UK Power Networks
Losses Discretionary Reward
Submission for Tranche 1

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UK Power Networks
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Our approach to understanding losses

Introduction

As the Distribution Network Operator (DNO)[1] for London, the East of England, and the South East, UK Power Networks serves over eight million customers covering more than 29,000 square kilometres. We distribute approximately 27% of the UK's electricity via our 130,000 substations and 170,000 km of overhead lines and underground cables. We have approximately 5,600 staff working to service standards developed by our industry regulator Ofgem.

Managing losses is an integral part of delivering sustainable electricity. With 27TWh[2] of electricity lost each year within Great Britain (GB) as a direct result of network losses, we want to lead the technical improvements which will bring benefits for customers, the environment and the wider GB community.

The GB Transmission System Operators (TSOs) have a good understanding of the causes and effects of losses, due to the necessity of highly accurate metering for system balancing. Currently DNOs do not have the same level of visibility and their understanding of the losses on their networks is therefore limited. This is mainly due to the complexity and size of the networks. Within UK Power Networks' areas alone there are around eight million exit points; the majority of which represent single phase, and hence, unbalanced loads.

These same reasons also drive the relative magnitude of electricity lost on British distribution networks – about 20TWh of the total 27TWh. With advancing technologies and increased monitoring we are now ready to tackle this challenge and see this as an exciting opportunity. Within this document, we present a package of new commitments to deliver a step-change in understanding losses. These commitments focus on technical losses and the understanding gained will allow us to focus on non-technical losses in later tranches.

A change in focus for managing losses

Our Losses Strategy has been carefully developed, to focus on optimising losses reduction across our three distribution networks. In accordance with Licence Condition 49 (LC49) it focusses on our assets rather than considering the holistic impact of losses on upstream and downstream stakeholders.

Ofgem's Losses Discretionary Reward (LDR) brings a welcome change in focus. It changes the remit from considering our current network losses in isolation to adopting targeted, proactive initiatives which provide us and the wider DNO community with a better understanding of losses. This understanding will enable optimal solutions to be implemented based on the impact, cost and benefits the solution offers., The knowledge gained will help UK Power Networks, and our stakeholders, to better manage losses as we prepare for our transition to a low carbon economy.

Our approach

To deliver the step change to be in a position where we better understand and share our knowledge of losses, we present a plan that mirrors the ambition of the LDR – through a package of commitments that we believe meets all of the criteria for Tranche 1.

This plan encompasses four primary focus areas:

[1] A full glossary of terms can be found in 'Losses Discretionary Reward Tranche 1 – Annex'
[2] Ofgem (2015) Energy Efficiency Directive: An assessment of the energy efficiency potential of Great Britain's gas and electricity infrastructure. https://www.ofgem.gov.uk/sites/default/files/docs/2015/06/energy_efficiency_directive_report_-_final_for_publication.pdf

1. **Identify source and volume of losses.** In order to provide best value for money we must first understand the source and volume of losses, before choosing and prioritising loss management solutions. To build this understanding we will expand our capability to model solutions and their impact on our network. This will align with our standard method to assess and quantify losses and we will consult with other DNOs on the development of this assessment framework to ensure that it is suitable for wider adoption.
2. **Explore solutions**. We plan to effectively engage with stakeholders to discuss the knowledge we gain and also to incorporate and embrace any insight that our peers, nationally and internationally, are able to provide. In addition, we plan to review international best practice to identify successful loss management solutions which might be suitable for us to bring to the UK. We want to quantify the impacts of these using our developed model and incorporate them into a shortlist of potential solutions for consideration.
3. **Select and deliver solutions.** We aim to use the learning from the focus areas above to develop processes to consider losses in a consistent manner, and ensure that they can be incorporated as either primary or secondary drivers in the business justification of the work that we undertake on the network. Through understanding losses, exchanging best practice with stakeholders, as well as using our modelling tool to assess solutions, we plan to select solutions that will have the most impact on losses and embed these into Business As Usual (BAU) activities. In preparation for the roll-out of smart meters, and to maximise the opportunities which smart meters present for loss management, we will validate our business case for developing an end-to-end IT system architecture.
4. **Anticipate the transition to DSO**. By understanding how innovative network solutions can minimise losses, including those trialled in our innovation projects, we will better understand how losses play a part in our current transition from DNO to Distribution System Operator (DSO). As a long-term commitment we will embed losses as a decision parameter in our DSO operating model, making sure we consider losses when we make decisions about system planning and operation.

These four focus areas will be delivered through the commitments detailed in Figure 1 below:

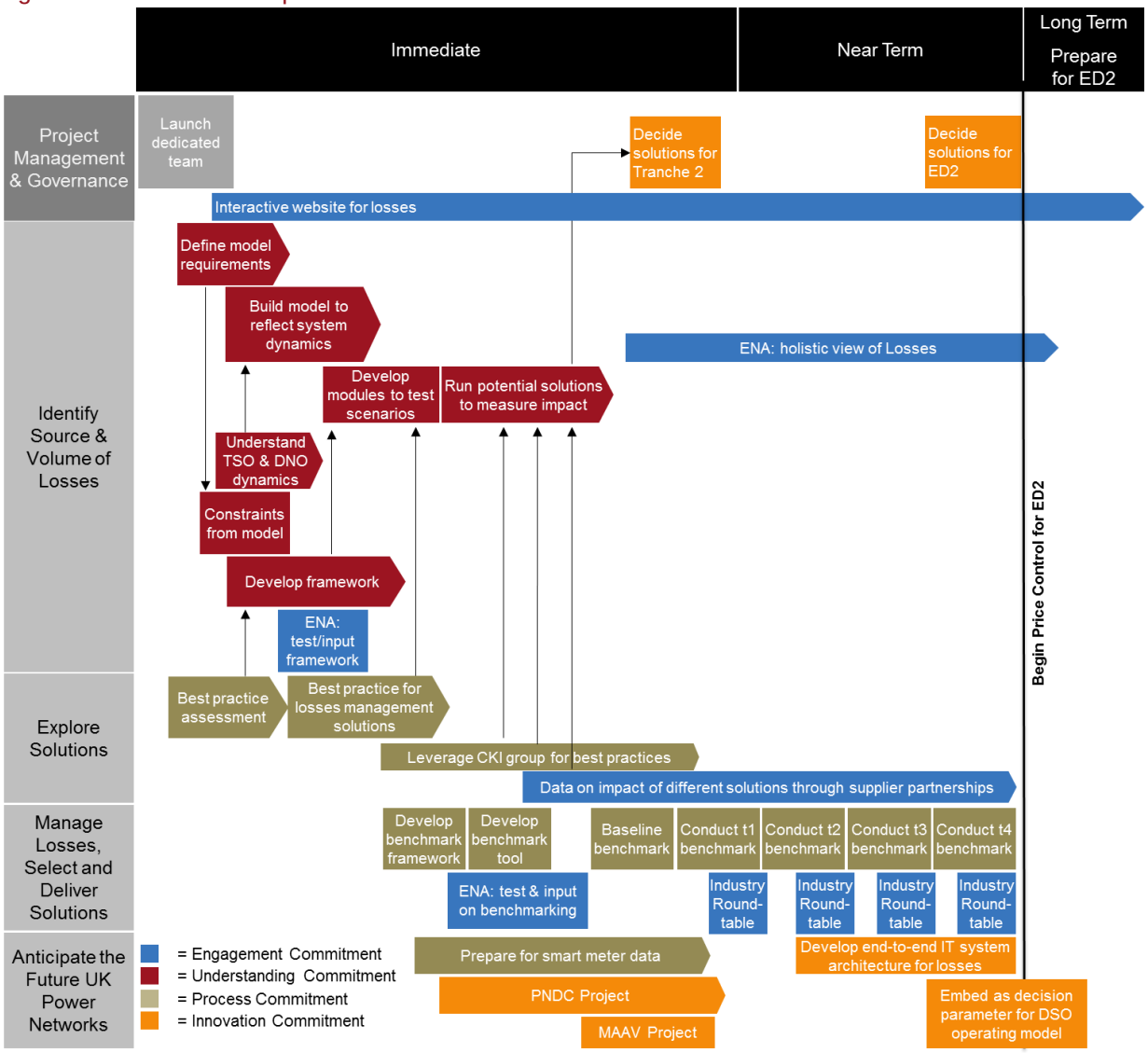
Figure 1: Our commitments to managing losses

	Identify Source & Volume of Losses	Explore Solutions	Manage Losses, Select and Deliver Solutions	Anticipate the Future UK Power Networks
Understand Losses	• Develop losses modelling tool • Develop standard losses assessment framework • Assess dynamics between ourselves and others (inc. NG)			• Determine the impact of innovative solutions on losses using the network modelling tool
Stakeholder Engagement	• Lead a sub committee of the ENA Losses working group • Establish a holistic GB view of losses	• Work in partnership with our manufacturers	• Make 'losses' accessible through a unique online platform	• Initiate dedicated industry events with a focus on losses
Processes to Manage Losses		• Review national and international best practice for losses management • Develop a benchmarking methodology for losses management		• Validate the business case for an end-to-end IT system architecture for effective smart meter data use
Incorporate Innovative Approaches	• Investigate use of Mobile Asset Assessment Vehicle (MAAV) to identify losses	• Trial the use of optimal feeder reconfiguration	• Employ the Power Networks Demonstration Centre (PNDC) to test solutions • Incorporate losses consideration into investment cases	• Embed losses as a decision parameter in the DSO Operating Model

The sections in this submission follow the structure set out by the LDR Guidance document. In assembling our plan, we have created a separate roadmap that embeds the Ofgem criteria within a set of activities that enable us to meet our commitments. We believe the commitments within this document showcase our significant ambition to surpass requirements under LC49.

The actions in Figure 2 below correspond to the Commitments Table in Annex A0.1.

Figure 2: Losses Roadmap



A dedicated team

In order to deliver these commitments we will establish a dedicated Losses Team, responsible for:

- Pushing forward the concepts contained within the Losses Strategy and LDR document, including leading the development of the standard assessment framework and network-wide model
- Starting processes and feedback loops to collect data and information from the various activities to test and report their effectiveness, and
- Sharing the learning both internally, within the company, and externally.

The team will report to the Director of Asset Management with a remit to work across the business and ensure activities are aligned. A strategic Key Performance Indicator (KPI) will be developed for regular reporting to the Executive Management Team who are keen to see real progress delivered. Ultimately the consideration of losses will become intrinsic to our business processes, so this team will be reduced and eventually dissolved, with the remaining responsibilities integrated into other functions.

