. • Throughout ED1 we intend to: o Endeavour to ensure that visits to install smart meters are used to identify tampering / theft. o Consider use of HV and LV network metering and smart metering to identify zonal problems.	Proactive
Unmetered supplies	• We will continue to proactively improve the accuracy of records for unmetered supplies by working closely with customers and settlement stakeholders. • We intend to audit some customers with unmetered supplies. • We will endeavour to identify customers who are not maintaining accurate and up to date inventories and consider reasonable ways to deal with the issues.	Proactive

Theft in conveyance	• As for Transactional theft. • Consider use of network data and smart meter data to identify theft in conveyance. • Continue to work alongside suppliers and metering service providers to improve settlement data and metering point registration accuracy. • Share information with UK DNOs as to how inaccuracies have occurred	Proactive
Innovation & Smart Meters		

Smart meters	• Endeavour to use smart meter data to identify areas to work with suppliers to encourage Demand Side Response or Time of Use tariffs.
	• We intend to make use of smart meter data, coupled with enhanced network monitoring to help reduce losses by:
	  ○ help target transactional theft, inconsistencies in unmetered supplies and theft in conveyance
	  ○ identify areas with high losses or rapid demand growth where losses interventions may be cost effective
		Proactive

Stakeholder engagement / Demand Side Management	• We intend to continue to make use of active network management technologies to actively facilitate or accelerate connection of renewable generation building on our Accelerating Renewable Connections (ARC) project. • We will work with suppliers and the ENA to identify a common way of working to encourage lowing peak demand via Time of Use (ToU) tariffs and directly controlling customer loads for demand response.	Proactive
Secondary substation and LV network monitoring	• We will install monitors to cover approximately 5% of our network in ED1 to collate enhanced data at HV substations and LV networks. • This will help up make more informed decisions and may be used to identify areas where losses interventions may be cost effective.	Proactive
Power factor correction	• Power factor correction actions are likely to emerge after monitoring project provides data records.	Opportunistic
Power Quality	• Phase imbalance and harmonics actions are likely to emerge after monitoring project provides data records.	Opportunistic
Operational efficiency by voltage management	• Building on work undertaken in our LCNF Flexible Networks project we will continue to investigate the optimal selection of normal open points to optimise for losses, in some areas this might be static adjustment as demand grows, or this may form part of smart network technology which automatically re-optimises as load changes	Opportunistic
(Enablers for losses reduction innovation)	• HV and LV network monitoring • Smart MDIs • Advanced automated network solutions at HV and LV and associated information/control streams • Enhanced losses modelling by development of stochastic network assessment tool	

Table 1.1 – Summary of SPEN losses reduction activities during ED1

1.4 Outputs

We will:

- Modify processes and technical documents to ensure that there is a culture of considering losses in every major investment appraisal we take.
- Implement investment decisions which are justified after considering losses.
- Employ lower loss transformers compliant with EU Regulation [548/2014]. There are options to go further and increase circuit capacity to reduce losses or to replace transformers earlier than their natural end of life. We discuss this further in Section 7 of this Strategy document. The following Table shows savings in carbon and cost from decision already taken in proactive actions.

We are replacing 1,673 transformers of which 1,111 are proactive replacements carried out because of this strategy. (For savings in Losses and carbon see Table 1.2, for cost impact see Table 1.4 below). Because we do not claim that every transformer replacement that we are undertaking is losses driven and we show separately below the total carbon savings and the losses strategy carbon savings.

Overhead lines and cables can be oversized for capacity requirement. This additional capital cost for larger conductors has three benefits:

- It reduces network losses;
- Improves operational flexibility; and
- May increase asset useful life.

We will seek to quantify benefits in losses related projects so as to ensure that such projects have the maximum chance of success.

We have justified an increase in size of much of our overhead line 11kV conductor from 50mm^2 to 100mm^2. We show the savings in Table 1.2 and Table 1.4 below.

We are replacing islands of our legacy 6.6kV cable network in both SPM and SPD with 11kV network. This contributes to total savings but was not justified by losses.

Our research to date shows it unlikely that there are any cases where it is justified to bring forward cable replacement for losses reasons alone so that is not recorded as an strategy based output, however, there could be specific instances where a bundle of drivers would not quite justify replacement without the losses consideration. If such cases arise we will report on them. Between now and January 2016 we will reassess our standard cable sizes policy for new and replacement work and report. This will cover in particular HV, LV and service cables. We expect that we may have different solutions for SPD and SPM.

Other network measures can be taken to improve voltage regulation, power factor, phase balance and to better level the flows throughout our network. Each of these has other benefits, but especially in the case of operational reconfiguration, there may also be hidden costs in terms of network security and operational convenience. These matters are explained later in Section 7 of this Strategy. They are unlikely to be major contributors to the overall losses reduction and can only meaningfully be considered / justified on a case-by-case basis. What is important is that the losses impact is properly valued in the decision making process.

Of course, smart metering linked to time-of-day or real-time energy prices could shift load away from the peak and this would impact losses which are most severe when the network is highly loaded. Using best information about expected behavioural change patterns we will study a small section of our network to determine whether the losses impact of behavioural change is a significant factor.

Smart metering is a tool which will improve knowledge and we see the roll out of the programme as providing more contact with customer premises. We plan to make use of that opportunity to reduce the incidence of theft.

	SPD Losses Reduction during ED1		SPM Losses Reduction during ED1	
Initiative	GWh	tCO_{2e}	GWh	tCO_{2e}
Grid Transformer Replacement	-	-	25.2	10,983
Primary Transformer Replacement	12.9	5,582	31.5	13,741
Conditioned based replacement of Ground Mounted Secondary Transformers (asset replacement programme utilising Tier 1 Ecodesign)	8.8	3,813	8.2	3,552
Early replacement of pre-1962 Ground Mounted Secondary Transformers (beyond condition based programme, specifically to reduce network losses)	22.7	9,877	28.1	12,224
Increase HV main line conductor size to 100mm2 (Normal Weather Area)	3.8	1,656	3.6	1,586
Increase HV main line conductor size to 100mm2 (Severe Weather Area)	5.5	2,384	5.0	2,191
6.6kV -> 11kV network uprating projects	1.2	522	1.6	700
Total	**54.9**	**23,835**	**103.3**	**44,977**

Table 1.2 – Anticipated Energy Losses Reductions and Carbon Saving attributable to activities described in this strategy

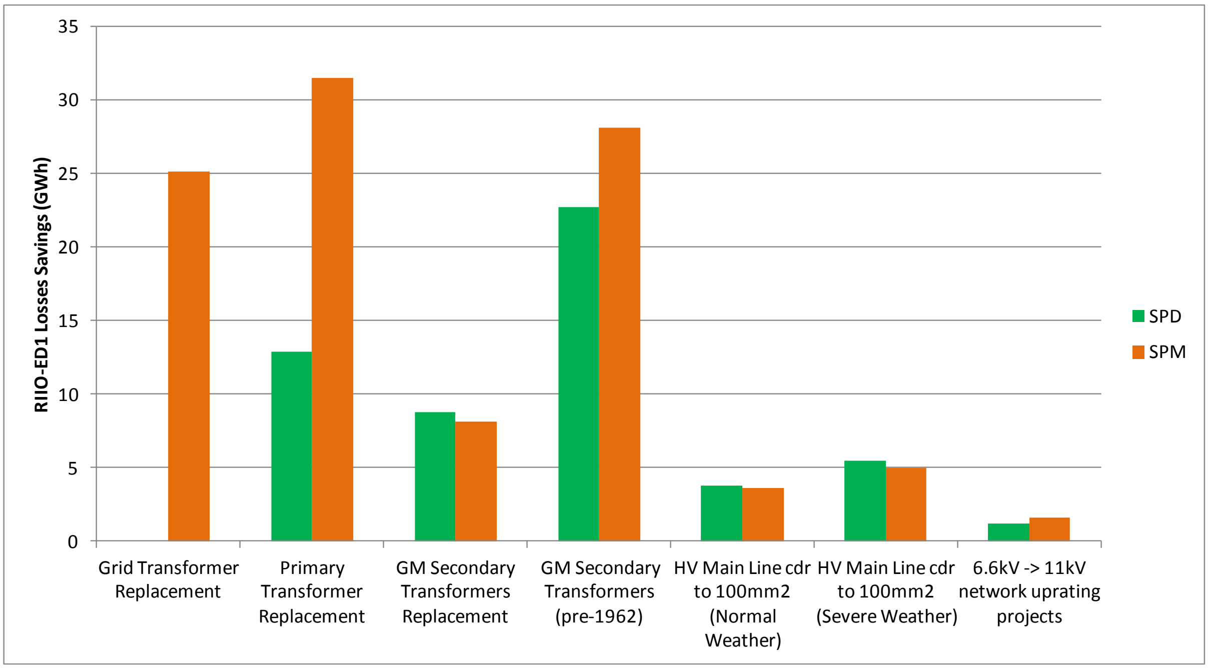

Figure 1.1 – Chart showing split of losses saving by activity and network

	SPD		SPM	
	Losses Reduction during ED1		Losses Reduction during ED1	
Initiative	GWh	tCO_{2e}	GWh	tCO_{2e}
Early replacement of pre-1962 Gound Mounted Secondary Transformers (beyond condition based programme, specifically to reduce network losses)	22.7	9,877	28.1	12,224
Increase HV main line conductor size to 100mm2 (Normal Weather Area)	3.8	1,656	3.6	1,586
Total	**26.5**	**11,534**	**31.7**	**13,810**

Table 1.3 – losses strategy driven actions

Approximately 48% (SPD) and 31% (SPM) of our predicted losses reduction during ED1 are attributable to pro-active activities as a result of this strategy.

		SPD				SPM			
		Volume	Losses-justified component of expenditure	Total losses benefits (£m)	Net losses related benefit (£m)	Volume	Losses-justified component of expenditure	Total losses benefits (£m)	Net losses related benefit (£m)
Category	Policy Driven Savings			During ED1	During ED1			During ED1	During ED1
Grid Transformer Replacement		-	-	-	-	16	£m 0.00	£m 1.40	£m 1.40
Primary Transformer Replacement		59	£m 0.00	£m 0.72	£m 0.72	70	£m 0.00	£m 1.76	£m 1.76
Conditioned based replacement of Gound Mounted Secondary Transformers (asset replacement programme utilising Tier 1 Ecodesign)		220	£m 0.00	£m 0.37	£m 0.37	197	£m 0.00	£m 0.35	£m 0.35
Early replacement of pre-1962 Gound Mounted Secondary Transformers (beyond condition based programme, specifically to reduce network losses)	yes	484	£m 4.65	£m 0.96	-£m 3.68	627	£m 6.58	£m 1.19	-£m 5.39
Increase HV main line conductor size to 100mm2 (Normal Weather Area)	yes	361	£m 0.49	£m 0.17	-£m 0.32	333	£m 0.45	£m 0.16	-£m 0.29
Increase HV main line conductor size to 100mm2 (Severe Weather Area)		519	£m 0.00	£m 0.25	£m 0.25	459	£m 0.00	£m 0.23	£m 0.23
6.6kV -> 11kV network uprating projects		2	£m 0.00	£m 0.07	£m 0.07	1	£m 0.00	£m 0.09	£m 0.09
Total Savings				**£m 2.55**	**-£m 2.59**			**£m 5.18**	**-£m 1.85**
(of which policy driven)			**£m 5.14**	**£m 1.13**	**-£m 4.00**		**£m 7.04**	**£m 1.36**	**-£m 5.68**

Table 1.4 – Cost impact of activities described in this strategy

2 Factors Impacting on Losses Strategy

Strategic Objectives

- Ensure compliance with all legal and regulatory requirements;
- Optimise value for customers
- Recognise the areas of technical constraint and where possible reduce constraints

2.1 The Business and legal Environment

2.1.1 National and International Legislation

International climate change agreements have resulted in 2015 proposals that all countries limit emissions by binding targets. These are to limit the rise in global temperatures to below 2 degrees centigrade.

