Losses Discretionary Reward Tranche 1 submission

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1 Our Plan

Introduction

The aim of the Losses Discretionary Reward (LDR) scheme is to incentivise GB Distribution Network Operators (DNOs) to better understand and manage electricity losses. Reducing losses is a key part of Electricity North West's overall business strategy and we are pleased to present this submission to Ofgem for Tranche 1 of the LDR.

Our approach to reduce losses, and deliver value to customers in an affordable manner, is built on a five-point action Plan. This Plan covers both technical and non-technical losses and identifies our initiatives which will lead to an evolution in our approach to reducing losses. A summary of our Plan is set out below:

Figure 1: Our five point action plan

These actions are part of an evolving story which will develop over time. As a direct result of the additional initiatives set out in this document, our understanding of losses is set to materially improve over the coming years.

Action 1: Where to look

We will upgrade the functionality of our existing Future Capacity Headroom (FCH) model to identify those locations on our HV and LV (secondary) network that are likely to have high technical losses.

Action 2: Interventions

We are drawing on both our and other DNOs innovation projects and initiatives to ensure that our solutions and interventions take account of the full range of options available for tackling losses, from conventional fixes to new and innovative approaches.

Action 3: Real options decision making

We will improve our investment decision-making and planning process, based on an enhanced real options cost-benefit analysis tool.

Action 4: Incentive mechanisms

We will use the learning from innovation projects and also take forward the work we have started under the Smart Grid Forum (SGF) to develop a losses mechanism that appropriately incentivises all DNOs to reduce losses.

Action 5: Non-technical losses

We are setting out a number of industry-leading initiatives which will help to identify and address non-technical electricity losses.

This submission demonstrates how, through our strategy and the initiatives it contains, we are shifting the expectations of what we are capable of in terms of understanding and managing losses. A summary comparison of what we are currently doing versus what we will do in the future is provided in Figure 2 below.

Figure 2: Our Plan

	Now	Future
1. Where to look	FCH model for initial programme of capacity related projects	Enhanced FCH model for initial programme of capacity and losses related projects
2. Interventions	Set of traditional solutions	Set of traditional and smart solutions
3. Real options decision making	Use Ofgem CBA to evaluate options	Use real options CBA (incorporating losses)
4. Incentive mechanisms	Help to develop incentive mechanisms	Incentive mechanisms adopted for RIIO-ED2
5. Non-technical losses	Initiatives to identify and address non-technical electricity losses	Continued commitment to spearhead best-practice activity and innovation

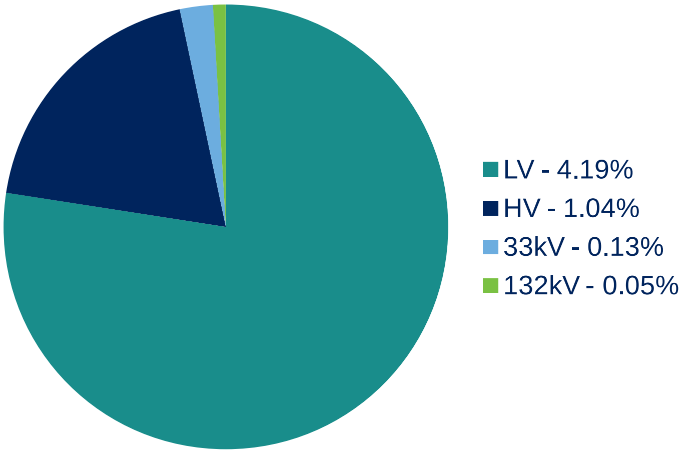
2 Understanding of losses

Understanding the level and source of losses is essential to reducing network losses. In this section, we outline our approach to improve the understanding of losses on our network as the first part of our Plan.

2.1 Where to look

In our Losses Strategy document we acknowledged that establishing a reliable baseline position for the accurate measurement of network losses is difficult without a much richer understanding of the load flows across our network. This is particularly true at the secondary network level, where most losses occur (see figure 3), and about which we have the least understanding.

Figure 3: Distribution network losses by voltage (5.41% total losses)



Our Losses Strategy sets out how we expect our understanding to be significantly enhanced by smart meter data and by the next generation of system modelling tools in development. It also highlights how some of our current innovation projects, such as our First Tier LCN Fund project on LV modelling, are helping to develop our knowledge and capability.

Going forward, we intend to use our Future Capacity Headroom (FCH) model (see Appendix A) to help us better understand the actual losses across our secondary network. It is our intention to make this part of our business as usual (BAU) network investment decision-making. The FCH model is currently used to estimate current and future maximum demand on each individual component of our secondary network. As part of this Plan, we will develop the FCH model by incorporating further asset data, and in time smart meter data. This will enable the model to identify where losses on our network are likely to be highest.

We originally developed our FCH model to identify the volume and location of network loading/capacity issues, in the context of a future where low carbon technology (LCT) connections are increasingly prevalent. The FCH model is similar to EA Technology's Transform model but offers the fundamental advantage that it is based on the actual configuration and real loading of the 150,000 circuits that make up our network as opposed to nine 'representative circuits' with assumed loads in Transform.