1. Understanding losses

Our commitments	
Develop a network-wide modelling tool for losses assessment	Together with experts at Imperial College London we are developing a losses assessment modelling tool. This will enable us to, amongst other things, calculate the impact of strategic network changes or pinpoint losses hotspots across our network. Clear outputs from this model will be a losses heat map, establishment of guidelines related to network types, and measurement of impacts which will help us to ensure we prioritise solutions correctly. We will be developing an existing model and key learning from this process will also help us improve modelling tools which are already in use across the business.
Develop standard losses assessment framework	We will lead the development of a standard losses assessment framework, including an 'assumptions book', to provide a common basis for comparison of losses, containing useful scenarios that could be adopted by other DNOs.
Determine the impact of innovative solutions on losses using the network modelling tool	The implications for losses through use of smart solutions are not straight forward. Reviewing real trial results builds the understanding that is vital to embedding them in our future operating model. We will build this understanding starting with our own innovation projects and use it to inform the development of our standard losses assessment framework.
Assess the dynamics of losses interaction with National Grid, neighbouring DNOs and generators	We have initiatives underway with National Grid and Scottish and Southern Energy Power Distribution (SSEPD) which provide a unique appreciation of interactions between DNOs, National Grid and generators. These initiatives will demonstrate the net impact that the utilisation of our respective networks have on overall GB network losses. This is the first step in establishing a holistic view of the wider British network.

Understanding the losses on our network is a vital first step to improving the ways we can manage and reduce losses. Once we have good understanding of where and when the losses occur, we will be able to select and deploy the right actions to optimally manage losses – in the broader context of how to best operate, maintain and renew our network.

We come from a good starting point. We already have an in-depth academic knowledge of losses in terms of both the causes and potential ways to manage them. This includes standard approaches such as using larger cables and replacing older, less efficient, equipment. There are, however, important areas where we want to strengthen our insight such as the source and volume of losses on our network. Historically these have been difficult to determine due to low levels of network visibility; particularly on the Low Voltage (LV) network. There has also been limited availability of network-wide tools for assessing losses and the impact of potential solutions. As outlined in the introduction the size and complexity of our networks present significant challenges in the understanding of losses; with almost eight million single phase domestic meters, and largely unbalanced loads.

We are also looking forward to making the most of important opportunities to help the industry as a whole, in terms of devising a consistent method for assessing losses, and the holistic consideration of GB network losses.

The transition to a low carbon economy, including the uptake of low carbon technologies, presents DNOs with new challenges and we are in a period of increasing uncertainty. To meet these challenges, we know that innovative approaches to managing and operating the network are required. We plan to strengthen our knowledge in the following areas:

Develop a network-wide modelling tool for losses assessment

Assessment of losses across our licence areas is fundamental to gaining important new insight into the complex drivers of network losses and the impact that loss reduction strategies are likely to have. This increased understanding will enable the prioritisation of loss reduction activities; allowing greater benefits to be realised.

We currently have detailed modelling tools to assess losses (to varying degrees). However they cannot deliver network-wide insight in a timely manner (hours rather than days). Although we are currently developing a unified and detailed modelling capability, which will cover our networks at all distribution voltages, we anticipate it may be impractical to use this across all networks simply due to the amount of computing power and running time required.

Instead, the best approach to most effectively gain understanding and assess the losses on our network is to first use a top-down modelling tool.

We have already engaged with Imperial College London to develop this powerful tool which will develop and repurpose an existing load flow model which was developed for the assessment of our RIIO-ED1 load related expenditure. It uses optimal power flow modelling to assess the impact of different load growth scenarios on power flows at all voltage levels across all networks. Currently, the tool is mainly used to identify overloaded assets however further development will incorporate the assessment of losses and enable us to identify key areas where we should use loss reduction strategies. The tool will quantify the impact of these strategies, allowing us to prioritise and implement the most effective solutions.

A detailed description of the scope can be found in Annex A1.1

The developed tool will assess the existing level of losses and provide quantitative insight into the impact of a number of drivers on loss performance, such as: voltage dependant loads, power factor, phase imbalance, and power quality. The tool will also be able to assess the potential future level of losses from accommodating low carbon technologies and increasing network utilisation, providing a visual representation through a losses 'heat map'. Those areas which are most impacted by losses can then be analysed further using existing detailed models. This detailed analysis will be supported by the Power Networks Demonstration Centre (PNDC) facility (see section 4), and from actual network measurements.

Crucially the tool will enable us to assess, and build support for, the business cases for loss reduction proposals, including network reconfiguration, and the optimal control of flexible demand, storage and reactive power compensation. It will also enable the evaluation of the impact of alternative network design strategies such as direct transformation i.e. 132kV directly to 11kV, instead of via 33kV.

This tool will enable us to prioritise the solutions identified in our Losses Strategy which provide the maximum impact. We will also have the ability to inform future solutions, which is a key step towards becoming a DSO, details of which are set out in section 4.

Outcomes from our commitments
Identification of the key areas of the network to target loss reduction strategies, including representation through losses 'heat maps'
Establishment of losses guidelines related to network types
Quantification of the impact of potential loss solutions, which can inform prioritisation of solutions

Develop standard losses assessment framework

Ofgem has highlighted within the LDR guidance document that an agreed standard approach to assessing network losses amongst GB network operators does not currently exist**.** A number of different modelling assumptions are used which have evolved historically in response to business needs. These different approaches mean that, presently, it is not possible to effectively compare existing losses or the loss impact of different schemes across DNOs.

The ability to compare losses across DNOs is important for several reasons. Firstly, it creates a level playing field for DNOs so that improvements in losses based on innovative investment plans can be compared on a like-for-like basis. Secondly, it creates a common set of assumptions for any network power flow model that attempts to simulate losses, and the impact that solutions can leverage. This enables DNOs to achieve greater benefit from each solution and ensures that they can be applied in a cost efficient manner. This can then be tied to investment planning through cost-benefit analysis (CBA).

We will develop an internal assessment framework that defines a common approach to assessing losses. We will go beyond current boundaries to undertake an international review of methodologies which can either be directly applied, or refined, to suit British network topologies and modes of operation. Where no existing methodologies are available we will develop our own.

We anticipate that the types of assessment approaches may include:

- **Identify approaches to measure losses**. Using our knowledge of the source of losses we will collaborate with industry peers to create an agreed measurement approach. This includes agreement on the timing of the measurement due to the varying magnitude of losses during daily, seasonal and annual variations in load. In some situations we expect that tackling losses for the maximum demand case may worsen losses for remaining times of the year. Similarly, due to the dynamic nature of network power flows, those which worsen the position one year may improve it in subsequent years following changes in load. Therefore it is important that the framework will consider the net position of losses improvement management rather than a snapshot based on maximum demand.
- **Review the most suitable assumptions for modelling loads.** This is related to timing of measurement but may also have broader network implications. Assumptions may include the use of load factors, load profiles and modelling of voltage dependant and time-varying loads.

The output of this work will be an overall approach, including an ‘assumptions book’, to capture, measure and record losses. This will be a key step forward in understanding losses and will need to be developed in consultation with industry peers. We will lead this project and ensure that the framework produced is suitable for adoption by DNOs, National Grid and any other relevant stakeholders who are interested. We will utilise the working group discussed in section 2, to develop, test and review the framework and its underpinning assumptions.

Outcomes from our commitments
A standard approach (framework) to determine and capture losses, which is shared, tested and refined with our stakeholders
An ‘assumptions book’ capturing the parameters, assumptions and boundaries of the approach

Determine the impact of innovative solutions on losses using the network modelling tool

Case study: Power electronics can prove beneficial for losses (Annex A1.2)

It is anticipated that innovative low carbon technologies are likely to significantly increase technical losses unless they are accompanied by network reinforcement. This is because many technologies are designed to (temporarily) change systems conditions to manage peaks in power flows or extreme voltage levels. This mitigates the need for building additional capacity, increasing overall network utilisation, and hence losses, given the quadratic relationship between utilisation and losses.

Technologies such as Active Network Management (ANM) can, however, be used to optimise network losses. Levelling power flows using Demand Side Response (DSR) or storage and matching demand with Distributed Generation (DG) locally can have an overall positive effect on losses if a longer timeframe is considered. FUN-LV, one of our Low Carbon Network Fund (LCNF) Tier 2 projects, was our first project to incorporate a basic losses consideration when using power electronics to manage LV networks. Data from earlier LCNF projects, however, were not losses specific and will therefore be considered as part of the modelling tool development.

To incorporate losses as a decision parameter we will build an understanding, based on real data, of when a solution increases or decreases losses; either quantitatively (where possible) or qualitatively through the use of scenarios. Our starting point for this research will be our own LCNF projects, including Low Carbon London (LCL) and Smarter Network Storage (SNS). We will implement the learning from these projects into the losses modelling tool to enable us to understand the impact that innovation projects have on losses, and hence, opportunities we may have to utilise innovative approaches differently to how they were first envisaged.

The findings will be shared, tested and refined with our stakeholders using the ENA Losses Working Group, industry events and our interactive losses website (see section 2).

Outcomes from our commitments

Utilise data from innovation projects in the network-wide modelling tool to identify and quantify, where possible, the variation in losses that innovative approaches have on the network.

Assess the dynamics of losses interaction with National Grid, neighbouring DNOs and generators to inform a holistic network view

Case study: Understanding the interactions with National Grid to improve losses (Annex A1.4)

There is currently limited industry knowledge about how the interactions between different systems, e.g. DNOs, TSOs and generators, affect losses. It is important to take a holistic approach when considering losses to avoid improvements in one area causing increased losses elsewhere on the system. We believe it is crucial that the net impact to the overall system is considered, so that a solution improves the overall position for GB. It is essential that DNOs are able to see losses on other systems so that these interactions can be understood, and a co-ordinated approach can be developed.

We currently have initiatives underway to improve our understanding of interactions between DNOs, National Grid, and generators. These initiatives will provide visibility of the way each stakeholder uses their respective networks affects the overall losses in the wider network.

At 132kV the existing LCNF project Kent Active System Management (KASM) provides a unique visibility of the impact that network reconfiguration has on power flows within UK Power Networks' 132kV network, National Grid's upstream network, the High Voltage Direct Current (HVDC) interconnectors to mainland Europe and a number of generators within the project's defined area. In isolation KASM will provide an understanding of how network operation impacts stakeholders upstream and downstream of our network. This visibility will be achieved through a communications link between the control rooms of UK Power Networks and National Grid.

The original project scope did not include the consideration of losses and we now intend to explore the establishment of an algorithm within the system software, once the project has been established. This will provide a unique view of losses within a network utilised by a number of stakeholders. From the data we obtain we will investigate a number of solutions, including how network configuration and associated power flows affect losses. We also expect to determine the optimal export of embedded generation relative to load in relation to a dynamic network. We will document lessons learnt and investigate whether these can be applied to network configurations at lower voltages.

To understand the dynamics at 11kV and 33kV we have started to engage with our neighbouring DNO SSEPD; discussed in more detail in section 2 and Annex 2.1. We will explore opportunities to engage with our other neighbours.