The transport and electricity industries are major contributors to the emissions. Against this background, the UK Government and the electricity regulator (Ofgem) seek continuous improvement in emissions from the electricity industry.

The EU has created legislation to help work towards these targets, including DIRECTIVE 2009/125/EC [establishing a framework for the setting of ecodesign requirements for energy-related products]. This is now implemented as follows: EU.548/2014 of 21 May 2014 with regard to small, medium and large power transformers. The implementation date for all Member States was 20 days after publication. The driver for this legislation is

"Total losses of the transformers fleet in the EU27 in 2008 amounted to 93,4 TWh per year. The cost-effective improvement potential through more efficient design has been estimated in about 16,2 TWh per year in 2025, which corresponds to 3,7 Mt of CO2 emissions."

There are three relevant exclusions mentioned in this regulation:

- Medium Voltage (MV) to Medium Voltage (MV) interface transformers up to 5 MVA;
- Large power transformers where it is demonstrated that for a particular application, technically feasible alternatives are not available to meet the minimum efficiency requirements set out by this Regulation;
- Large power transformers which are like for like replacements in the same physical location/installation for existing large power transformers, where this replacement cannot be achieved without entailing disproportionate costs associated to their transportation and/or installation.

'Large power' transformers do not include SPENs Primary and Secondary transformers as they do not exceed either 36kV or 40MVA.

The legislation sets out the losses at maximum load and at minimum load for transformers according to when the transformers are purchased. It has two applicable dates – transformers purchased after 1st July 2015 (Tier 1) and transformers purchased after 1st July 2021 (Tier 2).

As yet there is no legislation related to sizing of overhead line conductors or underground cables.

There is no legislation related to other network measures.

2.1.2 Electricity Industry Regulation

There are two matters of substance:

- Regulatory settlement broadly expects the best price for customers, consistent with safe and efficient network operation and ensures that network expenditure is just adequate to deliver quality and reliability of supply; this losses reduction network efficiency measure is therefore part of the total picture and not an isolated objective;
- The quantities of transformer replacement versus refurbishment are to some degree determined by the prices of the two options and the money available to spend. If therefore, additional money was needed for losses justified replacement over and above the minimum legally compliant requirements that is justified on a cost benefit analysis.

Ofgem has in mind a new competitive regulatory element[1] to incentivise reductions in losses using a discretionary reward (DR) arrangement at various points during RIIO-ED1 in lieu of the previous losses incentive mechanism. This may be managed through a visual indicator like a score card. The fund envisaged for all UK DNOs totals £32m and is awarded in three unequal stages £8m, £10m and £14m. We understand that there will be competition among DNOs for the fund.

We believe strongly that Ofgem should ensure that best practices are shared. We believe that competition is a good way to stimulate the development of best practice, but once developed the UK-wide carbon abatement targets, and long term cost base must have the opportunity to benefit from all successful initiatives wherever they originate.

We recognise that every network faces different challenges and each customer base is different, but to ensure that we have not over-looked any learning from other DNOs, we have reviewed the publicly available documentation published by the other utilities.

2.2 Stakeholder Issues

It is clear that customers benefit from lower levels of theft. As a company we also benefit by being seen to ensure that the allocation of costs to customers is as accurate and fair as we can achieve. Therefore we should:

- Always seek to dissuade theft of electricity whether from our networks or by interfering with the metering arrangements in premises;
- Where we have the right we will seek to recover our lost revenue and assist suppliers to recover their lost revenue, the cost of such actions or replacing /repairing damaged equipment up to the point where the cost of recovery exceeds the value gained for customers.

Network development and operational issues are less clear. We must comply with legislation. To go further requires some evidence that customers will benefit in the long run. The question then becomes how to make that assessment. This is where our design and operational guidelines need to fit with the situation. These guidelines must ensure that all relevant benefits are considered and appropriately weighted so that each project is given the maximum chance of achieving climate change objectives. There is also a question of over what period, we should weigh the benefits. The longer the period, the less chance there is that the customers who pay for capital improvement will actually reap the rewards. Yet, it is clearly an objective of an infrastructure company to maintain and develop improving infrastructure for the enduring benefit of customers. The time range realistically stretches from a single regulatory period (now 8 years) to the full life of assets (40-45years).

We are the custodian of important national infrastructure. The views of customers and other industry stakeholders and their understanding of our policies are important to us. We therefore intend to widen our existing stakeholder engagement meetings and other interactions to also include the losses strategy, performance and initiatives.

[1] Ofgem Losses Discretionary Reward (LDR) Guidance Document https://www.ofgem.gov.uk/sites/default/files/docs/2015/08/150807_-_tm1_1.pdf

We also specifically wish to hold regular interaction with our university partners and the supply chain to seek and to quantify initiatives.

An important initiative is to explore with Electricity Suppliers the incentives, the effects and implementation issues associated with customer time-of-day load pattern switching (see Section 9). There may be local differences in behaviour and Suppliers may have commercial or marketing strategies which could be disturbed by such tariffs.

2.3 Technical Constraints

Our distribution networks are complex. In many cases they are heavily meshed and the flows on any one part depend on the flows in other parts of the network. In parts of the network, geographically separated transformers supply a wide group of network customers, so decisions on reliability, loading and losses are inextricably linked. Changing cable sizes on the existing mesh network can disturb the flow patterns, although for network additions we can design the solution to factor in loss reduction. Even making an assessment of the losses implications of options in such complex environment is fraught with difficulty. An example is that adding capacity can improve losses but create other technical problems.

Retrofitting transformers in substations with units which are larger and heavier may not be simple if the low loss units require more space or heavier foundations.

We are developing solutions to these matters by:

- Improved complex meshed network analysis tools;
- Supplier interaction on transformer design.

3 Linkages with other Documents

This energy losses strategy forms an integral part of SP Energy Networks' RIIO-ED1 business plan and is linked to other sections and annexes within our overall submission, particularly those relating to capital expenditure, smart meters, smart grids and innovation. Further insights regarding interfaces between this losses strategy and other initiatives included in our March 2015 RIIO-ED1 business plan are provided in the documents contained in Table 3.1.

Document	Chapter / Section
SP Energy Networks Business Plan 2015-2023	Chapter C6 – Expenditure d. Load Related Expenditure e. Non Load Related Expenditure
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C7 – Smart Grid Strategy - Creating a Network for the Future – SPEN
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C7 – Smart Meter Strategy – SPEN
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C5 – Environmental Strategy – SPEN
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – Load Related Investment Strategy – SPEN
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – LCT Network Monitoring Strategy – SPEN
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C7 – Innovation Strategy – SPEN

Table 3.1 - Linkages to RIIO-ED1 business plan

4 What are losses?

About 6% of the energy entering the distribution system is not billed to customers. Much of this is lost in heat and noise as part electricity supply process. This energy is referred to as technical losses. In addition a small amount energy is stolen, or not fully recorded. This is referred to as non-technical losses. Electricity industry settlement systems charge suppliers for network losses and are therefore paid for by the customer.

4.1 Technical losses

Our electricity distribution networks convey energy from the interface with the transmission system to the low-voltage supplies used by our network customers. The system comprises overhead lines, underground cables, switchgear and transformers and is constructed for operation at several different voltage levels. The design is based on the principle that as the load to be transferred increases so does the operating voltage. This design ensures that the electric current does not become excessive which would create uneconomic losses. Each of these network components generates heat or noise or both as electricity is transferred. Because they are well designed, with efficient materials, they consume only small quantities of energy relative to the total energy delivered. In the case of transformers, there has been improvement in the efficiency of design and materials over time.

A number of terms are used to describe the behaviour of Technical Losses:

- **Fixed Losses:** Even if no power was being delivered to customers, the system has losses just because it is electrically energised. These are called the **Fixed Losses** or "**no-load losses**". Largely they arise because the steel in each transformer's magnetic core is reversing magnetic polarity in every AC cycle. This causes it to pulse (which emits a humming noise) and to heat up. Taken alone this steel inefficiency is called "**Iron Losses**". Also no electrical insulation is perfect and there will always be some small level of current flow across insulation used in transformers, lines and cables. Taken altogether these inefficiencies are the "No Load" or "Fixed Losses" on the system.

- **Variable losses:** All conductors whether coils in transformers, aluminium or copper wires in overhead lines or cables and even in switchgear have electrical resistance which causes them to heat when carrying electric current. This heat is lost to the environment. The amount or heat losses rises as the square of the current and therefore if the peak current was 10 times the minimum, that losses at peak would be 100 times as large as the losses at minimum load. Because these losses vary with the current flowing through the system such losses are called 'variable losses'. It follows that the variable losses from equivalent distribution assets carrying high currents (i.e. high asset utilisation) are significantly greater than those from lightly-loaded assets. It also follows that installing larger sized conductors reduces variable losses because the heating is less in larger conductors.

Clearly these two types of Technical Loss represent waste. Extra energy must be generated which causes excess atmospheric greenhouse gasses, assessed as atmospheric carbon. Also this waste energy has a price. Calculating the value of technical losses is complex because variable losses change with load on the circuit but the value of energy also varies with the time of day. Patterns of losses occurrence have been studied throughout the industry and "in the round" figures and methodologies have been generated for the price of fixed and variable losses. Having calculated the cost of losses, the target is to reduce them. They cannot be eliminated and the approach is to seek a proper economic balance. This is complicated by the view that as the generation industry is progressively decarbonised, each loss unit of electricity will contribute less carbon to the environment.

If some of the energy lost in our substation transformers could be recovered as heat and used, it is then open to debate whether that should drop out of the calculation, simply because it is now providing a useful societal function. We intend to consider in ED1 whether there are such applications and then hold that discussion.

The other type of loss categorised as a Technical Loss is our distribution system “house consumption account”.

- **Energy consumed by our equipment to ensure reliable network operation:** In addition to the fixed and variable losses described above, further energy is required to ensure safe and reliable operation of our networks. In our substations, energy is typically consumed for heating and lighting, dehumidification & cooling equipment, oil pumps, air compressors and battery chargers to maintain secure network operation and resilience[2].

This is entirely different. The approach is rather like a factory or hospital manager being charged with achieving energy efficiency targets. For us however, generating our own renewable energy to run our substations is made more complex because market rules established to achieve wider equity principles at present prevent us from generating energy other than in very special circumstances.

4.2 Non-technical losses

Non-technical losses primarily relate to unidentified, misallocated and inaccurate energy flows. In essence it is energy delivered but not billed. It is important to differentiate this from energy billed but where the bills are not paid. In that case we know who is consuming the energy. In the case of non-technical losses the end user is unknown or the amount of energy being consumed is uncertain. The three main types of non- technical losses addressed in this strategy document are described below:

- **Energy theft:** Illegal abstraction of electricity by a small number of customers, achieved through tampering with supplier meters or interference with our network assets. This remains an ongoing challenge for the electricity industry and concerted effort by a range of stakeholders will continue to be required to mitigate this problem. In addition to fraud there are serious safety aspects to be considered.
- **Unmetered supplies:** Not all customer supplies in our distribution areas are metered. Typical unmetered loads include street lighting, traffic lights and road signs, advertising hoardings and lighting in shared occupancy buildings. Such consumption is quantified by establishing accurate records for each unmetered supply and applying a representative profile to estimate consumption characteristics. Losses typically arise as a consequence of incorrect or incomplete unmetered supplies records and inaccurate estimated annual consumption information.
- **Conveyance – electricity delivered but not accurately recorded in energy settlements:** Situations arise where energy is consumed but is not accurately recorded in the national electricity settlement system and effectively becomes lost energy. Typical reasons for energy not being accurately recorded include missing/unregistered metering points, incorrect recording of metering point energisation and incorrect registration of metering systems which all result in inaccurate or missing consumption data.