2.2 Development of the FCH model

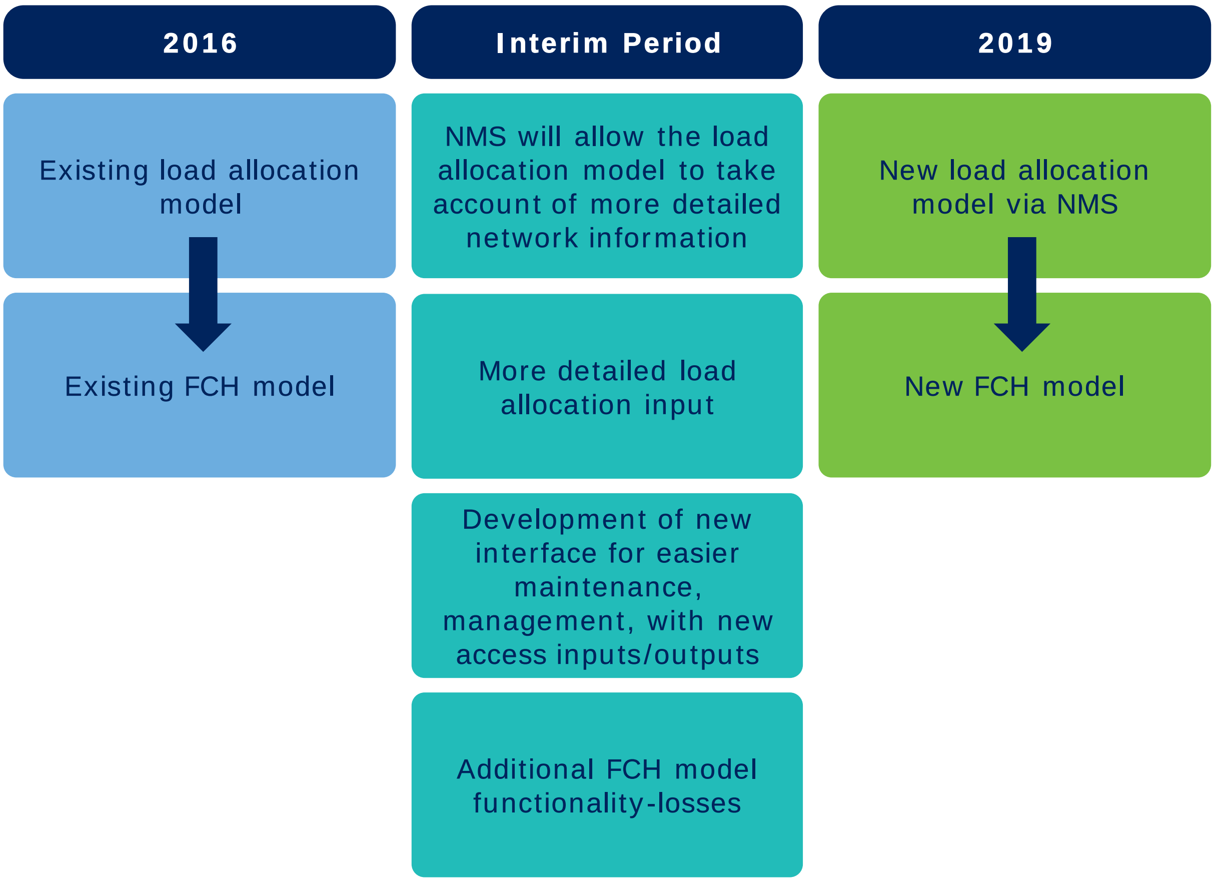
We believe that the unique capabilities of our FCH model, combined with our plans to enhance its capabilities, will put us at the forefront of DNO understanding and management of technical losses.

Part of the FCH model is a load allocation model which accurately allocates observed demand across the network components. The load allocation and network connectivity models are at present based on imperfect data.

We are currently implementing a new network management system (NMS). Part of the functional specification for the new NMS is the cleansing of existing network connectivity models and the provision of a load allocation methodology and software.. The new connectivity and load allocation models will be incorporated into the FCH model. Smart meter data will be included when it becomes available in 2018 – 20 but our FCH model will be usable much earlier than that enabling us to bring forward benefits for customers.

Furthermore, the FCH model and its methodology will be augmented with asset specific data (ie resistance values) that will facilitate a more sophisticated approach and a new functionality for identifying and then reducing losses on our networks.

Figure 4: Development of the FCH model



2.3 Transition to the new FCH model

Through the development of the FCH model we will identify parts of our network which exhibit (comparatively) high losses. This will allow us to include an assessment of losses into proposed solutions to load related expenditure and non-load related expenditure.

The FCH model currently identifies overloaded assets and helps us define a secondary network investment programme.

The new FCH model will also identify assets with high losses, which will help us define another secondary network investment programme aimed at reducing losses. In addition it will improve the accuracy of the existing identification of overloaded assets.

The enhanced functionality of the FCH model will allow us to optimise our investments taking into account both investment programmes. This will ensure that our investment decisions are based on the most relevant information available and fully reflect network losses hence delivering better value for customers.

2.4 An holistic approach – understanding how losses on our network affect others

It is important that our decision making incorporates a holistic approach to losses, taking account of how our initiatives can affect others.

We recognise the increasing need for closer cooperation on losses between ourselves as a DNO and other market stakeholders. There have been a series of national and international discussions and published papers which address the issues of greater integration between industry stakeholders. In September 2015 Ofgem published a position paper looking at the future role of the DNO and the requirement for flexibility in the role of the DNO. This paper presents two main conclusions:

- The role of existing market participants is changing and work is required to support these changes. For example, established participants such as DNOs and industrial and commercial customers now have greater opportunities to participate in flexibility, and will need to transition to new roles to make the most of these opportunities
- Non-traditional business models are likely to play a larger role in the energy sector. This could be the case, for example, for aggregators or storage providers.

These conclusions present a number of exciting challenges and opportunities as well as some risks. As a consequence of these anticipated changes, it is likely that DNOs will need to integrate further with, and operate closer to, other market participants at a technical and a commercial level. There will be less opportunity for us to operate in isolation and without regard for the impact on others, such as National Grid as system operator (SO) or transmission owner (TO), or new entrant service providers such as aggregators, distributed generators and storage owner/operators. The relationship between DNOs and the TO and SO will be key to the evolution and successful operation of the national electricity system in the low carbon future.

We expect discussion on the increasing amount of flexible demand connected to our network to continue. Distribution System Operators (DSOs) having ready access to a portfolio of responsive demand, storage and dispatchable generation, together with active network management and fully engaged and connected customers, has the potential to significantly affect the way in which the network is operated and the losses incurred as a result.