With the input from these initiatives we can start building a holistic understanding of losses. This understanding will be beneficial to the industry as a whole, and we will share the findings of our activities through stakeholder engagement. This is discussed in more detail in section 2.

Outcomes from our commitments
Report on the losses dynamics at 132kV and connected systems, and the losses dynamics with our neighbouring DNOs at 33kV and 11kV
Lessons learnt regarding matching demand and generation
Data to inform the standard losses assessment framework and losses assessment modelling tool

2. Effective engagement and sharing of best practice

Commitments	
Lead a sub-committee of the ENA to drive debate	We don't pretend to be able to achieve great advancements in this complex area, alone. We will be a proactive member of the group and encourage plenary discussion Beyond this, we want to lead a sub-committee to develop, test and share outcomes of our losses assessment framework, best-practice review, benchmarking methodology, and impact of innovative solutions.
Establish a holistic GB view of losses	We will establish a view of network losses holistically for GB, rather than in isolation for each network operator or generator. We will use our enlightened viewpoint having learned from existing projects like KASM, our existing relationships with SSEPD and National Grid, and our work in partnership with DNOs, TSOs, generators and other industry participants, to develop these projects to better understand the impact of our interactions.
Initiate dedicated industry events	We will host a series of events to spark engagement beyond our current stakeholders. These events will be a mix of larger conferences focussed on disseminating new learning and smaller round table debates to gather industry insights and inform our thinking. This will help keep us abreast of national and international best practices, increase awareness of the value of losses as well as leading industry learning.
Make 'losses' accessible through a unique interactive website	Our dedicated losses website will provide a single port of call for all relevant information to both increase awareness of losses and keep industry colleagues up-to-date with the challenges we face. It will make our approach to managing losses clearer with easy-to-understand content being the key to unlock engagement with a wider audience.
Work in partnership with our manufacturers and service providers	We will collaborate with our supply chain which covers manufacturers of traditional equipment as well as providers of new services such as DSR. We plan to initiate talks with transformer manufacturers to help shape a new product that combines our desire to minimise losses with the latest technical design specifications – while maintaining cost efficiency.

We recognise that while our strategy will deliver improvements in network losses across our three licence areas, further benefits beyond this can be realised through a holistic view of networks across GB. We anticipate that such effort will result in marked improvements in the efficiency of the GB electricity networks, significantly helping towards meeting the binding measures of energy efficiency set by the Energy Efficiency Directive (EED).

The ENA Losses Working Group is a very useful starting point for sharing learning and gathering best practice nationally but is likely to focus on the requirements and interactions of GB network operators only. We want to extend the debate to a wider audience, ranging from customers to manufacturers to academia, and seek long-term collaborations to continuously understand losses better over time.

In some instances we propose it may be suitable for this collaboration to develop into a more formal partnership; as has been the case with our work with National Grid (see KASM case study in Annex A1.4), with generators through our Flexible Distributed Generation (FDG) connection contracts, and our on-going involvement with Imperial College London. We will also seek to engage less formally via our industry round table debates which will allow the sharing of the latest thought leadership on losses or via individual discussions on our interactive website.

These commitments are detailed in the sections below showcasing our approach to effectively engaging with this wider audience and the benefits we aim to achieve.

Lead a sub-committee of the ENA to drive debate

We will be a highly involved member in the ENA Losses Working Group by contributing discussion topics and encouraging plenary discussion. We have already requested to launch and lead a sub-committee to achieve DNO discussion on the initiatives relating to LDR commitments. The sub-committee will be an effective platform for:

- Developing a standard losses assessment framework,
- Establishing a holistic GB view of losses,
- Gathering and sharing best practice,
- Developing a benchmarking methodology, and
- Sharing our insight on the impact of innovative solutions on losses.

The sub-committee will be the platform to develop, test and share the outcomes of our commitments for the benefit of all parties involved. This knowledge will be shared with the wider industry in an accessible way via our industry events and our dedicated website.

Outcomes from our commitments

Following leadership of a sub-committee, key lessons learnt will be disseminated amongst working group members with discussion to further develop and understand a standardised approach to losses

Establish a holistic GB view of losses

The amount of losses incurred by a network is the result of the interaction between power flows, voltages, assets and network configurations. These conditions are not only influenced by us, but also by those connected to our network such as generators, National Grid and other DNOs.

Case study: Optimising inter-network connections through engagement can reduce losses (Annex A2.1)

Traditionally we have had limited visibility of the networks we share an operational boundary with. Where two networks join different designs can cause efficiency issues which may lead to increased losses. Recognising the dynamic nature of losses, we must together understand these relationships better if we are to manage them effectively.

To achieve this, we have already begun working with SSEPD to find opportunities to optimise network operations at our DNO boundaries and with National Grid for the TSO boundary. The former is presented in more detail in Annex A2.1 and the latter in Annex A1.4.

Similarly, we have recently started talking to National Grid about the issues they face managing voltage within statutory limits during periods of low network load. This engagement has already proven to be a very productive partnership. By developing this relationship further we expect that it will be possible to identify other interactions which have a bearing on overall losses.

Through this engagement we expect to:

1. Identify specific ways to manage our networks differently to optimise for losses when focussing on system boundaries.
2. Better understand how individual DNOs apply their losses strategies and whether their approach offers benefits that we hadn't previously considered.

The ultimate achievement of this engagement process is to establish a holistic view of the GB network; enabling DNOs and TSOs to add an extra dimension to the justification for undertaking loss related work. This will ensure that the decisions we take as a DNO/TSO community are best for GB as a whole.

Outcomes from our commitments
Identification of whether there are specific ways that we can manage our networks differently to optimise for losses, initially focussing on system boundaries with other DNOs
An understanding amongst TSOs and DNOs of how solutions we take as individual companies trigger dynamic interactions on each other's networks that affect losses

Initiate dedicated industry events

To date, losses have been seen as a niche topic or hygiene factor in discussions with the wider industry. This is now changing due to the low carbon transition, new regulatory incentive schemes and new technologies that enable monitoring of losses in a far more detailed way than was ever possible before. We want to extend the discussion beyond those directly involved in the ENA Losses Working Group, and our immediate stakeholders, to find new insights to help shape our thinking and to share our findings for the benefits of all.

We believe that the best way to achieve this will be through a series of dedicated industry events including conferences and industry round table debates targeted to specific audiences. To give us access to the widest possible audience we will organise a range of events, leveraging our existing relationships and forging new ones. For example, we will increase our collaboration with the Institution of Engineering and Technology (IET); the leading information dissemination partner for our larger LCNF projects. This partnership will give us access to a far wider range of stakeholders than we have engaged with before and they can link losses to other wider industry initiatives through their Energy Sector Committee and Policy Panel for Energy.

The key aims of a dedicated event include:

1. Sharing best practice for assessment and measurement methods, existing solutions, and promising innovative solutions being developed.
2. The opportunity to seek views on a specific topic, technology or issue via industry round table debates.

We have successfully organised large events to disseminate the learning from our LCNF projects, such as 'Low Carbon London – Sharing the Learning' and 'Flexible Plug & Play – Sharing the Learning', and will use this experience to ensure conferences achieve their aim. Round tables will be more suited to in-depth discussions with industry experts to develop thought leadership.

Both types of events represent a level of engagement related to losses that is above and beyond our normal Stakeholder Engagement strategy.

Outcomes from our commitments
Dissemination of our learning
Leading industry insight gathered to develop thought leadership
Sharing of solutions that have had a measured impact, either positive or negative
Ensure that manufacturers and service providers understand the collective industry's need to manage losses

Making ‘losses’ accessible through a unique interactive website

Losses can be a fairly complex subject; particularly for individuals who do not have a technical background. In recognition of this we have already reformatted our Losses Strategy to provide a more user-friendly and accessible format.

In addition to this work we will now develop a specific area within our website focussed on network losses. Acting as a repository for our published material, it will also provide easy access to key messages and interactive demonstrations of the concepts within the strategy. The intention is that by simplifying communications we will be able to encourage interest and engage with a larger target audience – who will also be able to interact with us and others through an online discussion forum.

The website will include:

- How we measure losses from the electricity network
- Inspirational national and international best practice
- Helpful materials developed for engagement events, minutes/discussions captured from the same events and benchmarking round-table discussions
- How we are preparing for smart meters, and
- Our immediate, short-term and long-term plans for solutions to manage losses.

The aim of our unique online discussion forum is to:

- Promote further discussion – for example after an industry event
- Ensure everyone can see discussions we are having with other stakeholders
- Increase awareness of losses and inform industry about the challenges we face, and
- Attract stakeholders we are missing and thereby engage with a wider audience

Before we do anything we will consult to check that the type of content and frequency of updates matches the needs of stakeholders.

Outcomes from our commitments
An interactive website, developed in consultation with our target audience, to present our findings on losses and encourage debate
Easy access to key messages and interactive demonstrations to inform our stakeholders

Work in partnership with our manufacturers and service providers

For further information on the opportunity to reduce losses on distribution transformers see Annex A2.2.

We recognise that in engaging with our supply chain, ranging from manufacturers of traditional equipment to providers of new services such as DSR, on the topic of losses management there is potential to improve the design of products we will install or commission on our networks. Working more closely with manufacturers will allow us greater opportunity to input into the design process, delivering the most suitable specification for the needs of our network.

For example, we plan to initiate talks with transformer manufacturers to shape a new product. With them we will determine the current technologies which result in lower losses (such as amorphous steel-cored transformers) to inform a new design that fits the suite of transformers on our network. Our approach will include undertaking an impact assessment of the design change on physical dimensions and weight, cost and electrical parameters such as impedance. We will then build a business case to ensure cost efficiency considering the loss benefits against the purchasing costs, operating costs and the regulatory allowance.

If successful we will use this tested approach to liaise with other relevant manufacturers and service providers to create an optimised product design that combines our desire to minimise losses with the latest technical design specifications while giving consideration to the limitations of producing a commercially viable product.

Outcomes from our commitments
A business case for the use of alternative low-loss transformer technologies
A tested approach to engaging with our supply chain to explore loss reducing designs

3. Processes to manage losses

Commitments	
Review national and international best practice for losses management	We will carry out a focused review of national and international best practice for losses management and will test the suitability for GB adoption using the developed loss assessment model. This will result in an industry-leading report which we will share and discuss with our stakeholders and devise a number of opportunities to develop further. UK Power Networks is very well placed to make use of corporate links within our parent group, CKI, to better understand international approaches to loss management.
Develop a benchmarking methodology for losses management	We have begun international high-level losses benchmarking with the International Utilities Working Group (IUWG). Using the standard losses assessment framework we will develop and trial a more detailed benchmarking methodology which will allow DNOs to accurately assess performance against peers and identify opportunities for improvement and sharing of best practice.
Validate the business case for an end-to-end IT system architecture for effective smart meter data use	We will use our existing smart meter data sets from LCL to test and validate the business case to establish an IT system architecture that will enable the most effective use of smart meter data, including for losses management.