These non-technical losses do work for some element of society. They are therefore not a loss of energy to the environment but a loss of revenue to the system. Since all customers pay the costs through tariffs, they like non-technical losses add to costs. In pure economics, we should only invest in non-technical loss recovery up to the point where the expenditure equals the value recovered. However we believe that like Non-technical loss mitigation, it is necessary to take a long view. That view needs to somehow value the deterrent value of our actions.

2 Unlike the other losses described in this document, which are invisible to the settlements process, the electricity consumed at SPD & SPM substations is recorded as separate unmetered supplies and corresponding estimates of annual energy consumption are uploaded into the settlement system.

5 Improving Understanding of Losses

Strategic Objective

Progressively improve the quantity and quality of information available for:
- factoring losses into investment decisions;
- target setting and progress monitoring

We see the actions needed to create better understanding of losses as enabling effective implementation of the strategy by providing well researched information for project cost-benefit analysis and targeted/ monitored action. For this reason, we have not made any attempt to carry out a cost-benefit of these enabling actions.

5.1 Present position

The current approach to determining distribution network losses has several shortcomings:
- It is not possible to distinguish between technical network losses and non-technical losses,
- The process is very sensitive to data quality and accuracy,
- Estimated energy consumption is used to determine energy use from unmetered supplies, and
- Apportionment of losses across customers is reliant on educated estimates.

Ofgem has recognised these shortcomings and has withdrawn the previous losses incentive mechanism from the start of DPCR5 due to the challenges in obtaining accurate data to provide meaningful and consistent quantification of technical and non-technical losses.

5.2 RIIO-ED1 Strategy

5.2.1 Additional network metering

Establishing a reliable losses baseline within RIIO-ED1 will require an improved understanding of the load flows across our network from the Grid Supply Point to the consumer meter. To achieve this will require additional monitoring and metering capabilities across the network, particularly at primary and secondary substations and the LV network.

SP Energy Networks is already committed to the deployment of advanced monitors on LV feeders at 1,348 secondary substations across both licence areas. The purpose of this monitoring is to collate enhanced data from the secondary transformer and LV network interface to provide improved network operational information including power flow, power factor and phase balance. The combination of fixed and mobile monitors will be initially targeted at highly loaded sites where LV network losses are potentially greatest. This advanced monitoring capability will be augmented by the installation of smart MDIs (Maximum Demand Indicators) at a further 1,200 secondary substation sites across SPD and SPM to provide a monitoring capability at a total of 2,500 substation sites. More detail is provided in Section 7.5.3.

We will proactively pursue detailed analysis of smart meter data and endeavour to develop models to compare and reconcile data from the advanced monitors and smart MDIs. This approach will greatly increase our knowledge of LV network losses and will provide indicators on how best to improve uncertainties around the quantification of unmetered supplies and theft. Such detailed and localised quantification of total losses will increasingly influence our capital planning processes regarding asset replacement, network expansion and reinforcement strategies. Further information can be found in our smart metering strategy provided as **Annex C7 – Smart Metering Strategy – SPEN**.

5.2.2 LV Network Modelling

We will endeavour to develop an enhanced LV network modelling capability that aggregates energy density values to LV circuit and secondary transformer levels. This approach builds on the LV Template modelling techniques previously established by WPD and integrates customer connectivity, address and MPAN data to model energy density changes on the LV network and provide improved information on secondary substation utilisation.

5.2.3 Network Loss Modelling for Complex Networks

We are in the process of specifying a modelling tool aimed at allowing us to consider the losses implications of meshed network project options. This is discussed in more detail in Section 7.5. The output from this will form part of our decision making processes.

The stages of this development process are:

- Complete the specification of the tool;
- Tool creation and proving;
- Validation of the outputs of the tool against measured section of network.

We consider this to be a critical part of properly informing investment decisions in our HV network.

5.2.4 Using Data from Smart Metering

The availability of smart meter data, in association with enhanced network monitoring, will feature prominently in improving our understanding of the magnitude and location of losses, especially on LV networks, and will inform development of our baseline methodology. Smart Meter data will provide within-day consumption data for individual customers, which when linked with our network connectivity models will provide detailed insights into substation average and peak loading from which loss calculations can be performed. Substation monitoring will enable individual circuit loadings to be observed and circuit-specific losses can be calculated. Comparison of circuit loadings with smart metering data will give the magnitude of total losses and highlight specific areas of concern. Typically large unexplained differences or unusual patterns require investigation for non-technical loss The use of smart meter data is discussed further in our Smart Meter Strategy (**Annex C7 – Smart Metering Strategy – SPEN)**.

5.2.5 Learning from others

SP Energy Networks .always considers innovation and learning from other DNO initiatives, for instance, WPD's LV network templates and ENW's LV network modelling.

We also view information from organisations like CIGRE and CIRED to learn from international experiments and practice.

As stated earlier we believe that Ofgem should incentivise other otherwise encourage sharing of best practice and successes amongst all DNOs for the greater good.

5.2.6 Support for a common basis of Assessment

We believe that if our regulator is to be able to report with integrity on losses performance for the whole of the UK there must be a case for establishing some level of commonality in approach to assessing baseline and improvement, and we stand ready to fully support any such initiative.

6 The "Do Nothing" Case

6.1 Background

Historically, network losses were calculated using meter settlement data and reported annually to Ofgem. This practice ceased in 2010 at the introduction of DPCR5 due to inherent inaccuracies in calculating losses and the challenges of making meaningful comparisons between different DNO licence areas The chart in Figure 6.1 below indicates the range of losses previously reported to Ofgem and is provided solely for illustration.

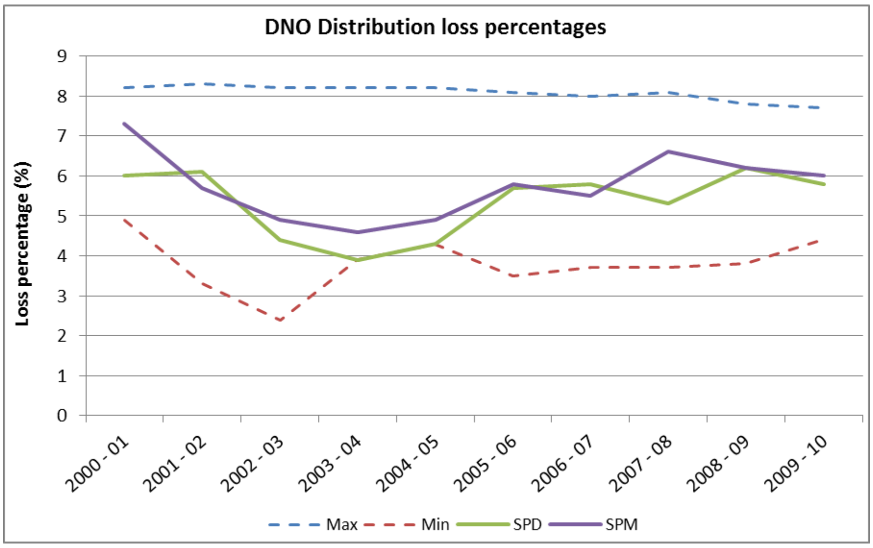

Figure 6.1 – Historic DNO losses

Source: Ofgem, Electricity Distribution Loss Percentages by Distribution Network Operator (DNO) Area

From 2005-06 onward, the start of DPCR4 and the introduction of the Ofgem losses incentive, total losses expressed as a percentage have remained relatively flat across all DNOs, including the SPD and SPM licence areas.

A major driver for system losses is the weather as this directly affects the system maximum demand and the associated system losses.

In 2009-10 SPD reported energy losses of 1,250 GWh, equating to 5.8% of the energy entering the distribution network and SPM reported losses of 1,040 GWh, or 6.0% of energy entering the network.

6.2 Impact of load growth on losses during RIIO-ED1

Our load growth forecasts are driven by a combination of economic forecasts and by Department of Energy and Climate Change (DECC) scenarios for the anticipated uptake of low carbon technologies. SP Energy Networks has adapted the DECC scenarios to its local operating environments and produced a 'best view' forecast based on the industry standard Transform model for the SPD and SPM licence areas.

Any assessment of the overall impact on losses from these technologies is subject to significant variability due to uncertainties regarding LCT adoption rates and locational factors (including clustering), and therefore it will be essential to monitor the network as LCT penetrations rise in order to mitigate any increase in losses appropriately. Our monitoring plans, particularly for secondary substations and LCT hot spots are described in Section 5

In general, from a qualitative perspective, increases in both peak and average demand can be expected to increase losses in existing network infrastructure due to higher levels of asset utilisation and corresponding increases in variable losses. However, where reinforcements and asset replacements are planned there will be opportunities to offset these increases by installation of new lower loss network infrastructure where economically justified by cost-benefit analysis.

6.3 Smart grid impact & increasing asset utilisation

We report Smart Grid and Demand Side Management encourage higher utilisation of the existing network. We report them here because they are existing initiates which may dis-improve overall losses unless carefully targeted.

From a commercial perspective, during the course of RIIO-ED1, we plan to develop demand side response solutions to allow more utilisation of the network. However by smoothing load profiles and reducing peak demand we can also target loss improvement. This is detailed within our innovation strategy as a key area of focus due to the possibility of multiple benefits being realised.

Similarly, contracting for localised generator support could be targeted to offset demand in specific areas reducing the distances over which energy is transported and the associated losses. This is included within our portfolio of smart solutions for general reinforcement in RIIO-ED1 and builds on the learning of DNOs through LCNF projects, such as Low Carbon London.

As the deployment of distributed generation and low carbon technologies accelerates, placing additional demands on network capacity and utilisation, it is envisaged that smart grid technologies will be deployed as a cost-effective solution to network capacity maximisation. SP Energy Networks is actively pursuing the development and installation of smart technology where appropriate. We again need to factor losses into scheme designs, however the prime driver to date has been increased network utilisation.

Active Network Management (ANM) and dynamic line rating schemes developed under other initiatives are increasing the capacity of our existing assets. Where this gives rise to voltage or quality of supply problems, Intelligent Voltage Control or FACTS type devices can be applied. This increase in asset utilisation has the potential to increase network losses, however, in many cases this may outweigh the value of losses and be the best economic solution for our customers.

7 Technical Losses

Strategic Objectives

- Amend SPEN networks development and replacement policies to align with the Strategic Vision
- Develop an action plan based upon the strategic vision
- Quantify expected Outputs
- State how outputs will be monitored

7.1 Loss Reduction Opportunities in Network Design and Construction

This part of the Strategy document shows how the Strategy has influenced and will continue to influence our network plan for the succeeding eight years and quantifies the impact on cost and carbon of our presently identified actions. It also reflects our understanding of the volumes of work at July 2015.

By January 2016, we will:

- Review and amend our design and operational guidelines to align with this Vision.
- Ensure that knowledge of the amendments is immediately promulgated and ensure that there is an engineering culture of considering losses in everything we do.
- Develop a points based traffic light system to determine the most profitable cases to analyse. It is likely that the parameters to consider are:
    - the loss profile of the existing assets e.g. with transformers assessed by manufacturer age and type;
    - the maximum loading level as a percentage of the nameplate rating
    - either the no-load losses or for more complete analysis the loading profile facing the assets which is related to the balance of domestic and other loads including the profile of embedded generation and in future electric vehicle changing.

At this stage, in line with our vision to "*Consider all reasonable measures which can be applied to reduce losses and adopt those measures which provide benefit for customers"* our decisions are supported by cost benefit analyses.

7.2 Transformers

7.2.1 Background

Transformers convert electrical energy into magnetic energy and then back to electrical energy at a different voltage. They are comprised of a tank, oil, primary and secondary windings and a steel core. When connected, the steel core pulses (hums) and heats whether load is flowing or not. This consumes unproductive energy and is known as the iron losses. The way to improve iron losses is to use better low-loss steel. These losses benefits are achieved for the whole life of the transformer irrespective of load levels. The copper or aluminium windings make a contribution along with the iron losses to the no-load losses but the heating effect in the windings rises dramatically with load. The way to improve these variable is to oversize the windings or improve the conductor. These improvements carry a cost penalty which can only be justified when factored into the lifetime cost equation. The pattern of use is important. Transformers with long daily periods at high load incur much greater variable losses.