We will no longer simply consider the costs and benefits accruing to our own network and business. Instead we will develop more holistic solutions that deliver wider benefits across the energy market. We will work with other stakeholders, including Ofgem, to identify and mitigate (or remove) any perverse incentives associated with a narrow, business-specific approach to the optimisation of losses. For example, as part of our ongoing discussions with National Grid we will be considering the impact on losses for both parties and, more generally, how developments in the operation of the energy market might affect commercial interactions.

2.5 Non-technical losses

In our Losses Strategy document we set out a number of industry-leading initiatives which are helping to identify and address non-technical electricity losses. We continue to work in collaboration with Ofgem, energy suppliers, the police and local authorities to tackle electricity theft and the under-declaration of metered supplies.

Following the publication of our first Losses Strategy (2015) we have continued to identify new initiatives to improve our understanding of the current level and source of non-technical losses.

This submission presents our 'new initiatives' which will improve our understanding beyond the initiatives set out in our published strategy document[1]. Through the integration of these initiatives into our BAU decision making we will continue to enhance

[1] A full list of our initiatives is set out in our 2015 Losses Strategy document

our understanding of non-technical losses and efficiently reduce the level of non-technical losses on our system to benefit our customers.

These initiatives include:

- Recruiting additional field teams to support the introduction of The Theft Risk Assessment Service (TRAS) in April 2016
- Benchmarking the steps to be taken when an unauthorised connection is found. This will result in a clear and consistent approach to reducing the number of unauthorised connections
- Reviewing and redrafting our policies to ensure we have a robust end-to-end process in place between all of our business areas for connection and disconnection
- Investigating the introduction of a credit control policy and methods of follow-up for non-payment of charges
- Further investigating our options for securing successful prosecutions for theft in conveyance.

Ultimately our approach will allow us to efficiently identify and target those areas that will deliver real value for customers and will ensure that losses are at the heart of BAU investment planning. Our approach will be transferable to other DNOs, allowing them to upgrade outdated models based on ‘generic’ asset types and representative feeders.

3 Effective engagement and sharing of best practice with stakeholders on losses

3.1 How we are planning to utilise stakeholder engagement to inform losses management and allow us to understand their impact

Stakeholder engagement plays a key role in the way we operate at Electricity North West. We recognise that some of our stakeholders have a keen interest in losses management and may have potential solutions to contribute. As part of our enhanced approach we will engage with stakeholders to allow them to understand and have the opportunity to inform our plans for losses management. We will also engage with those who have the expertise to peer review our thinking and provide recommendations for improvement.

By engaging with stakeholders who are affected by, or affect our operations, we can identify areas of shared interest or where initiatives may conflict with other stakeholders' priorities. This two-way process will highlight opportunities to collaborate and enable development of joint strategies. For example, as part of our ongoing discussions with National Grid we will be considering how to jointly manage total losses at a system-wide (GB) level. These discussions will also address how any change in the role of DNOs will affect commercial interactions given the shift in focus from a technical to a commercial solution for losses.

3.2 How we will engage with stakeholders to develop relevant partnerships which may help to manage losses (eg DSR)

Our approach will ensure that we are engaging with the right stakeholders, in the right way, at the right time, on relevant issues through a variety of mechanisms.

As we set out in our 2015 Losses Strategy, we provide opportunities for engagement of interested parties in our approach to addressing electricity losses and extend an open invitation to work in partnership with other stakeholders. This approach has led to successful engagement with a wide range of organisations as shown in Figure 5 below.

Figure 5: Stakeholders

<table>
<tr><th>Technical</th><th>Non-technical</th></tr>
<tr><td colspan="2">Ofgem</td></tr>
<tr><td colspan="2">DECC</td></tr>
<tr><td colspan="2">Environment Agency</td></tr>
<tr><td colspan="2">Other DNOs</td></tr>
<tr><td>National Grid</td><td>Police, Fire and rescue services</td></tr>
<tr><td>Supply chain partners including manufacturers and contractors</td><td>Home Office, UK Border Control</td></tr>
<tr><td>Academic partners</td><td>Housing associations, private landlords and letting agencies</td></tr>
<tr><td></td><td>United Kingdom Revenue Protection Association (UKRPA)</td></tr>
</table>

We will clearly set out the aims and objectives of our stakeholder engagement to detail to interested parties, what we are hoping to achieve through engaging and ensure our approaches remain inclusive when considering relevant partnerships.

It is important to act on the input and feedback from stakeholders whether or not joint projects or opportunities can be developed. The views of stakeholders will be essential in improving our understanding of losses.

In addition to the work and initiatives presented in our Losses Strategy, we continue to engage with stakeholders on a wide range of platforms. For example, we recently presented at the 'How to meet your Revenue Protection Obligations' training seminar in London in November 2015 (through our membership of the Executive Committee of the UKRPA). The target audience was electricity suppliers but attendees included industry partners and Ofgem representatives.

3.3 The processes we have in place to share our own best practice with relevant stakeholders

Our approach to effective engagement and sharing of best practice recognises specific audiences and the needs of different stakeholder groups. It also draws upon experience gained through the delivery of successful innovation projects. Below are the main stakeholders who have an interest in the effective and efficient management of losses.

- **Customers**: our customers are a crucial part of our dissemination agenda as customer behaviour can directly impact the level of losses incurred on our network. There are a number of customer groups with whom we engage, ranging from domestic households to large industrial and commercial customers.
- **Consumer groups**: consumer representative groups (eg Citizens Advice and the Energy Ombudsman) have a keen interest in the impact of our initiatives on customers and wish to ensure customers benefit from our plans.
- **Energy industry participants**: our industry stakeholders include generators, network operators (ie DNOs, IDNOs, and TOs etc.) retail suppliers, aggregators, technology vendors, equipment manufacturers, NETSO and the balancing settlement organisations. All of these stakeholders want to understand how we are better able to identify, manage and reduce losses on our network.
- **Industry groups**: The main industry group audience includes the Energy Networks Association, the Smart Energy Demand Coalition, Energy UK and industry groups such as Smart Grid GB. These groups have a key role in the dissemination of best practice and Electricity North West leads many of the technical, regulatory and commercial sub groups. In addition we lead the Distribution Code Panel and represent all UK DNOs on the Grid Code panel. This requires us to invest a significant amount of senior employee time but allows us to steer the industry to ensure customer value and environmental issues are properly included in technical standards, operating models and industry regulation.
- **Government and regulator**: DECC, Ofgem and other policy makers will be primarily interested in the outcomes of the initiatives, particularly where these have the potential to advance industry best practice for managing and reducing losses.