All GB DNOs have a licence obligation to ensure that losses from their networks are as low as reasonably practicable and other network companies across the world have similar obligations. Of course network design and operating methods differ globally and by assessing performance, and reviewing best practice, much can be learnt from these different approaches. In particular we believe useful insight can be drawn from countries which are ahead of GB in the transition to a low carbon economy -they hold valuable learning which can inform our future approach to operating electricity networks.

The roll-out of smart meters also presents a number of opportunities for managing the expected changes on our networks. In order to realise these opportunities it is necessary for DNOs to change their systems and processes in preparation for smart metering.

These commitments to extracting and sharing learning, and ranking performance, are explained in further detail in the sections below.

Review national and international best practice for loss management

Although there are numerous reports available that cite novel ways to minimise or control losses, most discuss specific algorithms or technologies to solve a specific source of losses. None present a comprehensive comparison of international best practice. To develop this learning we will take an approach that has never been tried before – to review internationally published literature while simultaneously engaging with international stakeholders.

We will seek sources from a variety of published literature including:

- **Existing Research.** UK Power Networks has already conducted research in conjunction with Sohn Associates, our partnership with Imperial College London and other project partners. The review will incorporate this learning to prevent duplication.
- **CIRED and CIGRÉ.** These forums will provide international thought leadership from the distribution and transmission community.
- **Outputs of the DS2030 project.** This is expected to provide important learning on the future management of losses (see Annex A3.1)

Additionally, we recognise that there are working groups and companies who we can engage with who can provide valuable input into our understanding and planning.

- **IEEE (Institute of Electrical and Electronics Engineers).** IEEE in the United States is a particularly useful resource for understanding how smart data can be used to minimise losses, as smart meters have been installed in over 50 million sites as of 2014.[3]
- **IUWG**[4]**.** As part of this working group we have surveyed other international network operators to understand what levels of losses they believe their networks currently experience. We have received a range of responses indicating network losses between 4% and 9% and we are now keen to understand the drivers behind these numbers.
- **Leveraging the CKI Group.** As part of the CKI group, a leading player in the global infrastructure arena, we have a unique opportunity to achieve a clear, unfettered flow of opinions and information from varied networks across the world including Hong Kong (HK Electric), Australia (SA Power Networks, CitiPower and Powercor) and New Zealand (Wellington Electricity).

The primary output will be a report that provides a comprehensive summary of losses and how to best manage them both by source and holistically. The results will be shared with our stakeholders and discussed in the ENA Losses Working Group.

Outcomes from our commitments
Report on national and international best practice for losses management covering measurement and solutions
A discussion in the ENA Losses Working Group around our findings

Develop a benchmarking methodology for losses management

In general benchmarking and performance indicators can help companies monitor, assess and improve their performance over time by identifying technical or financial trends – through comparing performance within a specific company or across an entire industry. In short, it is a useful tool which we think could help manage losses and improve performance.

For our approach to develop the benchmarking methodology see Annex A3.2

We have already begun high-level international benchmarking through our involvement in the IUWG. From this strong foundation, we plan to develop a more detailed benchmarking programme for losses management as it has the potential to identify differentials in performance. Through informed round table discussions between utilities, to explore where difference are stemming from, participants can gain applied understanding on solutions that are being trialled and share knowledge on how to improve performance.

As part of Tranche 1 we will develop and trial a benchmarking methodology, based on the standard losses assessment framework, in consultation with our peers. The methodology should be suitable for

[3] http://www.edisonfoundation.net/iei/Documents/IEI_SmartMeterUpdate_0914.pdf

[4] The International Utilities Working Group covers leading companies from around the world including the UK, France, USA, Japan, China and Australia

adaption by other GB network operators. We anticipate it will be appropriate to start using it during Tranche 2 to assess performance.

The insights gained from this work will inform our own approach and feed into the working groups with our stakeholders. Together with the outcomes of the review of national and international best practice, this will benefit the whole GB DNO community as DNOs will able to identify opportunities for improvement.

Outcomes from our commitments
Benchmarking methodology for assessing losses performance
A report to be shared with our stakeholders and discussed in the ENA Losses Working Group

Validate the business case for an end-to-end IT system architecture for effective smart meter data use

The transition to a low carbon economy presents a number of new challenges for DNOs; several of which can be better managed with the introduction of smart meters.

It is anticipated that low carbon technologies, such as heat pumps and electric cars, are likely to significantly increase technical losses unless they are accompanied by network reinforcement. The ENA has determined that DSR through Time-Of–Use tariffs or active control of flexible demand has the potential to minimise the need for network reinforcement while maintaining losses at a roughly constant level. Smart meters are an important enabler for demand side flexibility.

Additionally network visibility will become increasingly important to enable DNOs to better manage and operate their networks in a low carbon world; including the management of losses. Across the industry, however, there is currently limited monitoring at 11kV and very little at LV. Traditional meters which measure aggregate customer energy consumption do not have communications built in and therefore do not transmit information to DNOs. Smart meter data can offer a potential step-change to help DNOs understand their networks.

Case study: Effective use of smart meter data (Annex A3.4)

The roll out of smart meters presents significant benefits and opportunities across the energy sector. In the Department of Energy and Climate Change's Impact Assessment[5] it estimates, among other benefits, that smart meters will facilitate a £410million reduction in losses across all of the GB networks (using the DPCR5 incentive mechanism since withdrawn for RIIO-ED1).

In order to realise these opportunities DNOs need to make changes to their systems and processes by preparing to receive data and then by analysing and effectively using that data.

Informed by industry knowledge and our largest innovation project LCL, which has received national acclaim both in the media and across the industry, we have developed an end-to-end IT system architecture vision in order to realise the full potential of smart metering (as discussed in Annex A3.3). We will use our existing smart meter data sets from LCL to validate the business case to establish this IT system architecture

Case study: Power Quality Monitoring to understanding where losses actually occur (Annex A3.5)

We expect that the full implementation of our long term IT system architecture vision will enable the most effective use of smart meter data, enabling better informed control of the network with respect to losses. To maximise benefits we will seek to achieve a balance between the level of visibility required to realise the benefit, the need to aggregate data for customer data privacy and the ability to accommodate the high volume of data. On the transition towards the full implementation there are also expected to be benefits which can be realised, for example; using smart meter data to inform network planning to better manage

[5] Smart meter roll-out for domestic and small and medium non domestic sectors (GB) –Jan 2014

losses and using clusters of meters to validate network models. Annex A3.5 discusses how smart meters will be used with power quality monitors to better understand losses.

Outcomes from our commitments
Validation of the business case for an end-to-end IT system architecture for effective smart meter data use including losses management

4. Innovative approaches to losses management and actions taken to integrate these into BAU

Commitments	
Trial the use of optimal feeder reconfiguration for loss minimisation	We will trial an advanced application in our network control system to optimally reconfigure the network based on losses. We will run the application in shadow mode to compare optimal and actual network configuration losses and will assess the use of active network reconfiguration for loss minimisation.
Investigate using a Mobile Asset Assessment Vehicle (MAAV) to assist losses management	We are currently in the process of preparing a Network Innovation Allowance (NIA) submission to implement a MAAV to survey our LV networks. The current scope does not cover the management of losses but we will take this opportunity to fund this aspect of MAAV implementation separately to the NIA project if it proves promising.
Employ the PNDC to test innovative loss management solutions	We will use the Power Networks Demonstration Centre (PNDC) to quantify the impact on losses of potential solutions under both a traditional and DSO network design to seek the most effective loss management solutions.
Incorporate losses consideration into the investment cases of future projects	Losses will be included in the CBA of new innovation projects and we will incorporate loss benefits into the business cases for innovations that are transitioned into BAU.
Embed losses as a decision parameter in the DSO operating model	With our RIIO-ED1 Business Plan we started the DSO transition. In defining this new operating model, we will include the consideration of losses as part of any decision regarding system planning, operation or control.

Large power plants are shutting down in favour of smaller plants and customer demand profiles are changing due to the electrification of transport and heating. In addition there is potential for customers to feed power back in to the network. As such the low carbon transition is gradually re-defining what ‘business as usual’ means for network operators.

Innovative solutions are available to network operators to adapt their systems to deal with these changes and more are being developed; inspired by forward-thinking regulatory schemes such as the Network Innovation Competition (NIC). These solutions are wide ranging including technical (e.g. Energy storage, Active Network Management) and commercial (e.g. new types of connection

agreements) opportunities. At UK Power Networks we have invested considerable effort and leadership into our innovation projects, resulting in an Innovation team that is adding knowledge to this industry and recently won Utility Week's 'Smart Utility 2015' title.

The challenge for network operators is to bring all these solutions together; both innovative and traditional. This will redefine the meaning of BAU, or in other words, transitioning from a passive DNO to an active DSO.

In our RIIO-ED1 Business Plan we committed to start the DSO transition and the losses implications associated with this are complex. In this LDR submission we commit to include losses as a decision parameter in the DSO operating model; incorporating the consideration of losses into system planning and operating decisions. The understanding gained from the developed losses modelling tool and the assessment framework supports this commitment.

The following section illustrates in detail how we have initiated the transition to this new operating model, including innovative approaches to loss management and the incorporation of losses into decision making. These commitments are also summarised in the table above.

Trial the use of optimal feeder reconfiguration for loss minimisation

Advanced control applications can be used to optimise network operation and are expected to become increasingly important in future distribution networks. We have learned a lot from the recent experience of introducing an advanced application for automatic and optimal network restoration following a fault. On our London network we have rolled out the Automatic Power Restoration System (APRS) software in our Distribution Management System (DMS) PowerOn which assesses the different feeding arrangements post-fault on the 11kV network. A number of enhancements have been developed so that this system can be rolled out to our other licence areas.

We will use our experience with APRS to trial the use of another advanced application which has the potential to assist with losses management. Optimal Feeder Reconfiguration (OFR) analyses the distribution network and proposes switching actions to optimise its performance. We will trial this application in relation to minimising losses. This will involve running the application in shadow mode and comparing the losses for the optimal and actual network configurations. Importantly this trial will allow us to assess the potential of network reconfiguration for loss minimisation and understand the opportunity to develop this innovative approach into 'BAU'.

Outcomes from our commitments
Assessment of the use of network reconfiguration for loss minimisation based on trial results

Investigate use of a Mobile Asset Assessment Vehicle for managing losses

Case study: MAAV can help us understand the condition of our LV network (Annex A4.1)

We are currently in the process of preparing an NIA submission to implement a MAAV to survey our LV networks. This innovative vehicle will be able to assess the condition of our underground LV network and from these surveys be able to pinpoint any network defects and anomalies. MAAV is discussed in Annex A4.1.