SP Energy Networks procures all transformers based on the lifetime cost of the transformer, incorporating capitalisation of losses, over a transformer working life expectancy of 40 years.

Manufacturers offer transformer designs to provide optimised cost/losses benefits based on the following formula:

Lifetime Cost (£) = Purchase price (£) + (No load £/kW x No load loss kW) + (Load loss £/kW x Load loss kW).

Note that the load loss £/kW figure incorporates a utilisation factor that varies between transformer types to reflect typical duties, e.g. a secondary transformer utilisation factor is higher than that of a primary transformer. SPEN provides the £/kW figure to be used by all tenderers.

We have been using this optimised transformer procurement policy since 2005 and our experience demonstrates that manufacturers consistently provide transformers that are lower loss than required by our minimum transformer design specification. SP Energy Networks will continue to reinforce the challenge to manufacturers as the proposed Ecodesign transformer standards are adopted.

As stated in Section 2, EU Directive 2009/125/EC mandates the adoption of Ecodesign power transformers in two stages:

- Tier 1 on 1st July 2015; and
- Tier 2 in 2021.

The Ecodesign requirements specify levels of losses for no-load and maximum load conditions for most new power transformers deployed within our networks and peak efficiency requirements for new large power transformers.

7.2.2 Counting Losses

When we replace a high loss unit with a lower loss unit anywhere on the network, losses reduce in absolute terms over a design which left the old unit in place by repair or refurbishment work. When aggregated these actions show the total carbon benefit of our network design. We report that total benefit here, and we will periodically show progress against those expectations in annual reporting.

A measure of the soundness of our Losses Strategy is to also report on what part of our total carbon benefit is achieved by having considered losses as a driver of change. We do that here, and we will periodically show how the volumes of carbon savings are growing over RIIO-EDI.

7.2.3 New or enhanced Capacity for Major Substations - Policy

Our 2005 procurement policy for large transformers is known to deliver at least the level of losses benefit proposed by the EU Ecodesign. We have no plans to reduce these standards.

License	Voltage	Rating	Comments regarding Eco Design
SPD	33/11kV	12/24MVA	Designs already meet/exceed tier 2 from 1st July 2015
SPM	33/11kV	7.5/10MVA	Designs already meet/exceed tier 1 but not tier 2 from July 2015
SPM	132/33kV	60MVA	Designs already meet/exceed tier 2 from 1st July 2015
SPM	132/33kV	100MVA	Designs already meet/exceed tier 2 from 1st July 2015

Since we would anyway have been purchasing within our policy, we claim no additional “losses strategy benefit” for new or enhanced capacity work which matches Ecodesign and is carried out “just in time”. In fact we, together with many other UK DNOs, have more than matched that standard 10 years ahead of the EU Regulations.

It is different for any case where we bring forward a system capacity enhancement because we now additionally value a losses benefit. Typically an enhancement might involve changing to larger transformers or adding a new transformer location to relieve the load on other parts of the network.

Bringing forward reinforcement is a case-by-case analysis and we will now factor the losses value into our network enhancement as a means of determining the most appropriate date for network capacity increase. Where the results show sufficient benefit we will act on that and will then count the losses benefit of our Strategy for the time by which the project is brought forward.

Because this can only be considered case-by-case we have not been able to quantify the impact here but will report our findings throughout the eight year period.

7.2.4 Grid & Primary transformers

Investment Decision 1: Should we replace or refurbish Grid and Primary transformers?

We identified that, in general, it is more cost efficient to undertake on-site refurbishment of grid and primary transformers rather than to replace them.

However, some of our units are approaching end-of-life and SP Energy Networks will replace 16 grid and 70 primary transformers in SPM and 59 primary transformers in SPD during RIIO-ED1. This plan results in a loss reduction of 56.7 GWh in SPM and 12.9 GWH in SPD for the programmed grid and primary transformer replacements over the RIIO-ED1 period.

Existing Policies and New Requirements

As stated above, our current policy to procure optimised, high efficiency grid and primary transformer designs already exceeds the proposed power transformer EU Directive Tier 2 efficiency standard for 2020.

Decision Basis

These are interventions which are planned to maintain reliability in the network.

In CBAs 63, 64.1, 64.2 in **Annex C6 – Cost Benefit Analysis – SPEN** of our business plan, we identified that, in general, it is more cost efficient to undertake on-site refurbishment of grid and primary transformers rather than to replace them. This NPV analysis considers in detail a range of influences including the investment associated with CapEx (refurbishment versus procurement of new units) and OpEx (costs or benefits associated with inspection and maintenance, losses, security of supply etc).

However, although the general case promotes on-site refurbishment over replacement, there are a significant number of units which are approaching end of life (HI5) and will be replaced. These replacements will result in a relative reduction in system losses as new transformers are more efficient. These benefits are quantified here, although the replacement is not directly driven by losses benefits.

We will additionally (as in the case of new capacity purchases) consider whether any of these replacement transformers show a sufficient losses saving to be brought forward in time. This is a case-by case analysis and will be undertaken in the detailed pre-engineering works for each replacement. If analysis regularly shows that the losses benefits justify a brought forward case, we will advise our Regulator because we assume that such an approach might apply throughout UK. We will then discuss with Ofgem how such matters are best dealt with.

Risk Management

Both for the asset replacement and increased capacity cases we consider that it is necessary to have developed the improved losses assessment tools and proven them in order to give ourselves and our Regulator confidence that any brought forward decisions are sound.

We consider the present volumes analysis (below) to be based upon sufficiently sound information.

Cost Impact

The losses and carbon benefits resulting from Grid and Primary transformer replacement are outlined below:

	Category	Volume	Losses-justified component of expenditure	Total losses benefits (£m) During ED1	Net losses related benefit (£m) During ED1
SPD	Grid	-	-	-	-
	Primary	59	£m 0.00	£m 0.72	£m 0.72
	Total (SPD)	59	£m 0.00	£m 0.72	£m 0.72
SPM	Grid	16	£m 0.00	£m 1.40	£m 1.40
	Primary	70	£m 0.00	£m 1.76	£m 1.76
	Total (SPM)	86	£m 0.00	£m 3.16	£m 3.16
Total		**145**	**£m 0.00**	**£m 3.89**	**£m 3.89**

Table 7.1 – Cost impact associated with the losses benefits of grid and primary transformer replacement

Achievement of the losses benefit has already been embedded into our replacement programme and SP Energy Networks will continue our proven, cost-effective transformer procurement policy into RIIO-ED1.

Impact on Total System Losses

Grid and Primary transformer replacement programme				
	Transformer Volumes		Losses reduction over ED1 period	
License Area	Grid	Primary	GWh	tCO_{2e}
SPD (Primary)	-	59	12.9	5,582
SPM (Primary)	-	70	31.5	13,741
SPM (Grid)	16	-	25.2	10,983
Total	**16**	**129**	**69.6**	**30,306**

Table 7.2 - Losses reduction from grid and primary transformer replacements

Note - The high losses reductions achieved in SPM are due to the volume, forty-four, of particularly inefficient pre-1962 era transformers programmed for replacement in ED1.

Impact due to Losses Strategy

We do not claim any Losses Strategy driven carbon benefit for this work

7.2.5 Asset Replacement - Secondary (HV) transformers (Ground Mounted)

Existing Policies

Our policy since for our entire condition driven transformer replacement programme has been to install new units that comply with our lifetime cost optimised design methodology. Whilst the efficiency of these new transformers exceeds our minimum specification, they do not meet the efficiency standards of the proposed EU Directive Tier 1, due to come in to force from 1st July 2015.

New requirements

The legally required move to procuring new transformers to Tier1 in 2015 and Tier 2 in 2021 will represent a saving in losses over refurbishing existing units and to a much lesser extent a saving over continuing with our current procurement policy.

Quantifying savings

We first quantify our decision to procure new transformers against the refurbishment option as a way of showing the UK carbon advantage over our existing network asset base.

Accurate information risks

The greatest contribution to overall distribution network losses occurs across the secondary substation transformer and connected LV network, however, these are also the areas of network where the least is known in terms of demand patterns.

Decisions regarding HV transformers are, at present, principally based upon loss reductions arising from the improvements in no-load losses in modern transformers. As more detailed and more reliable data relating to the loading in these transformers becomes available, losses calculations will be able to better consider variable losses. Improved LV network measurement and information storage (Section 5) is key to enabling this analysis.

Investment Decision 2: Should we move to procurement of Tier 2 Ground Mounted Secondary transformers immediately instead of waiting until 2021?

This decision investigates whether it is reasonable to move to procurement of Tier 2 units immediately instead of waiting until July 2021. That would give a lifetime advantage of 45 years times the difference in annual carbon between Tier 1 and Tier 2. Is this justified?

We have analysed technical risks alongside a cost-benefit analysis for these units and our decision is to continue to procure Tier 1 units in line with the EU Regulations. SPEN will continue to review advances in this area and will revise our policy when it becomes cost efficient and practical for us to install transformers compliant with EU Directive Tier 2.

Risks Management

Cost risk

Having regard to the technical requirements and high volumes needed throughout Europe, manufacturers are taking time to quantify the impact for Tier 2 transformer costs. Our estimates are based upon the best information available. We will advise of any change resulting from more accurate cost information.

Technical risk

Low loss transformers of this capacity are generally larger in size and considerably heavier than similarly rated standard oil filled transformers. This issue has the potential to impact the footprint and potentially foundations required for ground mounted substations (with associated increases in total costs). If we are to replace existing units, we must make them fit within available space in the existing footprint, otherwise any benefits in terms of losses will be outweighed by construction of a new substation

SPEN will continue to review advances in this area and will revise our policy when it becomes cost efficient and practical for us to install HV transformers compliant with EU Directive Tier 2.

Cost and Losses Impact

Without considering the technical risks outlined above, the NPV of this option identified that the losses savings associated with the difference between Tier 1 and Tier 2 units were not sufficient to out-weigh the additional expenditure associated with these lower loss units.

The new legal requirement means that there is no Losses Strategy benefit to be factored into the analysis when replacing “must replace rather than refurbish” units or installing “new to the system” units. However, replacing existing units is still considered to provide losses benefit relative to refurbishment where this is an option.

Investment Decision 3: Should we replace or refurbish Ground Mounted Secondary (HV) transformers?

This decision investigates whether there is a losses based case for replacement versus refurbishment, or for bringing forward replacement of older higher losses units.

> Where condition assessments have identified transformers as needing action, SPEN will replace, rather than refurbish a total of 417 transformers (220 in SPD, 197 in SPM);
>
> We have identified an additional 1,111 transformers (484 in SPD, 627 in SPM) which incur high losses and we will pro-actively replace these during ED1.

Decision Basis

In CBAs 1.1 and 1.2 in **Annex C6 (Cost Benefit Analysis – SPEN)** of our business plan, we identified that it is cost efficient to pro-actively replace pre-1962 ground mounted distribution transformers because they are high loss units.

For decisions in this area we have categorised transformer interventions into the following two categories:

- Volumes of transformers needing action in the general population of transformers; and additionally
- High loss pre-1962 transformers. These transformers exist in both our Licence areas.

As with all asset management decisions that we make, it is a combination of factors which causes us to decide to change these units. In this case, age, condition and losses.

In the second group, the losses case arises because, prior to 1962, the quantity and quality of steel used and other factors in manufacture of the transformers, produced an iron core inferior to present day manufacturing practice with resulting high losses, reducing the transformer efficiency, over a modern unit, by up to 60%.

Whilst in both categories the assets could have been refurbished we have decided to replace them, based upon losses advantage. They have therefore been scheduled for replacement within the core asset replacement programme.