We will tailor our dissemination to best match the interest and structure of each of the stakeholders identified above. Our approach will be pragmatic, simple and targeted, and will use a number of different dissemination approaches to enable stakeholders to maximise their learning through their preferred communication and learning style.

This will include a dedicated area on our website, social media, conferences and workshops. Our programme of workshops will include:

- Bilateral discussions with National Grid to discuss TSO-DSO interactions and the effect that this may have on the management of losses
- Bi-annual meetings with other DNOs to highlight and share learning and best practice from the initiatives
- Workshops with commercial and industrial customers (load and generation)
- Engagement with residential customers to understand their views
- Engagement with our supply chain to harness their expertise and ideas.

Figure 6: Stakeholder engagement processes

All of the stakeholder engagement actions outlined in this Plan have a specific focus on losses and are not included in any previous submissions under the Stakeholder Engagement Incentive.

4 Processes to manage losses

4.1 Reviewing best practice nationally and internationally

We have undertaken a detailed review of international and national best practice for understanding and managing losses. In this section we provide a summary of our findings, with the full review set out in Appendix B.

Following this review we believe that our Plan will put us at the forefront of understanding and managing electricity losses for our customers.

The review has highlighted areas where we can continue to improve, particularly in relation to monitoring on our network. For example, the need for increased levels of intelligent monitoring and control systems on our distribution networks in order to measure losses. Incorporating and building upon this learning is one of our priorities. We recognise that without such systems the accurate calculation and measurement of losses on the distribution system will continue to be difficult.

The further development of the FCH model will provide us with a much greater understanding of the power flows across our network and provide the platform to utilise the planned monitoring data. In addition, we will keep abreast of the outcomes of other relevant work such as Western Power Distribution's Second Tier LCN Fund 'LV templates' project which uses monitoring equipment to understand customer usage patterns.

We believe we are leading developments in non-technical losses. For example our review highlighted that in many countries, non-technical losses are either ignored or not accurately measured; they are often assumed to be simply the balance between the estimation of the technical losses and the consumption.

4.2 How we are preparing to use smart meter data to develop specific actions to manage losses

Our Well Justified Business Plan (WJBP) sets out in detail how we will use Smart meter data to dramatically improve our understanding of technical and non-technical losses on our network and how this will deliver benefits to our customers.
We are working to ensure Smart Meter benefits are obtained as soon as possible, however the national programme has both slipped and changed in several ways. Therefore there is a risk that some of the benefits we planned may be deferred or reduced in value.

It is important that our customers not only receive the benefits in our WJBP but that the benefits are accelerated and increased in value. Our FCH model and the approach laid out in section 2 of this submission are central to accelerating and delivering these losses benefits. We will ensure that the necessary infrastructure requirements and associated elements of business change are identified, planned for and then implemented to support the future use of smart meter data.

As smart data improves, the accuracy of our state estimation and load allocation processes will increase dramatically, even with smart meter penetration levels as low as 70%.

4.3 Incentive mechanism

Electricity North West led the work-stream 6 subgroup on smart meter benefits and wrote the smart meter losses incentive paper which forms an important part of the WS6 report.

Incentivisation is a fundamental principle of RIIO and will form a critical part of the UKs overall losses reduction strategy. Our losses incentivisation paper outlines how the regulatory framework needs to be evolved to effectively implement losses reduction. It identifies a number of viable options for that not only drive down losses but enhance other incentives and drive value for customers. Further it explores the relative merits of these options and hence informs the design of the incentive mechanism itself.

We are working to ensure the ideas identified are taken forward with regulators and policy makers and used in the development of potential regulatory incentives for RIIO-ED2.

In addition, we are leading the industry review of the national network planning standard, Engineering Recommendation P2. We have placed the inclusion of losses and the innovative network design and management technologies developed under the LCN Fund at the centre of this review. This includes consideration of how a revised national planning standard would work alongside an incentive mechanism to reduce losses.

We continue to lead the development of losses incentives to stimulate industry and stakeholder debate. The work, which is part of the industry wide Smart Meter Sub Group[2], considers the potential for smart meters to help drive the efficient reduction of losses for customers through the identification of a number of viable options.

We identified a number of methodologies that can be used to enhance the management of losses by using the capability of smart meters to record half-hourly consumption data. These approaches include:

- **Gross volume assessment**: This is a simple count of the total number of units of energy delivered into the distribution network from NG interfaces, interconnectors and embedded generators minus metered outflows to customers. Smart meters will give a more accurate measure of where energy is leaving the system.
- **Bottom out model**: In this methodology the metered flows out of any given part of the network are known via smart meters (and other sources as detailed above) and hence the quantum of technical losses arising from these flows can be derived using a load flow model of the relevant network.
- **Load allocation model**: In this methodology all known energy flows are used to allocate load within a total network model (or indeed a subset of such a model eg by GSP). This is similar to the 'bottom out model' being driven by smart meter data; however unmetered power abstraction points are represented by assumed energy flows.
- **Representative network model**: An alternate approach is to use smart meter data to determine a representative load distribution curve for each feeder type and the associated peak demand. Smart meter data can be used as the basis for a detailed analysis of the power flows on each feeder type and all feeders can have a type allocation.

Importantly, our work shows that by following the methodologies identified, DNOs will be able to normalise the inconsistencies in measurement across the network and ultimately develop a common basis for comparison of losses. The options can also be combined to benefit customers, for example by use of the gross volume model to identify target networks and then use of the bottom out approach to identify specific circuits for intervention.

We are committed to continued thought leadership associated with the use of smart meter data to reduce losses for our customers.