From the results and learnings collated during an initial self-funded pilot study we have identified an extra opportunity to detect losses using the MAAV technology. Conventional losses strategies focus on the complex and costly practice of reducing resistive losses in conductors and optimising transformer designs and ratings. This innovative strategy could be tailored to accurately pinpoint losses at locations on the LV network. Finding and repairing these areas in a targeted manner not only reduces losses and system load, it also enhances the customer experience by improving grid resiliency and minimising power interruptions by efficiently removing ailing sections of cable from the network.

We will investigate the options the MAAV technology presents for managing losses and will fund this aspect of MAAV implementation separately to the NIA project if it proves promising.

Outcomes from our commitments

Additionally scoped and funded work stream to use the MAAV technology to manage losses

Employ the PNDC to test innovative loss management solutions

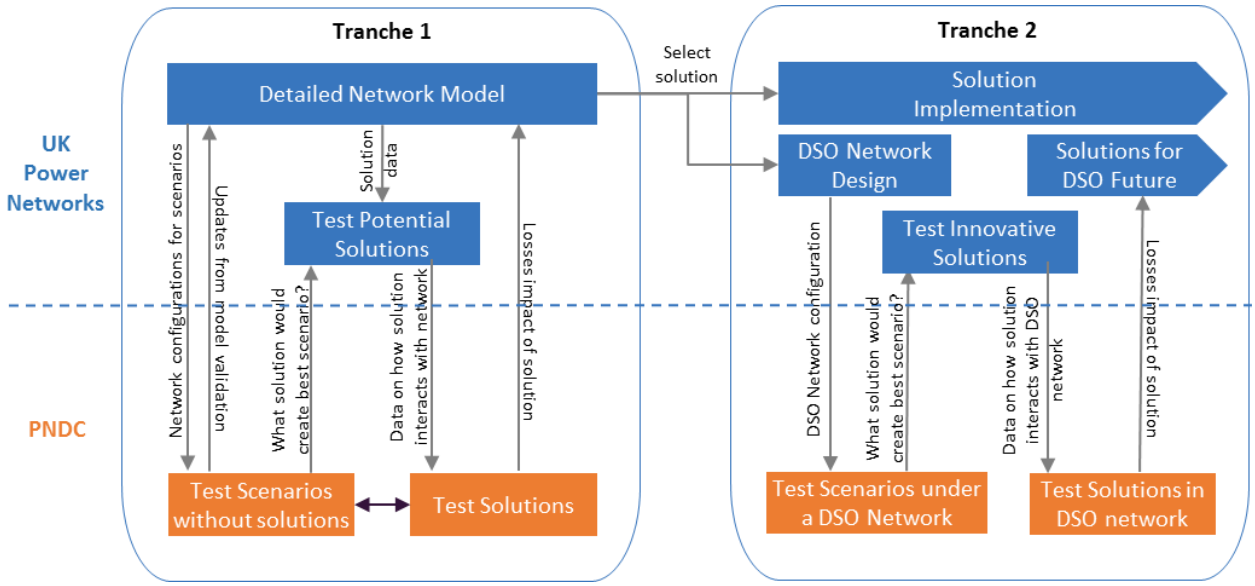
The PNDC has a working 11kV and LV distribution testing facility which enables the capability to research, test, and demonstrate hardware, software, and integrated system solutions before they are implemented on to real networks. We will use this facility to test and validate the models and assumptions for the loss management solutions which from detailed modelling were shown to result in the highest reductions in network losses.

During Tranche 1, this activity focuses on two main areas of work:

- **Definition of testing scenarios.** Our data sets will be applied to the facility's Real Time Digital Simulator (RTDS) to ensure testing is a credible representation of the envisaged network operating conditions with and without loss management solutions. We will then define the testing scenarios (such as different power factors), and measure losses when varying controllable elements such as load.
- **Testing of individual loss management solutions.** We will carry out black box network testing to characterise individual loss management solutions. This will involve quantifying the network losses with and without the solution, under different operating modes.

Fundamental to this testing activity is quantification of network losses with and without the solution applied and under different operating modes. We will consider all solutions which provide added value functionality. For instance, an electronic-based technology that provides power factor correction and voltage optimisation in addition to power flow management, could be a more cost effective solution compared to individual devices that perform these functions separately. PNDC can also quantify the benefits from multiple solutions applied simultaneously to understand the impact from a DSO view.

Figure 3: Interactions with the PNDC



This approach (as illustrated in Figure 3) enables a seamless transition to activities in Tranche 2, which involves implementing solutions and building on the learning from Tranche 1.

The results from this testing will inform which loss management solutions should be considered for deployment in Tranche 2.

The ultimate outcome is to glean the most economic and effective loss management solutions and combinations of solutions to facilitate efficient network operation while taking into account future GB grid constraints and electricity market participants' requirements.

Outcomes from our commitments
Quantification of the impact of sources of losses, potential interventions, and synergies from interventions
Quantification of the impact of interventions under a DSO network design

Incorporate losses consideration into the investment cases of future projects

The activities which we will carry out to better understand losses will create a set of considerations which will help in deciding the approach to best manage losses. At the moment we can only speculate about which approaches will be chosen, therefore committing to a set of specific innovations and innovative approaches would be premature. Instead, we are committing to manage losses in a way that incorporates and anticipates the future changes to distribution networks.

The culmination of the work set out in previous sections will create a wealth of information. The developed modelling tool (section 1) will have identified the best areas to target loss management solutions, and stakeholder engagement (section 2) and a comprehensive review of best practice (section 3), along with our own knowledge, will have created a list of potential solutions to consider. The model will have been able to test these potential solutions to identify the impact on losses across the network, along with the impact of smart grid innovative technologies, and we have been able to validate through further testing using the PNDC.

All of these activities will enable the assessment of which solutions we should pursue, with the solutions that best leverage opportunities in the future determining where we will invest. The valuable insight gained will be fundamental to incorporating losses into decision making.

The losses assessment tool in particular will assist with the development of investment cases. It will be held and governed centrally within our business and used internally by all relevant departments. This includes the innovation teams and network planning functions where the losses input to the Ofgem CBA tool will be guided by this. This input is currently mainly used where the project is directly considering the management of losses and is otherwise left blank. The tool, however, will enable us to isolate the losses benefits and provide that information for future innovation projects.

Losses will also be taken into account in the business cases for innovations which are transitioned into BAU. In doing so we will also take into account a number of other considerations including whether the solution can be leveraged with smart meter data and whether the solution can be embedded into the existing as well as the anticipated future system architecture.

By mid RIIO-ED1 we envisage using the assessment framework to incorporate the evaluation of losses directly in our project evaluation and governance. Once delivered the realised improvements in losses will be captured in the annual submission of information to Ofgem via the RIGs return.

The increased understanding of losses gained from a number of proposed commitments will enable us to incorporate losses into decision making and to maximise the benefits of our investments.

Outcomes from our commitments
Revised investment case for future projects including a consideration of losses

Embed losses as a decision parameter in the DSO Operating Model

The GB electricity industry has been embarking on a series of innovation projects as part of the NIC initiative, and the previous Innovation Funding Initiative (IFI) and LCNF schemes. The next step is to embed the learning from them into BAU. To achieve this at UK Power Networks, we recently defined a new capability model which we need to operate as a DSO across our three networks. The requirements of this new model are built from the foundation stones of our stakeholders' priorities, for instance as highlighted by of the

For our DSO transition diagram see Annex 4.2

Ofgem flexibility position paper, our DG Customer Forum and ENA DG Forums and Ofgem/DECC workshops on network constraints.

Our capability model considers four key areas:

1. Strategic planning and engagement
2. Investment planning and network management
3. Information communication technology
4. Operations and control

Key decisions taken in each of these areas, whether long-term strategic or short-term operational, are likely to have a positive or negative lasting impact on losses. Going forward we will include losses as a decision parameter in the new DSO operating model, considering losses as part of any decision regarding system planning, operation or control and exploring new loss solutions available to a DSO such as the procurement of ancillary services through demand side response. Embedding losses into the DSO operating model is an over-arching long-term commitment, as to execute this effectively, the true impact of innovative solutions on losses needs to be better understood first.

Outcomes from our commitments
Inclusion of losses as a decision parameter in the new DSO operating model

Closing Remarks

We believe that the ambitious commitments outlined in this submission will bring to fruition the vision created by the LDR, to expand the remit of losses management into a targeted, proactive approach. This progress will provide both UK Power Networks and the wider DNO community with a better understanding of losses and their impact, the cost and benefits of selected solutions, and how to manage them in anticipation of a low carbon economy.

Our approach is to first understand the source and volume of losses through sophisticated network modelling, creating a standard way to measure them, and study how losses are part of a holistic system. This is the critical first step towards identifying pioneering solutions which will work not just for us, but for industry peers. Through learning and sharing with the wider DNO community we strive to not only improve the service we provide but also the understanding of losses by the DNO community with the over-arching aim of improving energy efficiency within GB.

This is an exciting time as we forge ahead on our ambitious path towards becoming a fully formed DSO, embracing the findings of our innovative approaches to running our network and incorporating these changes into our existing and near-term business plans to ensure we are able to both exceed our customers' expectations and be prepared for future network requirements.

Our activities completed by the end of Tranche 1 will highlight a pioneering set of specific actions to implement in Tranche 2 enabling us to effectively manage our losses at a level that provides the best value for money for our customers. Tranche 2 will further enhance our understanding of losses when solutions are implemented and the impacts are monitored.

We believe the commitments in this submission, are crucial to the industry's advancement, and as such they underpin our vision to be a top class performer in the electricity distribution industry, and a respected corporate citizen operating in a sustainably cost efficient manner.