Within the pre-1962 category:

- SP Energy Networks has a population of 3,201 ground mounted secondary transformers installed pre 1962,
- We plan to replace a total of 1,528 during the RIIO-ED1 period; 1,111 from the losses driven initiative and 417 in the asset replacement programme.

In the general population, a combination of factors will be used to prioritise the work, in particular:

- asset condition;
- network outage availability; and
- transformer loading.

In the pre-1962 group, the prime driver in terms of losses will be to replace the oldest and heaviest loaded units first, so as to get maximum losses savings. However, we will also need to balance other factors such as network outage availability and cost efficiencies of any other site works.

Impact of Decision on cost

For both categories, the benefits arising from reduced losses as shown in Table 7.3.

	Category	Volume	Losses-justified component of expenditure	Total losses benefits (£m) During ED1	Net losses related benefit (£m) During ED1
SPD	Pre-1962	484	£m 4.65	£m 0.96	-£m 3.68
	Asset Replacement	220	£m 0.00	£m 0.37	£m 0.37
	Total (SPD)	704	£m 4.76	£m 1.33	-£m 3.42
SPM	Pre-1962	627	£m 6.58	£m 1.19	-£m 5.39
	Asset Replacement	197	£m 0.00	£m 0.35	£m 0.35
	Total (SPM)	824	£m 6.78	£m 1.54	-£m 5.24
Total		**1528**	**£m 11.23**	**£m 2.87**	**-£m 8.36**

Table 7.3 – Cost impact associated with the losses benefits of ground mounted secondary transformer replacement

Impact of Decision on Losses

Referring first to the change of transformers within the general population of transformers - any of these units could have been refurbished rather than replaced so the carbon savings add to the SPEN and UK total but also add to the savings driven by the Losses Strategy.

To enable results tracking, we present the savings separately for the general population and for the pre-1962 secondary transformers. We will continue to monitor and report in this way.

Conditioned based replacement of Ground Mounted Secondary Transformers (asset replacement programme utilising Tier 1 Ecodesign)			
License Area	Secondary transformer replacement volumes	Losses reduction over ED1 period	
		GWh	tCO_{2e}
SPD	220	8.8	3,813
SPM	197	8.2	3,552
Total	**417**	**16.9**	**7,365**

Early replacement of pre-1962 Ground Mounted Secondary Transformers (beyond condition based programme, specifically to reduce network losses)			
License Area	Secondary transformer replacement volumes	Losses reduction over ED1 period	
		GWh	tCO_{2e}
SPD	484	22.7	9,877
SPM	627	28.1	12,224
Total	**1111**	**50.8**	**22,101**

Table 7.4 - Losses reductions from ground mounted secondary transformer replacement under asset replacement programme and early replacement of pre-1962 units

The total contribution to UK losses savings over our existing network is set out in the following Table. It represents 1528 replacements.

Total of Condition Based and Early Replacement of Ground Mounted Secondary Transformers			
License Area	Secondary transformer replacement volumes	Losses reduction over ED1 period	
		GWh	tCO_{2e}
SPD	704	31.5	13,691
SPM	824	36.3	15,776
Total	**1528**	**67.7**	**29,466**

Table 7.5 – Total losses reductions from ground mounted secondary transformer replacement

Further opportunities to continue to review and assess

Replacement volumes are limited in RIIO-ED1 due to deliverability constraints and it is our intention to complete the programme by replacing the remaining 1,673 pre-1962 transformers in ED2. However, throughout ED1, SPEN will continue to prioritise and review our asset replacement programme and losses will continue to be factored into this.

7.2.6 Secondary Transformers (Pole Mounted)

Investment Decision 4: Should we proactively replace HV pole mounted transformers throughout ED1?

SPEN's ongoing policy is to replace PMT's on failure rather than proactive replacement based on losses.

During ED1 SPEN shall further evaluate the early replacement of high loss units during planned activities such as OHL refurbishment and rebuild.

Decision basis

Pole mounted secondary transformers are typically in rural areas and often lightly loaded (circa 20% utilisation).

Low loss transformers typically weigh more than older, higher loss units which means the pole structure may need to be enhanced to carry the extra weight of the equipment.

SPEN's ongoing policy is to replace PMT's on failure rather than proactive replacement based on losses.

During ED1 SPEN shall further evaluate the early replacement of high loss units during planned activities such as OHL refurbishment and rebuild.

We will apply our strategy vision test of adding benefit for customers.

7.3 Overhead lines and Cables

7.3.1 OHL at EHV and above

Investment Decision 5: Should we increase cross-sectional area of OHL conductors at EHV or 132kV to reduce network losses?

SPEN's existing design policy is maintained, however the losses benefit associated with increasing conductor size to be considered on a case-by-case basis

Decision Basis

At the higher voltages (132kV in SPM and 33kV in SPM & SPD) there is no clear and generalised cost benefit from upgrading overhead conductor sizes.

- EHV and 132kV networks generally only account for a small proportion of losses (circa 0.3% of total energy served)
- In general high loss circuits are old and of small cross sectional area (typically 0.1cu or lower). The wood poles supporting the line are usually unable to carry the weights and tensions associated with higher rated conductors. To significantly reduce the losses, the line needs to be surveyed, re-designed and reconstructed, the overall cost of which usually outweighs the customer benefits associated with reduced losses.
- In areas of interconnected network, any alteration in conductor size/impedance must be considered on a case-by-case basis. This is because the changes are likely to affect the balance of power flow across all interconnecting circuits in the group. The change in power-flows not only affects losses, but also can affect the capacity of the group. This analysis needs to consider the projected use of the network (including demand and generation growth) across the planning horizon to ensure that the network continues to be fit for purpose and as economically efficient as possible.

As a result of the above factors any replacement decision can only be taken on a case-by-case basis.

7.3.2 OHL at HV

Investment Decision 6: Should we increase cross-sectional area of OHL conductors at HV to reduce network losses?

All HV main line new build and offline rebuilds throughout the RIIO-ED1 period will be constructed using $100mm^2$ conductor.

Existing Policy
SP Energy Networks has been operating an overhead line resilience policy based on a geographical demarcation of normal and severe weather areas. Asset replacement and new build, reinforcement driven overhead line investments in normal weather areas are currently constructed with lighter $50mm^2$ conductor whereas those in severe weather areas utilise heavier $100mm^2$ conductor.

Decision Basis
Additional loss reduction options have been considered for normal weather areas during the RIIO-ED1 period and cost benefit analysis performed. In CBAs 68.1 and 68.2 in **Annex C6 – Cost Benefit Analysis – SPEN** of our business plan, we identified that, where practical to do so, losses reduction justifies installation of larger sized conductor when rebuilding OHL in both normal and severe weather areas.

The heavier conductor:
- Reduces network losses;
- Delivers enhanced network resilience in bad weather conditions;
- Enhances provision for load growth;
- Improves the ability to connect renewable generation in 11kV circuits.

Phasing of this work
Where we can identify any additional Carbon benefits through connection of renewable generation, circuits will be prioritised because, as stated in section 1, the de-carbonisation of generation has a proportionately greater impact on the overall carbon targets.

Cost Benefits
We have quantified the expected losses benefits for severe and normal weather areas separately as the upgrade of severe weather area is driven by ensuring that our network continues to be resilient and fit-for purpose.

These benefits will be subject to more detailed analysis on a circuit by circuit basis. Increasing the conductor size of some circuits may not be cost effective or achievable due to planning and wayleave constraints associated with a heavier construction line (which typically requires additional stays and H pole structures).

	Category	Volume	Losses-justified component of expenditure	**Total losses benefits (£m)** During ED1	**Net losses related benefit (£m)** During ED1
SPD	Normal Weather Area	361	£m 0.49	£m 0.17	-£m 0.32
	Severe Weather Area	519	£m 0.00	£m 0.25	£m 0.25
	Total (SPD)	880	£m 0.49	£m 0.42	-£m 0.07
SPM	Normal Weather Area	333	£m 0.45	£m 0.16	-£m 0.29
	Severe Weather Area	459	£m 0.00	£m 0.23	£m 0.23
	Total (SPM)	792	£m 0.45	£m 0.39	-£m 0.06
Total		**1672**	**£m 0.94**	**£m 0.81**	**-£m 0.13**

Table 7.6 – Cost impact associated with losses benefits of increasing HV main line conductor from $50mm^2$ to $100mm^2$

Losses Benefits

This revised policy provides the key benefit of a reduction in electrical losses. These are quantified below. These benefits are driven by the Losses Strategy so count both to the Total Losses benefits and the Losses Strategy benefits.

	Increase main line conductor size to 100mm^2			
	Category	Volume (km)	Losses reduction over ED1 period	
			GWh	tCO_{2e}
SPD	Normal Weather Area	361	3.8	1,656
	Severe Weather Area	519	5.5	2,384
	Total (SPD)	880	9.3	4,040
SPM	Normal Weather Area	333	3.6	1,586
	Severe Weather Area	459	5.0	2,191
	Total (SPM)	792	8.7	3,777
Total		**1672**	**18.0**	**7,817**

Table 7.7 – Losses reduction from increasing HV main line conductor from 50mm^2 to 100mm^2

Please note that increasing the conductor size also provides network capacity to approve connection of greater volumes of renewable generation and therefore this policy has significantly greater unquantified carbon benefits.

7.3.3 Underground cables at EHV and above

Investment Decision 7: Should we increase cross-sectional area of underground cables at EHV or above to reduce network losses?

SPEN's existing design policy is maintained, however the losses benefit associated with increasing cable size to be considered on a case-by-case basis

Decision Basis

At the higher voltages (132kV in SPM and 33kV in SPM & SPD) there is no clear overall benefit from uprating cables in conjunction with other works.

- EHV and 132kV cable networks generally only account for a small proportion (circa 0.3% of total energy served).
- Cable sizes tend to be larger at the higher voltage levels, the incremental costs associated with over-rating are therefore higher.
- In areas of interconnected network, any alteration in cable size/impedance must be considered on a case-by-case basis. This is because:
  - The changes are likely to affect the balance of power flow across all interconnecting circuits in the group.
  - The change in power-flows not only affects losses, but also can affect the capacity of the group.

This analysis needs to consider the projected use of the network (including demand and generation growth) across the planning horizon to ensure that the network continues to be fit for purpose and as economically efficient as possible.

7.3.4 Underground cables at HV and LV

Investment Decision 8: Should we increase cross-sectional area of underground cables at HV or LV to reduce network losses?

Referring back to the Losses Strategic Vision and the importance of information as an enabler, SPEN and EATL will update historic studies to better reflect our holistic approach, by newly considering the wider customer and societal benefits to be delivered over the RIIO-ED1 period.

Decision Basis

In 2009, SP Energy Networks commissioned a study by EA Technology Ltd (EATL) into the effects on losses from installing larger section LV and 11kV cables on a selection of typical circuits with varied demand profiles, e.g. domestic, commercial and mixed. The EATL report[3] analysed new installations only and included cost benefit analysis examining the benefits attributable to the DNO, customer and environment based on, respectively; a £48 / MWh incentive rate, cost reduction reflected in bills and reduced CO_2 production.

Whilst the overall benefit from totalling these three factors was generally positive, the benefit to the DNO alone could not be justified.

SP Energy Networks, therefore, did not change policy at that time to install larger section cables.

Decision

Referring back to the Losses Strategic Vision and the importance of information as an enabler, SPEN intend to update the 2009 EATL study to better reflect our holistic approach, considering the wider customer and societal benefits to be delivered over the RIIO-ED1 period.

The revised study will be extended to include additional factors such as future load growth, stock holding costs and procurement volume discounts on the cost benefit analysis. This gives the cost benefit case the maximum chance of succeeding

Decision under review

The incremental cost of installing larger cross section cables on new circuits is low compared with the total cost of installation. We are considering approving such a policy to be applied selectively to circuits. The key indicator is likely to be forecast demand profile of the circuit. We see this case-by-case approach as offering maximum benefit for customers by not applying a one size fits all solution.

The decision will be informed by:

- A revised CBA;
- Affordability on the basis that any marginal cost increases will be absorbed within our submitted expenditure.