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[2] This subgroup is part of 'Workstream 6 of Smart Grid Forum'

5 Innovative approaches to losses management

We recognise the importance of finding and exploring novel solutions to losses reduction so as well as employing conventional approaches, we are drawing on our innovation project experience to ensure that we capture the full range of creative options available for tackling losses.

In this section we present our innovative approaches to losses management with direct reference to our Plan.

5.1 Interventions

Through the development of the FCH model, we are building a hugely improved understanding of the source and magnitude of electrical losses on our secondary network. This understanding informs and drives our losses management activities. We will continue to review and analyse projects funded through the innovation mechanisms, and more widely across the industry and internationally. This will help us to identify proven techniques to create a toolkit of solutions, including traditional solutions that can be applied to reduce losses in a range of scenarios.

Examples of projects that could be employed are:

- Smart Street, which includes HV and LV network meshing and/or the installation of capacitors. Advanced optimisation software will be deployed to dynamically analyse network load and generation levels and to alter interconnected configurations and voltage profiles across HV and LV network levels. This project opens up new approaches to tackling losses that can supplement our asset replacement approach.
- Capacity 2 Customers which demonstrated the use of HV network meshing and the benefits for both capacity provision and losses reduction.

5.2 Real options

Before we deploy a losses reduction initiative it is important to ensure that it will deliver real value for customers over a range of potential future scenarios. Testing potential initiatives through the lens of a cost benefit assessment (CBA) model that incorporates these scenarios is therefore a critical part of our Plan.

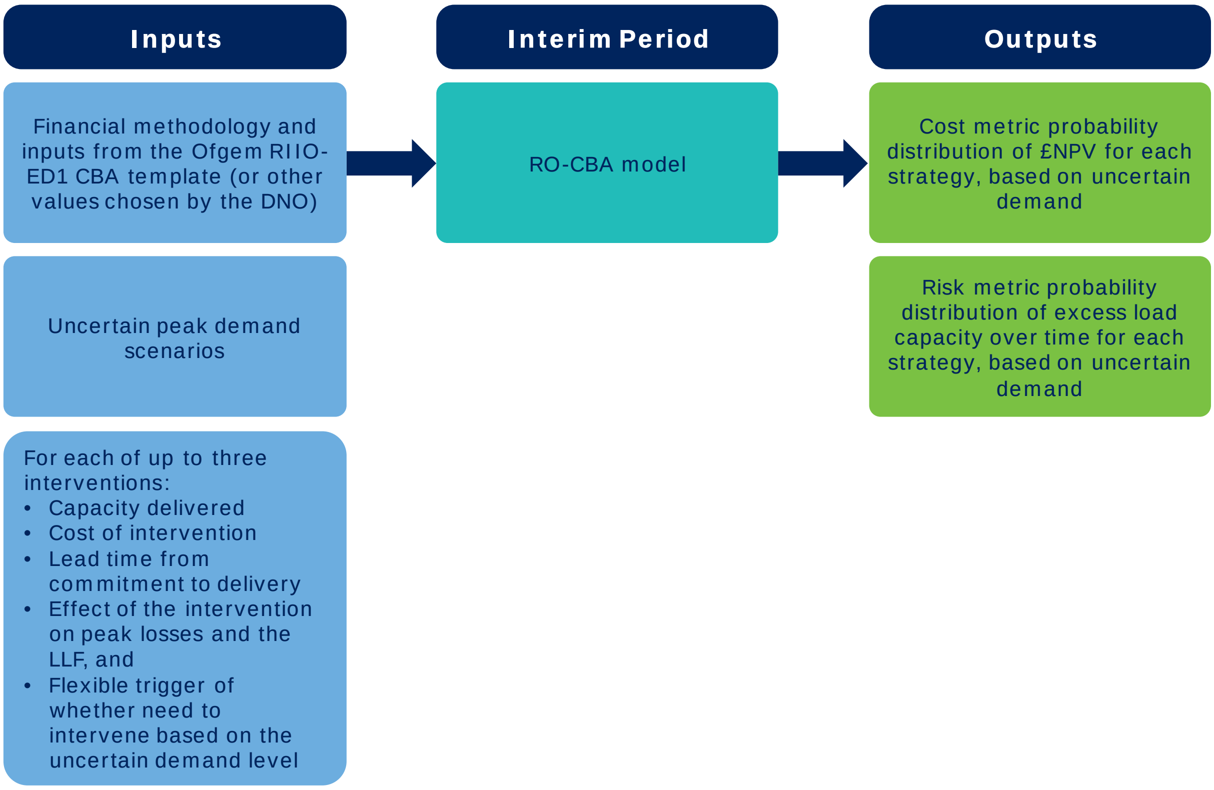
Our network investments are prioritised according to a CBA which appropriately balances the interests of our stakeholders. To date, we have utilised the CBA model that Ofgem provided as part of RIIO-ED1. From the start of RIIO-ED1, Ofgem introduced an explicit value for losses (£48.42/MWh) to provide a basis for the assessment of investments. This reference price for losses reduction is now embedded into our decision making, as described in our Losses Strategy. In developing our thinking on losses we have identified that the Ofgem CBA model does not adequately test how the value of a given investment may vary dependant on which of the various future demand and distributed generation scenarios occur.

To redress this and hence improve the actual value for customers we are developing a ‘real options’ model that uses a ‘real options’ economic modelling approach to represent future demand and generation uncertainty. This Real Options Cost Benefit Analysis (ROCBA) model will, when developed, be integrated into our business as usual decision making for all investments including losses.

ROCBA modelling will go far beyond the Ofgem CBA guidance by taking account of the future uncertainties in economic activity, energy policy, energy efficiency, generation and demand. We will, however, continue to price losses at the level defined by Ofgem. This development work is at our own cost.

ROCBA modelling is designed to address the significant uncertainties associated with electric heat types and load profiles, or the range of beyond-the-meter options for addressing secondary networks constraints. ROCBA is based on producing probability-weighted demand forecasts representing the various future energy scenarios and local economic activity forecasts as inputs to the options model. A summary of the approach is presented in Figure 7 below.