UK Power Networks
Losses Discretionary Reward
Tranche 1 – Annex

January 2016

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Delivering your electricity

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A0 Overview

A0.1 Table of Commitments

Commitment (High Level)	Details of commitments	Deliverables / Outcomes	Benefits
Understanding losses			
Develop a network-wide modelling tool for losses assessment	• Develop a network-wide model capable of assessing losses and the impact of solutions • Build upon an existing model which was developed with Imperial College London for the assessment of our load related expenditure for RIIO-ED1 • Create a model that is aligned to the standard losses assessment framework (below)	• Identification of the key areas across the network to target loss reduction strategies, including representation through losses 'heat maps' • Establishment of losses guidelines related to network types • Quantification of the impact of potential loss solutions, which can inform prioritisation of solutions	• Ability to focus effort and resources for greater benefit from loss solutions • Provides data and evidence to support cost benefit decisions on loss solutions
Develop standard losses assessment framework	• Lead the development of a standard approach to assess network losses • Develop this internally and invite other DNOs to provide input and assist in standardisation, so that the standard could be adopted by others in the industry • Continuously update based on new innovations, network studies, or smart meter data	• A standard approach (framework) to determine and capture losses, which is shared, tested and refined with our stakeholders • An 'assumptions book' capturing the parameters, assumptions and boundaries of the approach	• Provides a common basis for the comparison of loss management solutions, and performance • Decisions made to manage losses are informed and based on consistent information
Determine the impact of innovative solutions on losses using the network modelling tool	• Re-examine innovation projects and use the associated trial data and losses modelling tool to understand the impact that innovative network solutions have on losses	• Utilise data from innovation projects in the network-wide modelling tool to identify and quantify, where possible, the variation in losses that innovative approaches have on the network.	• Ability to incorporate losses impact into planning for innovations transitioning into BAU • Understanding of the impact on losses of trialled innovative solutions combined in one places
Assess the dynamics of losses interaction with National Grid, neighbouring DNOs and generators to inform a holistic network view	• Study the outcomes of the existing initiatives underway between DNOs, National Grid and generators to understand how the utilisation of their respective networks affects the overall losses in the wider network • Explore the establishment of a losses algorithm within the KASM system software once the project has been fully established	• Report on the losses dynamics at 132kV and connected systems, and the losses dynamics with our neighbouring DNOs at 33kV and 11kV • Lessons learnt regarding matching demand and generation • Data to inform the standard losses assessment framework and losses assessment modelling tool	• Aids future understanding of the wider-network in a holistic manner

Commitment (High Level)	Details of commitments	Deliverables / Outcomes	Benefits
Effective engagement and sharing of best practice			
Lead a sub-committee of the ENA to drive debate	• Lead a sub-committee of the ENA Losses Working Group to develop, test and share the outcomes of our losses assessment framework, holistic GB view and best-practice review, benchmarking methodology and impact of innovative solutions	• Following leadership of a sub-committee, key lessons learnt will be disseminated amongst working group members with discussion to further develop and understand a standardised approach to losses	• Opportunity to share and gain industry knowledge regarding losses • Ability to test and share the outcomes of our commitments • Gain acceptance of our proposed losses solutions such as the assessment framework
Establish a holistic GB view of losses	• Establish a view of network losses holistically for GB rather than in isolation for each network operator or generator • Work in partnerships with DNOs, TSOs, generators and other industry participants to better understand the impact of interactions	• Identification of whether there are specific ways that we can manage our networks differently to optimise for losses, initially focussing on system boundaries with other DNOs • An understanding amongst TSOs and DNOs of how solutions we take as individual companies trigger dynamic interactions on each other's networks that affect losses	• Enables DNOs and TSOs to add an additional dimension to the justification of doing (or not doing) loss related work • Enable potential future coordination of network operations and interventions • Enables identification of where synergies and other optimisation opportunities exist
Initiate dedicated industry events	• Host a series of events to engage beyond our current stakeholders including insight dissemination conferences, and round table debates	• Dissemination of our learning • Leading industry insight gathered to develop thought leadership • Sharing of solutions that have had a measured impact, either positive or negative • Ensures that manufacturers and service providers understand the collective industry's need to manage losses	• This will not only enable a greater scope of debate and expert input, it will also give us access to a far wider range of stakeholders who we have not engaged with before and losses can be linked to other wider industry initiatives • Manufacturers have a business case for developing new technologies or for investing in ways to modify existing products to manage losses • Academic institutions can develop research areas that meet industry needs
Making 'losses' accessible through a unique interactive website	• Develop a specific area within our website focused on network losses • Build and populate a repository of our learning and engagement on losses • Build a discussion forum for industry participants and stakeholders	• An interactive website, developed in consultation with our target audience, to present our findings on losses and encourage debate • Easy access to key messages and interactive demonstrations to inform our stakeholders	• Build the GB knowledge base on managing losses to contribute towards moving to a low carbon economy • Engage and promote discussion with a larger target audience

Commitment (High Level)	Details of commitments	Deliverables / Outcomes	Benefits
Work in partnership with our manufacturers and service providers	• Collaborate with our supply chain, including manufacturers of traditional equipment, as well as providers of new services, such as demand side response, on opportunities to better manage losses. • Engage with our transformer manufacturers to help shape a product that combines our desire to minimise losses with the latest technical design specifications, while giving considerations to the limitations of producing a commercially viable product	• A business case for the use of alternative low-loss transformer technologies • A tested approach to engaging with our supply chain to explore loss reducing designs	• These partnerships will offer the opportunity to influence the design of products and services, ensuring they are fit for purpose with regards to losses management • Findings to share with the wider DNO community
Processes to manage losses			
Review national and international best practice for losses management	• Conduct a focused review of national and international best practice for loss management and test the applicability for GB adoption using the developed loss assessment model • Make use of our connections within the CKI group to better understand international approaches to loss management • Review published material including the reports produced by CIRED and CIGRÉ as well as the outputs of the DS2030 project and IEEE	• A report on national and international best practice for losses management covering measurement and solutions • A discussion in the ENA Losses Working Group around our findings	• The sharing of learning and discussions around national and international best practice will provide a step change in understanding amongst GB DNOs and related stakeholders on the most suitable way to manage losses in a GB context
Develop a benchmarking methodology for losses management	• Develop and trial a benchmarking methodology, based on the uniform losses assessment framework	• Benchmarking methodology for assessing losses performance • A report to be shared with our stakeholders and discussed in the ENA Losses Working Group	• The methodology will allow performance to be assessed and the insights gained from this analysis will inform our own approach and feed into the working groups with our shareholders • Builds the general knowledge of GB DNOs to collectively manage losses better
Validate the business case for an end-to-end IT system architecture for effective smart meter data use	• Use existing smart meter data sets to test and validate the business case to establish an end-to-end IT system architecture for effective smart meter data use	• Validation of the business case for an end-to-end IT system architecture for effective smart meter data use including losses management	• Validating the business case enables best value decisions to be made regarding effective smart meter data use

Commitment (High Level)	Details of commitments	Deliverables / Outcomes	Benefits
Innovative approaches to losses management and actions taken to integrate these into BAU			
Trial the use of optimal feeder reconfiguration for loss minimisation	• We will trial the use of an advanced application in our network control system to optimally reconfigure the network based on losses • We will run the application in shadow mode to compare optimal and actual network configuration losses and will assess the use of active network reconfiguration for loss minimisation	• Assessment of the use of network reconfiguration for loss minimisation based on trial results	• Provides understanding of the opportunity to develop this approach to loss minimisation into BAU
Investigate use of a Mobile Asset Assessment Vehicle for managing losse	• Investigate the options the MAAV technology presents to understanding and managing losses. Separately fund this aspect of MAAV implementation from the NIA project which is being scoped	• Additionally scoped and funded work stream to use the MAAV technology to manage losses	• Enables us to pin-point losses on the LV network
Employ the PNDC to test innovative loss management solutions	• We will use the PNDC to quantify the impact on losses of potential solutions under both a traditional and DSO network design to seek the most effective loss management solutions	• Quantification of the impact of sources of losses, potential interventions, and synergies from interventions • Quantification of the impact of interventions under a DSO network design	• Enables proof of concept for interventions to determine which are best value for money • Saves time and money in acquiring measurement data from the simulator, rather than through active trials on the network
Incorporate losses consideration into the investment cases of future projects	• We will ensure that losses are included in the CBA of new innovation projects and will incorporate loss benefits into the business cases for innovations that are transitioned into BAU	• Revised investment case for future projects including a consideration of losses	• Provides understanding of the opportunity to develop loss management solutions into BAU
Embed losses as a decision parameter in the DSO operating model	• Embed losses as a decision parameter in the new DSO operating mode, including the consideration of losses as part of any decision regarding system planning, operation or control	• Inclusion of losses as a decision parameter in the new DSO operating model	• Ensures that losses have a reserved place in the planning of the future UK Power Networks

A1 Understanding Losses

A1.1 Losses assessment modelling tool (Imperial College London scope)

Objectives

The proposed programme has three major objectives to:

- Provide new insights in key drivers of electricity distribution network losses
- Assess the effectiveness of alternative loss management strategies, including the opportunities for application of novel distribution network operation policies supported by smart grid technologies
- Develop alternative loss-inclusive network design strategies

These objectives are to be met by enhancing an existing model to enable it to be used for loss assessment, and using this tool to identify the areas of highest losses and to assess the business case for a number of loss management strategies. The programme of work will provide learning to be disseminated to Ofgem and industry peers and it will align with the development of a standardised losses assessment framework.

WP1: Development of a network-wide losses assessment modelling tool

The aim of this Work Package is to understand the key parameters which drive losses. This learning will feed into enhancements to an existing modelling tool to enable it to be used for network-wide loss assessment, including assessing how changes to network operation affect losses.

Task 1: Understanding drivers for network losses

This task will involve comprehensive quantitative analysis of the:

- Load related losses, including possible load dependency on voltage and the impact of conductor temperature on losses
- No-load losses in transformers and their dependency on voltage, such as, but not limited to, how penetration of distributed generation impacts no-load losses
- Losses across different network assets considering typical GB network designs and configurations (from densely populated urban to sparse rural networks)
- Impact of cable tapering on loss performance
- Impact of power factor on network loss performance
- Impact of phase imbalance on LV network loss performance
- Impact of power quality i.e. harmonics on losses

Typical relevant network designs and asset parameters will be established. This will include development of a set of representative networks ranging from densely populated urban to sparse rural networks, installed asset parameters such as load and no-load losses of transformers, and assets of different characteristics and/or ratings.

Task 2: Enhancements of modelling tools for network loss analysis and control

This task involves enhancing the existing top-down network-wide model used for load related expenditure to:

- Assess losses and to generate losses ‘heat maps’
- Support cost-benefit analysis for establishing business cases for different operational and investment propositions for loss reduction in distribution networks
- Include strategic network planning

- Enable optimisation of the operation of distribution generation, storage and demand side response to minimise energy losses, while meeting all network constraints
- Enable dynamic optimisation of network topology for loss minimisation

WP2: Assessment of operational measures for losses reduction

This Work Package will analyse operational measures for losses reduction.

Task 1: Reducing losses through optimisation of open points

The aim of this task is to carry out an assessment of the potential benefit of optimisation of open points. A set of typical networks agreed with UK Power Networks will be created and the losses will be estimated for different positions of normally open points. ICL models for optimising network configuration to minimise losses will be enhanced and applied, which will be used for quantifying the benefits in different network types. The analysis will consider a range of network reconfiguration timeframes, for example, hourly, daily, weekly, monthly or seasonally to determine the least-cost option, which will be used to establish a business case for reducing network losses through dynamic network topology reconfiguration.

Task 2: Reducing losses through balancing load across phases

The key aim of this task is to assess potential benefits of balancing loading across different phases, considering a full range of different overhead and underground network types. This will be used to establish a business case for alternative solutions for enhancing load balance across phases including the application of novel power electronics based technologies for phase balancing, voltage control and reactive power compensation.