Up to now, CBA results clearly demonstrate that the significant costs of excavation during cable installations are so large as to prevent any case for replacing existing installations.

We will quantify the expected savings when we publish the policy. If the decision could not be supported without the losses savings then the Losses Strategy will be credited with the savings.

[3] Reduction of Losses and Carbon Dioxide Burden in Cables, G. J. Le Poidevin, February 2009.

7.3.5 LV Service cables

Investment Decision 9: Should we increase cross-sectional area of LV service cables to reduce network losses?

The losses benefits in this area were found to be fairly small, we will continue to assess the merits of up-rating service cables and whether there is a justification for an increase in service conductor sizes.
We intend to feedback our findings in this area to Ofgem and the other DNOs in order to support adoption of efficient designs holistically across the industry.

Existing Policy

For new or replaced service cables, our design policy to-date has been to employ either 25mm^2 or 35mm^2 Aluminium conductor for standard domestic customers. Designs take account of a range of aspects including voltage drop and thermal loading.

Accurate information risks

The reduction in losses arising from installing larger LV service cables is sensitive to the energy used by each property. The benefits are assumed to vary considerably based on customer behaviour and equipment installed. For example, a 4-5 bedroom family house may be expected to use more energy than a single pensioner in a 3-bed semi - unless the latter is electrically heated. Additionally, because variable losses are non-linear, the I^2R losses for a flat profile will be less than for a peaky profile - even if the energy used by the customer is the same.

A wide penetration of electric vehicles, heat pumps and photo voltaic generation is forecast for the coming years. The projected losses benefits are very sensitive to the probability of Low Carbon Technology uptake on houses with a replaced LV service.

Decision Basis

We have already carried out analysis to understand whether there is overall benefit from increasing the size of 25mm2 service cables to 35mm2. The analysis results are sensitive to a number of factors and also the range of benefits assumed. We are continuing to work on this issue and intend to publish our findings.

We intend to feedback our findings in this area to Ofgem and the other DNOs in order to support adoption of efficient designs holistically across the industry.

We will continue to review our quantification of benefits in this area as more accurate information becomes available from smart meter data and monitoring of LCT clustering. This future assessment could involve consideration of areas where LCT is clustering and whether there are cost-efficient opportunities to pro-actively bringing forward the replacement of targeted LV services to defer reinforcement and reduce losses.

7.4 Network Architecture and Voltage Rationalisation

7.4.1 Voltage Up-rating

Investment Decision 10: Should we rationalise voltage in legacy areas of 6.6kV to 11kV?

The programmed work to upgrade the 6.6kV islands to 11kV will continue.

Decision Basis

SPEN operates the distribution system with standard voltage levels of 132kV (SPM only), 33kV, 11kV and 400/230V. There are some legacy island networks which operate at non-standard voltages such as 6.6kV. The non-standard voltage networks can result in constrained system capacity.

The diminishing population of plant also presents risks from the perspective of fault repairs and spares availability.

SP Energy Networks has ongoing programmes, in both SPD and SPM, to uprate islands of distribution network currently operating at 6.6kV to 11kV.

Decision

The programmed work to upgrade the 6.6kV islands to 11kV will continue.

We have considered prioritising the actions by losses benefits but there are more complex matters to be managed in this case. Considerable pre-engineering work is required to deliver our voltage uprating and rationalisation programme resulting in delivery constraints. A total of three 6.6kV islands, 2 in SPD and 1 in SPM, will be uprated during RIIO-ED1 with all remaining SPD islands uprated in ED2. A further 3 island groups in SPM will be uprated during the RIIO-ED2 period and the final island groups completed in ED3.

In the absence of delivery constraints, we have considered whether there is justification to upgrade all islands based on losses considerations only. However the cost associated with replacement of all legacy HV circuit breakers and secondary transformers in the group outweighs the NPV benefits associated with losses.

Cost Impact

There are no capital cost impacts driven by losses considerations as these programmes are considered to be demand and capacity driven.

			Losses-justified component of expenditure	**Total losses benefits (£m)**	**Net losses related benefit (£m)**
	Category	Volume		During ED1	During ED1
SPD	6.6kV -> 11kV	2	£m 0.00	£m 0.07	£m 0.07
SPM	6.6kV -> 11kV	1	£m 0.00	£m 0.09	£m 0.09
	Total	**3**	**£m 0.00**	**£m 0.16**	**£m 0.16**

Table 7.8 – Cost impact associated with the losses benefits of uprating 6.6kV islands to 11kV

Losses impact

This work programme is demand and capacity driven but will also contribute to our loss mitigation endeavours. These projects will serve to reduce:

- Fixed losses – these projects require replacement of the majority of the 6.6kV/LV transformers with newer dual-ratio (11kV or 6.6kV / LV) units. These newer units are more efficient.

Variable losses - increasing the voltage will reduce the current. The non-linear relationship between current and losses will lead to variable losses on the HV circuitry to reduce to approximately 36% of existing levels. Because the programme driver is to achieve higher capacity on these networks, we do not to count the loss savings as Strategy driven, however they will contribute to the total savings in losses. These are quantified below:

Voltage Uprating Projects (6.6kV > 11kV)			
	6.6kV Islands	Losses reduction over ED1 period	
License Area		GWh	tCO_{2e}
SPD	2	1.2	522
SPM	1	1.6	700
Total	**3**	**2.9**	**1,222**

Table 7.9 – Losses reduction from uprating 6.6kV islands to 11kV

7.5 Other unquantified Technical Loss Reduction Options

SP Energy Networks is committed to the pursuit of loss reduction and intend to evaluate a range of other opportunities with the potential to reduce technical losses during RIIO-ED1.

Key areas for further evaluation in the short-term include:

- Voltage regulation and optimisation;
- Optimisation of network configuration;
- Secondary substation and LV network monitoring; and
- Transformer 'standby' opportunities in SPM.

We expect the above secondary substation monitoring initiative to provide data that will help us to target other loss reduction issues. These are likely to include:

- Phase imbalance locations;
- Areas where the harmonics levels are excessive;
- Areas where the power factor is poor.

Whilst it is too early in our progress to quantify the likely outputs from such activities they are being actively pursued and we will report on our expectations as soon as we are able. Whilst not to be ignored, these are smaller contributory factors to worsening losses. They are however important in maintaining a high quality of supply for customers. Of the three, power factor may deserve earliest attention from a losses perspective.

7.5.1 Voltage Regulation and Optimisation

Project 1

The characteristics of load behaviour against voltage are complex. A simple electric cooker illustrates this. Reducing voltage reduces the heating load, but each of the thermostatically controlled units stays on for longer so the combined effect of a voltage reduction may be to increase the periods of peak load from the cooker. As part of our current Tier 2 LCNF Flexible Networks project, we are examining the voltage dependency of load and the opportunities presented to optimise the voltage set-point at primary substations in relation to demand and loss management. The initial focus is on rural networks where circuit lengths are considerably longer, voltage drops are more significant and losses potentially higher.

Anticipated Outputs

- Loss reduction
- Accommodation of more renewable generation on our networks
- Input to voltage control philosophy for Grid and Primary substations and the application of associated technology
- Information to support our system operators at times of network stress
- Information to support the Transmission System Operator at times of system stress

Project 2

SP Energy Networks has identified an opportunity, to be pursued in RIIO-ED1, to improve voltage control philosophy and associated technologies at primary and grid substations.

This programme will initially be focussed on more rural sites where circuit lengths are considerably longer, voltage drops are more significant and losses potentially higher.

Anticipated Outputs

- Losses reduction
- Extending the capacity of our network to accept renewable generation.
- Voltage optimisation improving power quality.

7.5.2 Optimisation of Network Configuration

Project

Network open points requiring manual operation, were usually located to provide ease of access to operational staff. This was particularly important on rural overhead networks. Remote control and automation is now more prevalent making an opportunity to re-assess the location of open points. The optimum location can now optimise the balance of load on each side, thereby minimising overall losses.

In a Smart Grid, measurements might automatically change the location of the open points several times per day, however that is expensive and as a first stage we plan to optimise for losses on a more static approach. A prototype tool has been developed[4] in partnership with the University of Strathclyde that can be used to determine an optimised network configuration. The first consideration is network reliability, and within that constraint, the tool recommends a normally open location based on capital cost versus the estimated benefit of loss reduction.

Anticipated Outputs

- In RIIO-ED1 the tool will be further developed, and we will transfer it from a test environment and integrate it into existing network management systems for deployment in both operational and planning environments.
- We are planning to interface this network configuration optimisation tool into automation and smart control initiatives during RIIO-ED1 hence moving from the above static management of normally open positions to dynamic management. At that stage, and particularly with embedded generation, there are various drivers for the location of the open point and we will apply our losses Strategy Vision as a guide to prioritisation.

7.5.3 Secondary substation and LV network monitoring

The greatest contribution to overall distribution network losses occurs across the secondary substation transformer and connected LV network.

Project 1

SP Energy Networks will focus on collating enhanced data about this part of the network by installing fixed and mobile advanced monitoring devices.

Initially sites experiencing high load growth, high utilisation and those forecast to become likely LCT hot spots will be monitored.

A total of 1,384 monitors will be installed in RIIO-ED1, 880 in SPD and 504 in SPM. We will be monitoring approximately 5% of the ground mounted substation population.

Anticipated Outputs

Improved knowledge for decision making regarding:

- Demand growth pattern and types of load,
- Emerging trends and issues resulting from the expansion of low carbon technologies,
- Phase imbalance, the impact on losses and appropriate mitigation actions,
- Power factor correction and any solutions required that may reduce losses, and
- Harmonics contributions from the demands connected to the LV network.

Power factor correction, phase imbalance and harmonics related actions will emerge after monitoring project provides data records.

[4] A constituent part of innovation project IFI-0615 SP Active Research Centre.

Project 2
We will be considering methods to reconcile smart meter data with the substation monitor data (see **Annex C7 – Smart Metering Strategy – SPEN)**

Anticipated Outputs
- Improved quantification of losses across the LV network.

Project 3
Install smart MDIs (maximum demand indicators) to monitor the demand at secondary substation LV busbars at 400 sites in SPD and 800 sites in SPM. These will provide considerably more information than just the maximum current experienced since the meter was last reset and will store information such as load duration curves / daily profiles.

This MDI project will be co-ordinated with the planned LV board replacement programme.

Anticipated Outputs
The MDIs will provide substation loading information to improve decision making.
- More confidence in demand growth patterns,
- Transformer loading and phase imbalance,
- Better understanding of the impact of losses mitigation actions,

7.5.4 SPM secondary transformer 'standby' opportunities

As described in **Annex SP Manweb Company Specific Factors**, the SPM distribution network architecture differs from most other GB electricity distribution networks as follows:
- High levels of interconnected meshing between urban substations at all voltage levels.
- Urban networks have higher average transformer loadings and smaller cross-section cable, particularly at 11 kV. The SPM interconnected HV network operates with groups of up to 5 interconnected transformers.

Both of these considerations can result in higher than average technical losses.

Project
SP Energy Networks intend to evaluate loss reduction opportunities in urban SPM networks which would involve switching transformers out of service where interconnected networks retain sufficient redundancy during light loading periods, e.g. selected transformers could operate on 'cold standby' in summer months.

Risk analysis

The following analysis is required before any field action:
- Quantify the trade-off between the reduction of reduced fixed losses and increased variable losses;
- Factor the network reliability and customer service impact into the risk and cost benefit analysis.

Anticipated Outputs
- A report on findings dealing with different types of substation and network configuration quantifying savings and risks and making recommendations.

7.5.5 Development of enhanced SPM modelling tools

With increasing penetrations of embedded/distributed generation, power flows on our networks are becoming more stochastic in nature.