Figure 7: Real options cost benefit analysis



We will also use our ROCBA decision tool to inform our investment plans for 'load related' and 'non-load related' activities as part of our submission for RIIO-ED2. We believe that using the ROCBA in conjunction with our FCH model will enable us to design the optimum losses investment plan for customers and deliver much greater value than plans based on the 'Transform' or similar models.

We will make a simple to use ROCBA model available to all of our designers and policy makers to use in investment planning and operational decision making. This tool and supporting business policy and processes will ensure the strategy developed will be implemented as BAU in RIIO-ED1 and incorporated into our RIIO-ED2 investment plans.

The example in Appendix C illustrates how we currently utilise the Ofgem CBA model to assess options to reduce LV network losses on a proactive basis. This analysis is based on a static picture of demand and therefore losses and produces only a marginal justification for some of the options.

We believe that the ROCBA model, which considers different views of future demand growth, will strengthen the case of some of these options. The potential value of losses under certain load growth scenarios could justify the case for carrying out losses investment today because of the combined benefits of losses saved and future reinforcement requirements.

NIA and previous IFI funding has been used for the initial development of the FCH and ROCBA models, but costs to develop these models for losses was not included in innovation funding or in our RIIO-ED1 business plan.

5.3 Non-technical losses

We believe that our revenue protection team is leading the industry in understanding and managing non-technical losses. We are committed to continuing to spearhead best practice activity and innovative thinking in this area, and to support Ofgem and other stakeholders as part of this work.

All of the processes and initiatives described below have been developed since the submission of our Losses Strategy document. Through the integration of these processes and initiatives into our business as usual decision making, we will continue to enhance our understanding of non-technical losses and reduce their level on our system.

Revenue protection

- To better achieve the requirements of the National Revenue Protection Code of Practice we are developing a number of new initiatives. For example since our Losses Strategy was published we have begun recruiting a new field team to support the introduction of the Theft Risk Assessment Service (TRAS) in April 2016. The new team will help suppliers to investigate, detect and prevent illegal abstraction of gas and electricity and tackle theft.

Theft in conveyance

- After consultation with the Ombudsman, we have strengthened our processes for removing unauthorised connections. Our new approach includes a 30-day notice of disconnection issued with a quote for all rectification work. This is followed by a seven-day final notice of disconnection and on day eight, an instruction to disconnect the supply. If the customer accepts and pays for the rectification work to be carried out, the disconnection will be suspended with immediate effect. We have shared the findings from this review with other DNOs through the UK Revenue Protection Association.
- Following this review, we are redrafting our policies to ensure we have a robust end-to-end process in place between all of our business areas.
- We are investigating the introduction of a credit control policy and methods of follow-up for non-payment of charges. This will provide transparency and a fair process for all.
- Our legal team is investigating options for prosecution, without which there is no deterrent to electricity theft. As a member of the UKRPA, we participated in a workshop in November 2015 which was designed to address the challenges in securing successful prosecutions; it is our intention to actively pursue all opportunities in this area.

6 List of Appendices

Appendix number	Title
A	Future capacity headroom model
B	National and international review
C	Appendix C: Losses analysis – low voltage cables

Appendix A: Future capacity headroom model

Our future capacity headroom (FCH) model was used to estimate the load on each key element of our secondary network in preparation for our RIIO-ED1 business plan. At present our losses driven investments are in line with our no regrets upsizing and transformer replacement programmes as outlined in our Losses Strategy. Our load reinforcement plans for secondary networks are reactive to customer connections and the adoption of LCTs.

The use of the FCH model to assess losses driven investment will be based on the following four stages which are discussed in more detail below:

- **Stage 1:** Use load allocation to identify current loading per LV feeder by half hour
- **Stage 2:** Create growth assumptions per LV feeder in 2016 and 2023
- **Stage 3:** Combine growth assumptions per LV feeder in 2016 and 2023
- **Stage 4:** Analyse capacity headroom for LV feeders, distribution transformers and HV feeder sections.

The original purpose of FCH model was to estimate the counts and likely location of overloaded assets in given future years, by combining the current state of the Electricity North West network with predictions about future changes in customers usage patterns and uptake rates of new technologies.

We use our load allocation model to calculate loads on all assets for a given period by analysing the entire network, half hour by half hour and then feeder region by feeder region. The model also uses actual switching conditions to properly represent the network and mitigate the effects of load transfers and fault conditions that would otherwise distort its results.

The FCH takes the results from the load allocation model for the days in which it is interested, applies its algorithms to each region, and produces its own results. The results produced comprise lists of detailed assets requiring investment and summaries of various counts of asset overloads and other information relating to the state of the network in any given year.

The results represent current asset loadings versus thermal ratings and voltage capacity and are used together with the FCH growth scenario inputs to forecast future year load and voltage levels.

Appendix B: National and international review of losses

National and international best practice on processes and methods to manage losses

In this appendix we present an international review of network losses across different countries. As part of this review we initially provide a summary of the magnitude of losses within different countries. We then discuss the context in which these losses are presented, focussing on the different calculation methodologies used in the countries.

Level of losses

Losses on the electricity networks differ considerably across the world. While the average level of losses stands at around 13% this figure is inflated by countries such as Togo (82%) and Haiti (55%) where losses are much higher. In these countries the majority of losses are non-technical losses and result from social issues as opposed to technical issues.

Losses in Europe and North America are lower; on average 9% (Great Britain is 8%). However, there are still considerable differences with these countries. For example in Montenegro losses are 24% compare to 4% in Germany and Finland[3]. Even within Europe countries there are structural differences that will impact on the level of losses, based on the relative size of the transmission and distribution network. For example countries with proportionally smaller distribution systems will have lower losses.

A study by the European Regulators Group for Electricity and Gas (ERGEG[4]) presented data from across the EU 17 countries on how they define and measure losses within the country. While definitions and approaches to measure technical losses are broadly consistent across the EU17, definitions and approaches to measuring non-technical losses vary considerably and many countries do not attempt to measure theft or non-metered public lighting etc.