Task 3: Reducing losses through reactive power compensation

Departure of load power factor from unity will increase losses in distribution networks. The aim of this task is to quantify the increase in losses and potential benefit of reactive power compensation considering different network types, which will be used to establish a business case for deployment of alternative compensation strategies.

Task 4: Impact of active network management on losses and opportunities for loss reduction

Accommodating the growing penetration of DG already challenges traditional operation and design of GB distribution networks, and this will increase further in the future with the penetration of other low carbon technologies. In order to reduce the network investment smart grid solutions (active network control, dynamic line rating etc.) are being applied, which could potentially increase losses. Active network management can however present potential opportunities for loss reduction.

This task will assess the increased level of losses at present and in the future driven by increased network utilisation enabled by different smart grid technologies. It will also assess the loss-related benefits of controlling flexible demand, energy storage, reactive compensation and voltage. The impact of distributed generation on losses will be assessed and a business case will consider the merits of constraining distributed generation output to reduce losses. The benefits of matching load with distributed generation with the aim of reducing network energy losses will also be investigated, and the potential benefits of flexibility will be investigated and quantified.

Task 5: Retrospective consideration of several Future Networks' projects

The impact of several Future Networks' projects on losses will be retrospectively considered. These projects are yet to be determined but may be included in the broad/shallow model where possible.

WP3: Development of loss inclusive network design strategies

This Work Package will evaluate the impact of alternative network design strategies on network loss performance and carry out corresponding cost benefit analysis of the long-term asset investment cost and the corresponding cost of losses including carbon implications. The objective is to indicate what the proposed solutions may be to achieve lower losses than would otherwise be achieved by the traditional approach to equipment specification, network design, construction and operation.

Task 1: Development of low-loss distribution transformers

This task will review the losses related parameters of different types (and ages) of transformers used in UK Power Networks DNO areas and develop a strategy and business case for applying low-loss transformers.

Task 2: Loss-driven replacement of overhead lines and underground cables

This task will assess the business case for loss-driven replacement of overhead lines and underground cables considering a wide range of network types and load conditions. This will include comprehensive analysis of different load profiles across different types and voltage levels and overhead line and underground cable costs for different voltage levels, including the cost of losses.

Task 3: Impact of distribution transformer density

This task aims at establishing the business case for changing transformer density including the benefits of reduced network losses for different network configurations and types. Increasing the density of secondary distribution transformers/substations in cases where feasible, may enhance the ability of distribution networks to cost effectively integrate low carbon generation and demand technologies. This will in the longer term reduce the length of LV feeders and will hence reduce the network losses and the exposure to violating voltage and thermal constraints driven by load growth.

Task 4: Network voltage levels rationalisation

This task will focus on the assessment of changes and rationalisation in voltage levels. It is envisaged that this analysis will start by comparison of the four- and three-voltage level network designs such as, but not limited to, 132/33/11/0.4 kV and 132/11/0.4 kV designs. Potential benefits of increasing high voltage level to 20 kV will be also assessed, including consideration of losses. This task will also assess the potential benefit of strategically replacing legacy networks (2, 3.3 and 6.6 kV) with modern equivalents.

A1.2 Flexible Urban Networks – Low Voltage (FUN-LV)

Project overview

The FUN-LV project explores a cost effective and flexible solution to the increasing demands on LV distribution networks arising from the wider use of low carbon technologies and distributed generation. As an alternative to network reinforcement this project trials methods which provide controlled interconnection. In interconnected networks, also described as meshed networks, customers are supplied via two or more different routes through the LV network, with the result that their demand can be shared across substations. We have run parts of our networks meshed for many years. In urban and central business districts, both in UK Power Networks and other DNOs, there is potential for further meshing. Controlled interconnection, including the use of soft normally open points, enables access to spare capacity from neighbouring substations. Additionally the equipment capabilities allow the investigation of secondary benefits such as improving voltage control, harmonics, power factor and phase imbalance.

The project aims to deliver several key ambitions as part of the equipment trials:

- Allow flexibility in the network (necessary to accommodate uncertainty in volume, timing and location of the low carbon transition);
- Demonstrate increased visibility across low voltage networks in trial areas; and
- Provide remote control functionality for low voltage switching and power transfer.

Technical solution

The project trials three different methods to provide LV interconnection:

- **LV circuit breakers and link box switches:** This method allows for the capacity to be shared between two substations but the sharing is uncontrolled.
- **Dual-terminal power electronic devices (soft normally open point):** This method shares capacity across two substations and allows for the control of power flow from one substation towards the other.

- **Multi-terminal power electronic devices (soft normally open point):** This method shares the capacity across three substations and allows for the control of power flow from one substation to either of the other two.

Impact on losses

One of the key areas that the project aims to understand is the effects of the trialled methods on network losses. The complex impact on losses will be assessed, including through the use of high-level calculations, LV monitoring and modelling.

The impact is expected to be observable across four main areas; copper losses, iron losses, reactive power flow and phase imbalance. The potential effects and preliminary considerations for these areas are described below:

- **Copper losses.** These are the variable losses associated with the power flows on the network, which will be changed by the trialled methods. It is assumed (in order to be conservative) that those losses follow an I^2R rule, and that from the load profile change the proportional change in copper losses could be estimated. It is currently uncertain whether transformer load equalisation (via controlled interconnection of secondary substations) will have a net increase or decrease effect on network copper losses. Initial indications have shown that simply interconnecting networks may increase losses although this is dependent upon the degree of power transfer and specific network topology.
- **Iron losses**. These are the losses associated with energising a new transformer (most typical reinforcement solution), of which could be incurred at a later date depending on the extent to which the methods can defer reinforcement.
- **Power factor.** The dual and multi-terminal power electronic devices are capable of controlling reactive power at the point where they are installed on the network, therefore resulting in a net reduction in the apparent power (MVA) required to serve a given real power (MW). However, it is uncertain whether an overall reduction in reactive power will then be observed at the distribution transformer level.
- **Phase Imbalance**. This factor also contributes to copper losses (thermal) and it is anticipated that the power electronic devices can reduce the resistive losses on individual phase currents through managing individual phase power transfers.

In addition to these factors, it has been highlighted that through the utilisation of the equipment an additional thermal loss could be incurred by the heating of the power electronic devices' inverters. To address this factor, the algorithm ensures that the unit only operates where the net benefit of power transfer outweighs this loss. Secondly, it has been identified that by running transformers at a higher utilisation (likely to occur in each of the methods) the copper losses may increase compared with upgrading to a higher rated transformer.

The loss interactions are complex and this project will provide important insight and understanding on how losses are affected by controlled interconnection, including the use of soft normally open points.

A1.3 LCNI projects to provide losses insight

We anticipate building insight related to losses based on the reports and data sets from the following projects:

Low Carbon London (LCL)

LCL was a flagship innovation project designed to understand how DNOs may invest and operate in the future. The project carried out extensive trials to understand the impact of a wide range of low carbon technologies, including trials involving smart meters, electric vehicles, distributed generation, demand side response and active network management. A wealth of knowledge has been, and is continuing to be, generated from the project. It presents an opportunity to provide losses insight in a number of areas, including in relation to the use of smart meter data for improved network planning considering losses. It is also expected to provide insight into the impact of distributed generation on losses, and how demand side response can reduce losses.

Smarter Network Storage (Leighton Buzzard) and Hemsby

We have carried out several trials in relation to the installation of storage on distribution networks. This includes the installation of a 200kWh battery in Hemsby, as well as the Smarter Network Storage project which involved the installation of a 6MW/10MWh battery and is the largest battery storage project in Europe. The Hemsby project demonstrated that storage can provide multiple benefits, including network support and allowing the connection of more renewable generation on a constrained network. Following on from this the Smarter Network Storage project is helping to improve the understanding of the economics of storage by trialling business models for multi-purpose application. This project presents the opportunity to provide insight into the loss improvements from the use of storage for demand flattening and the impact on losses of the use of inverters for power quality improvements.

Flexible Plug and Play (FPP)

The FPP project involved the trial of new technologies and commercial arrangements to connect distributed generation to constrained areas of the electricity distribution network. As well as offering flexible connections, a number of smart devices were trialled including active network management, dynamic line rating, novel protection schemes and quadrature boosters which are devices which are able to control the flow of power through two parallel circuits. The project has proven to provide significant benefits to distributed generation customers in terms of reducing the upfront cost and the time to connect. It presents an opportunity to provide insight into the increase in losses from increased network utilisation through active network management and dynamic line ratings. It is also expected to provide insight into how losses are impacted by novel connection arrangements as well as by quadrature-boosters.

Kent Active System Management (KASM)

The KASM project involves the trial of coordinated contingency analysis, using a communication link between the control rooms of National Grid and UK Power Networks to share real-time data. As mentioned in Section 1 of the main report, we will explore the establishment of a losses algorithm within the KASM system software and will study the outcomes of this project. This will allow us to gain insight into the interactions between distribution network operators, National Grid and generators and how the utilisation of their respective networks affects the overall losses in the wider network. The case study in Annex A1.4 discusses the project in more detail.

Flexible Urban Networks – Low Voltage (FUN-LV)

The FUN-LV project trials a number of methods which provide controlled interconnection to optimise the capacity on the LV network. These methods also have a number of secondary benefits including improving voltage control, harmonics, power factor and phase imbalance. One of the key areas that the project aims to understand is the effect of these methods on losses. The project will provide insight on the impact of losses of active network management using switches and power electronic devices on the LV network. Annex A1.3 provides more information on this project.

A1.4 Case study: KASM (132kV)

Understanding the interactions with National Grid to improve losses

The KASM project involves the trial of coordinated contingency analysis, using a communication link between the control rooms of National Grid and UK Power Networks to share real-time data. It is the first trial of contingency analysis on a UK electricity distribution network and it will enable better planning and operation. The area has specifically been chosen due a high number of network issues including over-voltages, the presence of HVDC interconnectors and the high amount of generation.

Contingency analysis is a valuable tool in predicting the effect of outages and in taking actions to keep the distribution network secure and reliable. The project is expected to demonstrate that the network can be run closer to its design limits, releasing network capacity and deferring the need for significant reinforcement. It will also maximise the renewable electricity output by

reducing the need to curtail during essential maintenance or equipment faults.

The learning from KASM will contribute to our understanding of losses and will feed in to our new DSO Operating Model. The project also uses IT systems which mirror those that we expect to use as a DSO. The learning will help us to prepare for the availability of smart meter data and the methods in which we may use this in the future to better manage losses.

http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/kent-active-system-management/

A2 Effective engagement and sharing of best practice

A2.1 Case study: Engagement with SSEPD (11kV and 33kV)

Optimising inter-network connections through pro-active engagement can help improve network efficiency and reduce losses

Historically DNO licence areas have been operated as separate entities without significant interconnection between other licence areas. There are existing shared sites where DNOs have feeds direct from adjacent network operators as well as sites where the 11kV or 33kV switchboard may be shared. These sites are normally at or near to geographical boundaries.