Deeply embedded generation generally serves to shorten power flow paths between generation and demand (unless sited in a heavily generation dominant area). The interaction between generation output and demand requirements give rise to complex, time varying, power flow relationships - particularly in a meshed network as the power flow across a large area of the mesh may be affected. In addition to this, changes like power factor correction or transformer tap position will also serve to impact losses as these serve to alter the voltage and therefore the current.

In a meshed network like SPM, in general, the parallel paths within the mesh should serve to reduce the losses compared to a "like-for-like" radial network – though obviously the impedance is crucial. In some areas of network some additional losses may be introduced due to power flowing through the SPM network in parallel with the National Grid network. However, this is generally limited.

Demand growth over ED1 will serve to increase losses, particularly as the network is pushed harder and the larger voltage drops give rise to larger currents. Load related reinforcement schemes will reinforce the network in areas where the demand growth introduces voltage/thermal/fault level constraints.

Project
Creation of power-flow modelling tools to calculate the life-cycle losses impact of interventions by making use of historic demand trends/ time series data coupled with forecasted demand

Anticipated Outputs
We consider this to be a critical part of properly informing investment decisions in our HV SPM network.

- Improved decision making for load related and asset replacement projects
- Could form a basis for near real time operational decisions, for example adjustment of voltage control set-points or normal open points
- Tool could be used to specify optimised set-points for planned innovative network components such as Phase Shifting transformers, STATCOMs

7.5.6 Improvement of our house load

In addition to the fixed and variable losses, energy is required to ensure safe and reliable operation of our networks. In our substations, energy is typically consumed for heating and lighting, dehumidification & cooling equipment, oil pumps, air compressors and battery chargers to maintain secure network operation and resilience.

Throughout ED1, we will continue to consider energy efficiency of our 'house load'. We will monitor and report on the baseline and improvements.

We are in the process of updating SPEN's suite of civil specifications for substations across all voltages. These updates consider energy efficiency. For example we are considering proposals to:

- Reduce the internal lighting level requirements for buildings generally. This will include GIS switch halls but exclude control rooms. This will be reduced from 200 lux average / 100 lux minimum to 100 lux average / 50 lux minimum.
- Reduce the external lighting level requirements for substation compounds, including AIS compounds. These will be reduced from 20 lux average / 5 lux minimum to 6 lux average / 2.5 lux minimum.
- Make use of a higher standard (U-value) of insulation in walls and roof insulation
- Significantly reduce the provision for heating

8 Non – Technical Losses

Strategic Objectives

- Reduce and deter theft anywhere in the electricity supply chain
- Improve accuracy of the record of unmetered supplies
- Improve accuracy of the metering of energy supplied (Conveyance)

SP Energy Networks categorises non-technical losses as:

> "*Energy that is delivered and consumed but is not accurately recorded within the settlement process".*

The resulting missing revenue adds to costs and therefore results in increased electricity costs for customers.

It is important that all stakeholders in the electricity supply chain proactively detect, remedy and deter increases in non-technical losses. The actions resulting from such collaborative working improve the accuracy of the energy consumption record within the electricity settlement process.

As part of our overall strategy for electricity losses, SP Energy Networks remains committed, throughout the RIIO-ED1 regulatory period, to reducing:

- Electricity theft;
- Unmetered supplies; and
- Electricity Conveyance losses.

8.1 Theft & Revenue Protection services

SP Energy Networks is committed to reducing electricity theft.

Reducing theft:

- Improves the equitable allocation of energy costs across customers,
- Addresses very significant safety concerns for the perpetrator, occupants of that and neighouring properties, contractors, emergency services and the industry staff associated with the illegal abstraction of electricity,
- Assists enforcement agencies in the prevention of criminal activities.

We believe the threat of detection combined with the prospect of legal recourse provides a deterrent to the illegal abstraction of electricity in future. Consequently, SP Energy Networks will remain committed to Revenue Protection throughout the RIIO-ED1 period by:

- Working closely with a range of industry and social stakeholders;
- Employing efficient Revenue Protection Services

8.1.1 Revenue Protection Approach

Revenue Protection forms part of a global Iberdrola 'Customer Service Network Integration' project to address fraud. The revenue protection team is participating in this information sharing and best practice initiative. We procure Revenue Protection who provides services to all suppliers. The objectives of the project are as follows:

- Protect our revenue and assets through strong prevention and detection;
- Employ advanced fraud/theft detection practices through new technology and skilled resources;
- Develop global fraud prevention methods to ensure accurate customer records; and
- Accurate timely billing of theft/fraud cases and debt collection (based on country specific regulations).

Throughout ED1 SP Energy Networks intend to:

- Analyse the activity of the Revenue Protection team to determine trends and hot spots;
- Work closely SP Metering Services and all suppliers to enhance the scope and effectiveness of revenue protection services throughout the RIIO-ED1 period.
- Assess and manage the risks and opportunities posed by the roll out of smart metering.
  [During the roll-out, we anticipate higher detection rates of meter interference as a consequence of the increased number of site visits, which will create new opportunities but also impact the Revenue Protection workload. We will monitor the technical and value aspects and ensure that provision is made to allow the Revenue Protection service to adapt to this.
- Continued evaluation of policy during smart metering roll-out.
  [There will be an on-going requirement to inspect metering installations to detect tampering. Smart meter tampering information will be automatically routed to suppliers and DNOs. The increased granularity of consumption information will also provide opportunities to detect unexpected consumption patterns. The frequency of site visits by metering staff is likely to reduce due to the introduction of remote meter reading and therefore the Revenue Protection service will need to target high-risk areas and suspicious consumption trends accordingly. Other risk factors need to be considered in setting the appropriate response.
- Investigate whether there is potential for effective correlation between smart meter information and Revenue Protection activity.

Overall, we believe the roll-out of smart meters could be used to further reduce and quantify non-technical losses. It will expose existing theft as meters are replaced and could enable earlier detection of theft and defective meters in future. This is viewed as a great opportunity for all parties engaged in Revenue Protection as there is effectively an opportunity to inspect every meter. Accordingly, we will be actively engaging with all meter operators to enhance their knowledge of energy theft and how this should be reported.

8.1.2 Revenue Protection services

For the RIIO-ED1 regulatory period we plan to retain SP Metering Services as the provider of Revenue Protection services to SP Energy Networks.

The Provider

This Revenue Protection service is fully compliant with all requirements of the Revenue Protection Code of Practice of Great Britain. The Code details the rights and obligations of DNOs and suppliers in relation to the prevention of meter interference and other forms of illegal electricity abstraction. Our Revenue Protection service provider is a member of the UK Revenue Protection Association whose staff are highly trained and experienced, actively participating in relevant electricity industry forums.

The Service

- Provides updates to information systems and customer records arising from Revenue Protection activities conducted for SP Energy Networks;
- Works closely with electricity and gas industry stakeholders, sharing knowledge regarding meter interference and detection techniques to continually improve effectiveness;
- Engages strongly with the UK Revenue Protection Association (as Vice-Chair);
- Is actively engaged in the procurement, development and delivery of the Theft Risk Assessment Service (TRAS) [expected live operation in 2016];
- Contributes to the Home Office's group addressing cannabis cultivation and works closely with Police in this field;
- Works closely with Merseyside Police and deploys (since Jan 2013) a Revenue Protection Technician full-time the police force (and is actively developing a similar relationship with Police Scotland);
- In conjunction with the UK Revenue Protection Association, engages with the CPS in England and Wales and the COPFS in Scotland to seek an appropriate level prosecution;
- Works with other agencies including Housing Associations, Local Authorities and emergency services to highlight the importance of Revenue Protection activities;
- Conducts an on-going awareness programme for internal staff and external parties e.g. emergency services and housing authorities;
- Deploys a mobile facility to improve customer awareness;
- Engages with other stakeholders to develop the Theft Risk Assessment Service (TRAS)
- Collects national and international experience by taking a proactive role in all in working groups (e.g.DCUSA) and through Iberdrola Fraud Group (USA, Spain and Brazil). [One current DCUSA project is a Theft Assessment Calculator]; and
- Works to raise general industry awareness within SP and with external parties.

During the RIIO-ED1 regulatory period, the Revenue Protection service will build upon its track record of theft detection and debt recovery.

Starting in 2016 we will be increasing the number of staff working in Revenue Protection by 22% (field and support). The service offers Revenue Protection services to all suppliers in the SPD and SPM areas including all smaller suppliers and new market entrants as well as providing guidance and education where required to all parties.

Key activities include:

- Planning and & undertaking targeted customer site visits and meter inspections;
- Responding to tampering notifications and 'tip-offs' from a range of stakeholders;
- Replacing meters & making installations safe;
- Effecting repairs to electricity services and mains supplies;
- Assessing unrecorded energy and updating information systems accordingly;

- Liaison with enforcement agencies; important activities are that the RP service has had a successful cooperation with a member of our staff deployed with Merseyside Police Cannabis Dismantling team for about 3 years. RP also works closely with Police Scotland;
- Participation on industry and government groups regarding energy theft;
- Storing meters where interference has been identified for evidence purposes;
- Provision of stakeholder training and awareness initiatives; and
- Preparation of cases for enforcement action and pursuing prosecutions.

8.1.3 Resources & Cost Projections

The funds arising from the detection and recovery of electricity theft have not been sufficient to offset the costs of Revenue Protection services. Whilst according to our Losses Vision, it could be argued that we should spend less on the activity, we believe this would have a long term dis-benefit to honest customers. We believe it would not be helpful ebb and flow the service as a result of its successes. Therefore, it will be necessary for a proportion of the costs of the Revenue Protection service to be recovered through Distribution Use of System charges.

Debt recovery from offenders will remain challenging during RIIO-ED1. Our tactics are to maintain and enhance close cooperation with other stakeholders (particularly suppliers) to improve current recovery rates and reinforce deterrence.

Actions

During ED1 we will:

- Maintain net expenditure on Revenue Protection related services during RIIO-ED1 at the current levels of £0.59M pa and £0.43M pa for SPD & SPM respectively.
- Review and flex expenditure requirements throughout the period in the light of
    - Uncertainties regarding potential increases in workload;
    - The impact of smart metering; and
    - The development of new business processes to improve detection.

8.2 Unmetered supplies

The present position

Not all customer demand in our distribution areas is metered. Typical unmetered demands include street lighting, traffic lights and road signs, advertising hoardings and lighting in shared occupancy (often public sector) buildings. Energy consumption from unmetered supplies is quantified by agreeing inventories and demand pattern information. Annual consumption is then calculated.

Non-technical losses associated with unmetered supplies can be attributed to:

- Incomplete database records of unmetered customer loads;
- Inaccurate equipment inventories; and
- Errors regarding the assumed demand characteristics.

Typically these considerations result in the under-recording of unmetered energy consumption.

Actions

Throughout RIIO-ED1, SP Energy Networks will continue to proactively improve the accuracy of records for unmetered supplies in SPD & SPM working closely with customers and energy settlement stakeholders. The Revenue Protection service works closely with SP Energy Networks in respect of un-metered supplies and carries out site visits on request. The initial objective is to get a meter installed and MPAN set up. The follow up action is to recover any outstanding monies due.

Whilst we have always audited, to achieve greater impact we intend to target audits with some customers who have unmetered supplies and to develop an audit selection/initiation process based on a number of factors. We will develop appropriate tactics to deal with difficulties.

We will endeavour to identify customers who are not maintaining accurate and up to date inventories and consider reasonable ways to deal with the issues.

Our actions must be proportionate but we understand that we have a duty to all other customers to avoid cross-subsidies.

An emergent trend that we anticipate continuing throughout the RIIO-ED1 period relates to large customers (often in the public sector) retrofitting energy efficient equipment within their asset portfolios to lower energy consumption. Clearly, such customers are strongly incentivised to work closely with DNOs to agree revisions to their energy consumption. Our action here is to ensure that the process is also set up to also capture previously unrecorded equipment and improve the accuracy of the inventory. Again, in line with our Losses Vision our actions must be proportionate and we will first target the largest customers which typically include councils and local authorities.