While Great Britain compares well with the rest of the world, its losses are higher than those identified in other EU countries with similar GDP. A report by Imperial College London and Sohn Associates[5] also identified this issue and they highlighted the following six factors affecting the validity of the comparison.

1. **Definition of 'distribution':** There is a diversity of operating voltages across Europe and the distinction between transmission and distribution is drawn at different voltages, eg distribution in England and Wales includes 132kV but not in Scotland.
2. **Transmission losses**: Some countries' reported losses do not disaggregate transmission from distribution losses.
3. **Input vs output**: Some countries record their losses as a percentage of network input and some as a percentage of network output, requiring adjustment in making direct comparisons.
4. **Non-technical losses**: The simple difference between input and output also includes non-technical losses which include metering errors, theft and data errors, all of which are difficult to determine (eg theft cannot be assessed unless it is detected).
5. **Nature of company**: The size of distribution companies varies, with some countries having a single company and others having multiple companies of different sizes and customer types (eg urban networks compared with rural networks).
6. **Embedded generation**: Some countries' reports do not take account of the impact on losses calculations of embedded generation.

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3 http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS/countries/1W%20display=default

4 Treatment of Electricity Losses by Network Operators ERGEG Position Paper, 2009

5 Imperial College London and Sohn Associates; Management of electricity distribution network losses, February 2014

As a result of these uncertainties we agree with the outcome of the Sohn Associate Study which highlighted that while considerable work would be needed to develop a true comparison, such a project would be worthwhile.

Measuring and calculating losses

At the macro level, measuring the total losses on an electricity system is relatively straightforward; inputs from the transmission system minus metered energy consumed by customers. However, accurately defining and understanding the quantum of losses at each level of the network is much more challenging. The diversity of electricity systems, and the difficulty of accurately assessing non-technical losses, makes it difficult to gather comparable information both within and across countries.

In the majority of cases, and especially in regard to distribution system, the level of losses needs to be estimated based on calculations of the technical specification of the network and any information known about the non-technical aspects. An accurate picture of losses, and hence the derivation of an efficient mitigation investment plan, would only be possible where the network has continuous metering of all consumption and generation, which is not currently the case (in general), especially in distribution networks.

Transmission losses

For transmission networks continuous metering is normally available; this delivers a fairly accurate assessment of losses on the system. However, there are still a number of differences in the calculation methodology used by different transmission system operators (TSOs).

A study by the New York State Energy Research and Development Authority[6] presented the loss calculations and methodologies for calculating transmission losses for New York based utilities. The study found many differences in the methodologies used. These differences occur due to network structural differences and variations in the in-house methodologies that have been developed over time within each utility.

As part of this study the paper presented a summary of some of the approaches used in the US for loss calculations. The accuracy of the loss information is related to the complexity and sophistication of the process in place. For example, the study highlighted that some TSOs used ‘peak analysis’. This involves estimating a single coincident peak system load flow and developing loss factors to calculate annual energy losses. However, this approaches does not account for the changing levels of generation and network re-configurations that affect power flows and hence losses.

The study also highlights more sophisticated approaches; for example the study found that most TSOs tend to use ‘hourly load level scenarios’ to more accurately model losses. This method involves the collection of hourly data points such as metered or SCADA data, together with a representation of the network conditions; this is then modelled through sophisticated software tools. This approach generally provides more accurate results.

Distribution losses

On the lower voltage networks of the distribution system ERGEG found that in the majority of countries technical losses are based on a mix of calculation and estimation. The measurement of energy inputs to the distribution networks is usually accurate. However, the majority of the meters at customers’ premises are accumulation meters designed to measure energy flows as opposed to time based power flows. In many countries, non-technical losses are either ignored or not accurately measured. Rather, they are assumed to be simply the balance between the estimation of the technical losses and the consumption.

The main finding was that the estimating of annual losses within electricity distribution networks is essentially an accounting process, basically trying to offset the information from metering against the actual data on energy inputs. This is the specific deficiency that we have designed the enhanced FCH model to address.

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[6] Assessment of Transmission and Distribution Losses in New York; Final Report, November, 2012

Some countries do have better metering on the distribution network allowing them to differentiate across voltage levels. For example, in Finland and Portugal losses are calculated annually ex-post by network type and generally by voltage level, by measuring the difference between input and output.

A summary of the treatment of losses (ie 'calculation vs metering') on the transmission and distribution networks for the EU17 countries is provided in the table below:

Calculation vs metering

	Ex-ante calculation	Ex-post calculation	Metering	HV/MV metering
Transmission	IT, PT, RO, ES	CZ, FI, FR, EL, IT, NO, PT, SK, ES, UK	AT, CZ, DK, FI, HU, IT, LU, PL, PT, RO, SK, ES, SE	EL, IT, NO, PL, PT, RO, SK, SE, UK
Distribution	AT, IT, PL, PT, RO, ES, UK	CZ, DK, FI, FR, EL, HU, IT, NO, PT, RO, SK, ES, SE, UK	CZ, DK, FI, PT, SK	AT, DK, FI, EL, IT, NO, PL, PT, RO, SK, SE, UK

Review of domestic DNO activity

Electricity North West has also reviewed the losses strategies of all other GB DNOs. This review focussed on the latest documents submitted by the DNOs in April 2015. This review found that the majority of DNOs followed similar approaches to those we put forward in our own strategy.

In terms of the technical solutions to losses reduction, the majority of the submitted strategies present similar approaches; for example, through compliance with the EcoDesign Directive which involves the replacement of older transformer assets and over-sizing of cables to reduce losses. Many of the DNOs highlighted the potential of smart meters to increase profile accuracy and also to provide customers with peak price signals, both of which have the potential to alter system losses.

For non-technical losses such as theft and inaccuracies in conveyance and settlement, the majority of DNOs opt to pursue a proportionate/low cost approach in the short term. The plans generally state that these losses are presently quite hard to identify but are expected to become less difficult to identify with the implementation of smart meters. As a result, many of the DNOs plan to adopt a 'wait and see' approach to the reduction of non-technical losses. This is not our approach and we have outlined above the additional measures we are implementing.