These actions will:

- Improve the accuracy and equitability of the settlement process;
- Improve our understanding of non-technical losses attributable to unmetered supplies.

SP Energy Networks will also continue to monitor settlement data, use Elexon's UMS data quarterly reports and best practice guidance to continually seek to improve the accuracy of unmetered electricity consumption in the SPD & SPM distribution areas.

8.3 Conveyance & settlement inaccuracies

Situations arise where energy is delivered and consumed but is not accurately recorded in the electricity settlement system and therefore becomes lost energy. The main causes of these types of non-technical losses are:

- Missing and unregistered metering points
- Incorrect recording of the energisation status for metering points; and
- Incorrect registration of metering system information

Leading to inaccurate customer consumption data. Such non-technical losses are often regarded as 'Conveyance' related.

There are cash-flow implications for DNOs linked to such settlement inaccuracies and SP Energy Networks remains committed to identifying and rectifying the causes of these non-technical losses throughout the RIIO-ED1 regulatory period.

Actions

Throughout ED1 SP Energy Networks intend to:

- Work closely with suppliers and metering service providers to improve settlement data and metering point registration accuracy;
- Continue to focus on reducing the numbers of metering points without a registered supplier (*We have already implemented tighter controls on the allocation of new Metering Point Administration Numbers (MPANs) to property developers*);
- Continue to proactively monitor the number (and check the status) of metering points registered as disconnected and de-energised by suppliers;
- Cooperate fully in Elexon Audits to check settlement data and resolve any inaccuracies identified with corresponding commitments to refine internal processes to prevent any reoccurrences;
- Work with all relevant stakeholders to develop robust industry procedures to ensure settlement accuracy is maintained throughout the transition to smart metering. During the process high volumes of meters will be changed within relatively short timeframes, which could capture previous discrepancies but if not tightly managed could also result in additional errors.
- For each occasion where an inaccuracy in record has arisen record whether we understand how this may have happened, as a basis of policy development to prevent recurrence of common mistakes. This will be shared with the other UK DNOs
- In line with Revenue Protection Code of Practice, receive monthly reports from all suppliers detailing all instances of theft in conveyance detected

9 Innovation supporting losses reduction

9.1 Summary of actions

We have a wide range of innovation projects which we choose carefully. These projects are selected because they support a range of our strategic objectives. We have listed here the main innovative activities which have a clear bearing on helping us to understand and improve losses.

We continually appraise the value of innovative projects and listing which projects are significant contributors to the losses strategy is a clear signal that Losses benefits need to be factored into innovation programme assessment.

Losses improvement Activity	Programme which Supports the Activity	How it supports the Activity	Long term
Transformer change programme	Additional network metering and smart MDI installation	Improved understanding of demand patterns and growth should lead to improved decision making on operational configuration, power factor and other technical factors which can: • reduce losses in transformers and circuits • prioritise transformer replacement	Fully integrated with Smart Grid Investigate an integrating programme which calculates transformer losses based upon MDI half hour value, so that losses information is improved.
11kV overhead line loss reduction	11kV rural network automation	Smart network management – which optimises normally open positions to reduce losses	Smart network technology automatically re-optimises as load changes and takes account of voltage management.
All networks	Optimise voltage targeted to minimise losses	Minimises losses or allow more renewable connections to assist in de-carbonisation of generation base	Fully integrated with other innovation activities
SPM meshed network losses optimisation	Creation of new tools to calculate the losses impact of options by making use of historic demand trends/ time series data coupled with forecasted demand	Improved decision making	Tool could form a basis for near real time operational decisions
LV network optimisation	LV network metering / measurement initiatives	Decision making on investment and network operations	Input to Smart Grid optimisation decisions
Theft and meter tampering	Smart metering	Expose existing theft as meters are replaced Improved understanding of demand patterns and growth	Could be used to further reduce and quantify non-technical losses

Table 9.1 - Summary of innovation actions supporting our losses reduction Strategy

9.2 Smart meters

Our Smart Metering strategy (see **Annex C7 – Smart Metering Strategy – SPEN**) outlines our intended expenditure on and benefits from smart meters. We explain our ambition to create a future proofed data infrastructure that will allow us to take full advantage of smart meter information in a range of different areas, including using Smart Metering to achieve the following goals:

- Provision of day to day operational support for the smart meter installation process
- Improve the customer experience
- Improve our outage management and fault resolution processes
- Improve our design and management of the network
- Improve our understanding and management of losses

We see smart meters as facilitating reduction of both technical and non-technical losses as follows:

9.2.1 Smart meters reducing non-technical losses

As discussed in Section 5.2.4 of this strategy, we will proactively pursue detailed analysis of smart meter data and endeavour to develop models to compare and reconcile data from the advanced monitors and smart MDIs. This approach will greatly increase our knowledge of LV network losses and will provide indicators on how best to improve uncertainties around the quantification of unmetered supplies and theft.

Within SPEN we see this area of loss analysis closely linking to the preparatory work we are doing with substation monitoring in the Flexible Networks LCNF project. Flexible Networks supervisory level of metering compliments the domestic monitoring of smart meters allowing spurious losses in LV lines to be identified.

We are, at present, considering the development of future looking systems to improve our use of smart meters to increase the efficiency of non-technical loss reduction. We intend to publish further ideas in due course. This will include plans to link the roll out of smart metering with network and connectivity data, substation monitoring data and geographic /address point data.

Further to this, we also see the smart meter roll-out programme as providing more contact with customer premises and we plan to make use of that opportunity to reduce the incidence of theft.

9.2.2 Smart meters will provide information for network planning

Such detailed and localised quantification of total losses facilitated by smart meters will increasingly influence our capital planning processes regarding asset replacement, network expansion and reinforcement strategies.

9.3 Stakeholder engagement

9.3.1 Demand Side Response (ToU tariffs and load control)

Lowering peak demand via Time of Use (ToU) tariffs and directly controlling customer loads for demand response is potentially one of the largest benefits that smart meters can provide and supports our Smart grid strategy and losses reduction strategy in exploiting this capability. Both ToU and load control, can smooth this demand profile, avoiding peaks and therefore reducing losses. These mechanisms can both release capacity and reduce losses.

We remain committed to engaging with these mechanisms and we will engage actively with suppliers, via the ENA, to identify a common way of working to enable Time of Use tariffs and load control.

9.3.2 Facilitating connection of renewable generation

SPEN continue to make use of active network management technologies to facilitate or accelerate connection of renewable generation by building on our Accelerating Renewable Connections (ARC) project. We prioritise this activity because we recognise that de-carbonising generation has a much greater impact on total CO_2 than network loss reduction.

Where generation is located close to demand, (i.e. in demand dominated areas), the I^2R network losses will also be reduced (at least generally up to the point where generation is equal to the load).

10 Overall value of the strategy for stakeholders

Strategic Objectives

Continually demonstrate that we are doing the maximum to reduce network losses with our Losses Strategic Vision

As with all long term Strategies it is necessary to incur some extra initial costs to provide a long term improvement. Our Losses Strategic Vision is based on the principle that we will consider losses and we will act where customers benefit. To assess that benefit we need to consider the stream of costs and revenues over the life of assets. We will try to take all realistic benefits into the assessment because we believe that the wider consequences of climate change are very significant and our customers and society worldwide benefit from reductions in greenhouse emissions.

We have for the moment taken the position that it is right to value the whole life benefits because the impact of a lesser stream of benefits must be lower capital investment in carbon reduction. If the long-run social penalty of carbon emissions is indeed extremely high, then we should seek to maximise our reasonable present efforts to mitigate it.

By reporting our plans and taking views from our customers and other stakeholders throughout the period ED1 we will allow all our stakeholders to input into our ideas and our philosophy.

Of course where there is legislation that has already been consulted on and so is deemed the will of the European peoples and those questions have past. Our prime driver in this strategy is to so organise our actions as to make our loss related activity congruent with other drivers so that the maximum loss improvement benefit is achieved at the minimum extra cost to customers. We believe stakeholders will relate well to that approach however we will still test the philosophy and report publically and to our regulator on views expressed.

11 Strategy for Continuous Improvement

Strategic Objectives

Deliver the Losses Strategic Vision with the most appropriate initiatives for the period in time and taking account of all network drivers

We will continue with successful programmes up to the point where they just continue to deliver value for customers or where other initiatives deliver better value.

We plan to continue to harvest ideas and to develop plans based upon:

- Our growing accuracy of internal information, studies and research;
- Funded external studies and research;
- Sensing best practice in other places :
    - Using parent company links,
    - Ideas, track records and research shared between UK and if possible wider as in Ireland and other Member States in Europe,
    - Low Carbon Networks Fund, and
    - INI initiatives.

Our intention is to continually reassess the value from existing strategy, and to list and rate the likelihood of other loss reduction initiatives working for our networks.

We remain committed to work with industry, academia and manufacturers to develop initiatives which achieve multi-driver solutions. Our strategy is therefore to sense the opportunities, expose them to wide views and try to pick ideas and solutions, whether mundane or more leading edge, which not only deliver losses benefits but also contribute to the direction that our customers and our network are moving.

12 Change to Strategy and Reporting

12.1 Change to Strategy

Our approach to change to the Strategy is to inform stakeholders about our updated thinking and take their views before implementation. We would describe stakeholder responses to any matter within our proposal and then state how that has influenced our thinking.

We envision that the time when we are reporting annually in writing and to stakeholder forums is the ideal opportunity to also seek to discuss changes to our approach. Our new strategy would then emerge sometime after we have assembled and digested views.

It is our experience that stakeholders who hold strong views make them known to us in a number of ways outside formal consultation and we will keep these channels open.

We also think that bodies like the Distribution Code Review Panel and the Low Carbon Network Fund should be kept aware of the activities which are going on in DNOs to meet the various drivers placed on them, so that their deliberations recognise the differences and changing approaches which DNOs are taking to network design as a result of the drivers places upon them.

As we consider acting on load-voltage characteristics, optimising voltage and various design and operational actions, the Transmission System Operator may hold views and we should hear those.

12.2 Reporting

We will report annually showing our expected and calculated or measured position. We will also highlight the error band that we estimate.

Our objective is to improve continually losses over our “Do nothing” scenario but also to reduce the error band over ED1.

13 Summary of Proposed Actions

1. Adopt the Losses Strategic Vision as a driver within our investment policy and process and amend such process documents accordingly to show that:
    a. The nature of the investment may be affected
    b. The timing of the investment may be affected
    c. The prioritisation /phasing of actions may be affected

2. Amend design and operational guidelines to ensure losses quantification / consideration is a prominent requirement including to prioritise equipment assessment or action;

3. Promulgate the requirement to consider losses throughout SPEN

4. Comply fully with the requirements of EU Directive 209/125/EC as expressed in Regulation 548/2014 referring to maximum losses in small, medium and large transformers by:
    a. Immediately adopting Tier 1 requirements for new transformers
    b. Supporting early UK initiatives to seek practical design for Tier 2 transformers

5. Replace 145 of our larger transformers with Tier 1 or Tier 2 units over ED1;

6. Replace 1,528 of our secondary transformers of which 1,111 are losses driven actions; Prioritise the 1,111 replacements according to losses benefits;

7. Adopt a minimum conductor size of 100mm^2 for all HV main line new build and offline rebuilds;

8. Revisit EATL cable study to determine the cost benefit for larger cross section cables, factoring in such things as higher asset utilisation going forward. Report on whether there is a justifiable case for standard cable size increase going forward.

9. Further assess merits of discontinuing 25mm^2 service cable. Feedback findings to Ofgem/ENA.

10. Report on the losses and security implications of periodic outage of transformer to save on iron losses.

11. Report on any further development of opportunities for losses benefits arising from voltage optimisation approaches.

12. Report on any further development in power factor, power quality or harmonics opportunities

13. Set targets and timetable actions on data use from network metering and MDI roll out.

14. Set specification and timescales for development for stochastic network assessment tool to assess losses in complex HV networks

15. Describe plan for implementation of Demand Side Response