European Union directives to incentivise reduction in losses

The European Union sets out directives that are designed to help network operators manage and reduce network losses. There are two main European Union (EU) Directives that deal with the reduction of electrical losses:

Energy Efficiency Directive

In order to meet this Directive (2012/27/EU), there is a requirement to consider potential options for energy efficiency in networks, the treatment of energy efficiency in network tariffs and alternative policies for improving energy efficiency. Through the energy efficiency improvements there is an expectation that losses will reduce.

EcoDesign Directive

The EcoDesign Directive (2009/125/EC) establishes a framework which sets out ecological requirements for energy-using and energy-related products sold in the EU member states. As part of this regulation the European Commission has implemented regulation in regard to small, medium and large transformers from June 2014.
This regulation includes:

- Minimum energy performance requirements for medium sized power transformers
- Peak efficiency requirements for large power transformers.

To comply with the EcoDesign Directive, manufacturers will have to find ways to reduce the level of losses inherent in their products. It is also essential that the revised equipment is of the same (physical) size as existing equipment so that it can be easily installed into existing substations.

These standardised guidelines should lead to a reduction in transaction costs because the equipment will be built to a certain specification. This ought to lead to improvements in the economies of scale for the manufacturer and the DNOs buying the equipment.

Appendix C: Losses analysis – low voltage cables

An analysis has been undertaken to examine the benefits of reinforcing low voltage networks with larger cables to reduce electrical losses. The majority of technical losses in a circuit are the product of the circuit's resistance and the current carried by the circuit. The losses can be reduced by simply replacing with a larger cable of lower resistance. Alternatively losses can be reduced by adding additional circuits to reduce current in each individual cable. Current levels can also be reduced by techniques such as meshing and changes in voltage regulation approaches.

The analysis presented below considers a number of options, ranging from a simple replacement with a larger cable, to more complicated network reconfigurations. The cost of each option was estimated using current cable installation rates. The reduction in losses was then calculated using standard formulae and methodology to determine the financial benefit per year. This then enabled a cost benefit analysis using Ofgem's standard model.

Options evaluated

A simplified low voltage circuit was modelled for the purpose of the analysis. The circuit comprised ten segments, with an even demand reduction of 10% for each segment. The circuit was comprised 0.1 square inch copper cable throughout its 500 metre length. This type and size of cable is common on low voltage networks.

All options examined, aim to either reduce resistance of the circuit, reduce current, or both. An important consideration is the relationship between losses, resistance and current:

Losses are proportional to ***current^2 x resistance***

Hence, if current is halved, losses are reduced by a factor of four. So, if a second circuit is added to share the current of the first circuit, the losses can be halved. In this simple analysis we have not included the future potential level of load or generation, rather the current has been assumed to be constant.

Option 1 Replace all 500 metres with larger cable

This is the simplest option and also the most expensive. All services to individual customers connected to the existing low voltage cable must be transferred onto the new cable. The existing cable then becomes redundant and is no longer used to provide supply. All reduction in losses is obtained by reducing the resistance of the circuit.

Option 2 Install a second circuit alongside existing, transfer half of load

This is the same as option one, except the existing cable is left in service. Half of the customers are transferred onto the new cable.

Option 3 Install larger cable for first 50 metres (50 metre J loop)

A larger cable is installed for the first 50 metres of the circuit. The new cable is then jointed onto the existing cable, feeding back the first 50 metres and the remaining 450 metres. This reconfiguration is called a 'J Loop'. The first 50 metres of the circuit carries the highest current, hence this option achieves the maximum benefit. There is no need to transfer customer services as the original cable is left intact.

Option 4 Install 2 larger cables to 200 metre point (Double J Loop)

This option takes advantage of the reduced cost of installing a second new cable alongside the first. Both cables are then connected to the existing circuit 200 metres along the circuit, with each circuit feeding either way. Again there is no need to transfer customer services from the original cable.

Option 5 Install larger cable to 100 metre point (100 metre J Loop)

Similar to option 3 with the connection point 100 metres down the circuit.

Option 6 Install larger cable to 100 metre point fed from start and 100 metre point (Hybrid 100m J loop)

As option 5 except the existing cable is left connected at the substation, splitting the current flow into two paths. This reduces the current flowing in every segment, hence reducing losses.

Calculation of annual reduction in losses

The annual reduction in losses has been calculated using standard methods and formulae.

$LLF = (A \times LF) + (1\text{-}A)LF^2$

LLF = Load loss factor

LF = Load Factor (variable, dependent on load)

A = empirical constant

Annual Losses = (current^2 x cable resistance per km x LLF x 8760 x cable length) / 1,000,000

Load Factor varies depending on the type of load. Normal domestic load typically has a load factor of 0.55. Commercial and industrial loads have higher load factors, 0.6 to 0.75. Some industrial loads have higher load factors up to 0.8. The load factor was varied in the modelling to examine the benefits

Results

Option	Description	Cost £k	Losses reduction MWhrs/year	NPV at PF = 0.6 (£k)		NPV at PF = 0.75 (£k)	
				16 years	32 years	16 years	32 years
1	Overlay all 500m	69.05	36.2	-77.677	-9.854	-48.522	-49.358
2	Install 500m second circuit	35.35	33.2	-37.353	-46.636	-8.208	2.548
3	J Loop to 50m	3.921	2.097	-1.349	-1.353	-.26	0.484
4	Double J Loop to 200m	21.31	6.968	-10.576	-12.83	-6.960	-6.723
5	J Loop to 100m	8.235	4.896	-2.472	-2.056	0.071	2.059
6	Hybrid J loop to 100m	14.867	8.4715	-4.732	-4.485	-0.333	2.939

This simple analysis shows that it is practicable to identify justifiable traditional expenditure on sections of cable networks based on reduction of losses. When such intervention are enhanced by lower costs smart techniques and combined with our innovative ROCBA model, the value generated is much higher allowing interventions and their value to be brought forward for our customers.