In order to better understand the impact that actions within our distribution networks have with interconnected networks such as other DNOs or TSOs, Scottish and Southern Electricity Power Distribution (SSEPD) and UK Power Networks are working together to understand the impact that their respective networks have on the other's. We participated in an initial meeting with SSEPD in October 2015. The discussions provided an understanding of the existing processes and willingness of both parties to consider alterations or improvements.

From the work to identify best practice it has been agreed that there could be potential benefits from having a more structured, collaborative approach. The work has since shifted from understanding the potential issues of the current practice to sketching a rough layout of a process to define the principles required to improve DNO operational boundaries.

The ambition is for all DNOs to work together to refine the process over the coming months and the work is expected to complete during 2016. The completed process will highlight the options available to DNOs when managing new connections, building new substations or making alterations to the network at or near to geographical boundaries. The process will detail how to attain key information required to perform network analysis outside of the DNO area with appropriate contacts of network planners aligned to support inter DNO analysis. It is anticipated that the new process will not be constrained by geographical boundaries e.g. a new connection within a particular DNO's area may be closer and more cost effective to connect to an adjacent DNO's network with an associated reduction in network losses. The aim of the process is to ensure losses are considered at a whole network level, as opposed to a DNO licence area level, and ultimately reduce costs to customers without being constrained by existing boundaries.

A2.2 Reducing losses on distribution transformers

The volume of distribution transformers is far greater than the volume of primary and grid transformers and so reduction in the losses of new distribution transformers is expected to provide the greatest benefit.

The European Parliament issued a Directive implemented in July 2015 defining the maximum losses for transformers. The Directive states the losses target in two Tiers, the first being in July 2015 and the second in July 2021, but the situation is to be reviewed in 2018 to gather the views of stakeholders throughout Europe on the feasibility of this further reduction.

New contracts for distribution transformers were recently awarded to enable compliance with the first tier of the European Directive. Designs are complete for the most commonly required transformers and type testing of prototypes is nearing completion.

No-load losses are present at all times when the transformer is energised, whereas the load losses are only present when feeding a load and vary with the load being supplied. A lightly loaded transformer would benefit from having lower no-load losses, even at the expense of slightly elevated load losses.

Both no-load and load losses can be reduced, but the penalty will be cost and a potential increase in the size of some of the range of distribution transformers used. The reduction to the Tier 2 of the Directive has been considered and discussed with manufacturers. There is a probability that amorphous steel will need to be used in some of the transformers to achieve the required reduction. Amorphous steel is much less readily available than standard magnetic steel and there is a premium for this raw material. This steel is also much more difficult to manufacture into the core, making manufacturing more costly. The manufacturers have also advised that because of the shape of the amorphous core, the load losses are likely to increase as well as the noise level.

To understand the use of lower loss transformers in the future we will liaise with manufacturers to investigate the options and to understand the impact on physical dimensions, weight and cost. Based on this information business cases will be produced.

A3 Processes to manage losses

A3.1 Case study: DS2030

Understanding the management of losses in 2030

The future of distribution networks incorporating the high uptake of low carbon technologies presents a number of challenges and uncertainties for DNOs. DS2030 is an industry-wide ENA project to gain a better understanding of the technical viability and characteristics of the electrical system of 2030. Through detailed technical studies the project will assess how smart solutions will be operated, and the roles and responsibilities that a DNO will be required to undertake as part of its transition to a DSO.

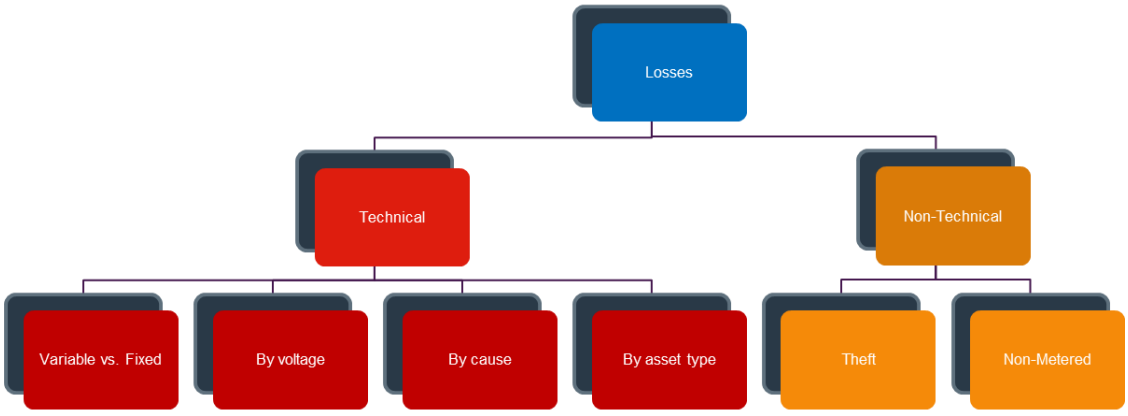
The project will answer a number of questions compiled by the Smart Grid Forum Work Stream WS7 (which we are a member of), including the question 'What is the anticipated impact on distribution network losses in a 2030 network and can new opportunities be identified by loss optimisation?'. This study will provide important learning on the future management of losses and we will carefully review the outputs of this study when the report is published in Q1 2016.

http://www.smarternetworks.org/Project.aspx?ProjectID=1623

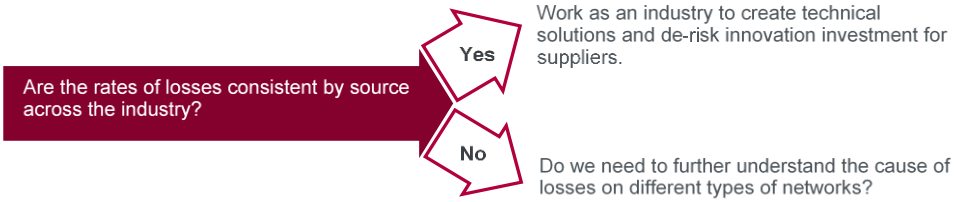
A3.2 Our approach for developing the losses benchmarking methodology

To give a flavour of the potential indicators for our benchmarking methodology, comparisons could be made of the parameters in Figure 1 below:

Figure 1: Potential benchmarking indicators



Typical questions that drop out of benchmarking results could create detailed discussions such as:



Industry benchmarking at a detailed level already take place across utilities and has proven successful in sharing best practice and lessons learned. One such example is for streetworks, where utilities have their own set of performance metrics which DNOs, telecom, gas, and water utilities all submit data to. The insights gained from our benchmarking will inform our own approach and feed in to the working groups with our stakeholders.

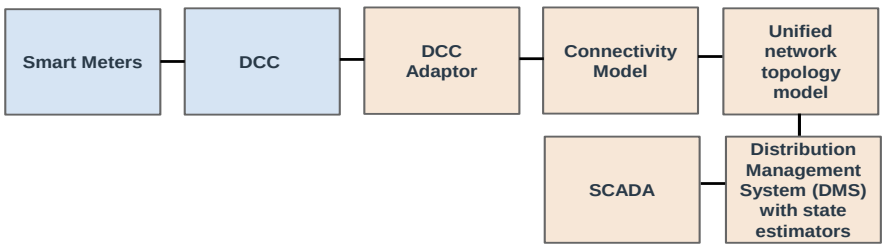
A3.3 Our proposed end-to-end IT system architecture to realise the full potential of smart metering including losses management

Our long-term vision, business case dependant, is to develop an end-to-end IT system architecture which will realise the full potential of smart metering. We have identified that the following is required:

- **DCC adaptor.** The Data and Communications Company (DCC) will provide communication services to all smart meters in GB. In order to communicate with smart meters it is necessary to connect to the DCC through a DCC adaptor. The DCC adaptor is the system within our business through which all smart meter commands will be sent and all data will be received and stored.
- **Connectivity model.** It is important to identify the exact phase and feeder which the meter is connected to for analysis of losses. A connectivity model which correctly maps the MPANs (unique meter identifiers) to the LV model is required.
- **Unified network topology model.** A unified network topology model is required which contains the models for all license areas and all voltage levels. This enables a system wide approach to analysis of losses, and to management of losses (when integrated with the distribution management system (DMS)).
- **Integration of our DMS with the unified network topology model and SCADA.** Integrating these systems enables the unified network topology model to take account of real-time changes in network configuration using SCADA data (from our ENMAC system), and enables the DMS (PowerOn) to inform and take operational decisions based on model load flow analysis (including actions to reduce losses).
- **State estimators within the DMS.** State estimators will be required as an integral part of the DMS monitoring system to account for gaps in smart meter data on mass roll-out.

Our long term vision for this IT system architecture is aligned with the identified requirements above, which will enable the most effective use of smart meter data, including for the management of losses. An overview of the relevant parts of this system architecture is shown in Figure 2.

Figure 2: Overview of IT system architecture vision for best use of smart meter data (blue is external to UK Power Networks)



A3.4 Case study: LCL

Incorporating learning from LCL to prepare for effective use of smart meter data

Our LCL project, involving the installation of over 5,000 smart meters, has contributed significant industry insight into the data which smart meters will provide, the ways in which this data can be used to provide benefits to network operators and the immediate requirements for DNOs to prepare for a low carbon transition.

A series of reports have been produced as an output of the project, including those which discuss the planning, operational and system changes required to deal with smart meter data, and the use of smart meters as an enabler for demand side response.

This project has also resulted in smart meter data sets and we will use this to validate the business case for anend-to-end IT system architecture vision.

http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Low-Carbon-London-(LCL)/

A3.5 Case study: Power quality monitoring

Power quality monitoring will give us a better understanding of where losses actually occur

Obtaining increased visibility of network parameters such as current and voltage is necessary if our understanding of losses is to be developed beyond that gained through our network modelling analysis. This visibility will also enable us to implement interventions in areas that provide maximum impact in respect of reduction of losses. Historically this data only tended to be available through specific voltage and current transducers connected to our control centre systems. Data is becoming more widely available and can now be obtained through a variety of equipment on our network including protection relays, power quality monitoring and HV RTUs.

Throughout RIIO-ED1 we will be implementing our power quality strategy which establishes fixed power quality monitors at key 11kV, 33kV and 132kV busbars. Typically, we configure these devices to monitor power quality parameters on a ten minute average basis. We have the option to configure these devices differently though and can take much shorter average measurements to provide more granular datasets. Where we observe high penetration of smart meters we will establish trial networks to better understand energy flows in to, and out of, a network. By comparing the data from the smart meters to that of the revised power quality measurements we expect to gain a better understanding of where actual network losses are incurred which we will use to further validate our network models.

A4 Innovative approaches to losses management and actions taken to integrate these into BAU

A4.1 Case study: MAAV

Embracing international innovative best practice can help us understand the condition of our LV network

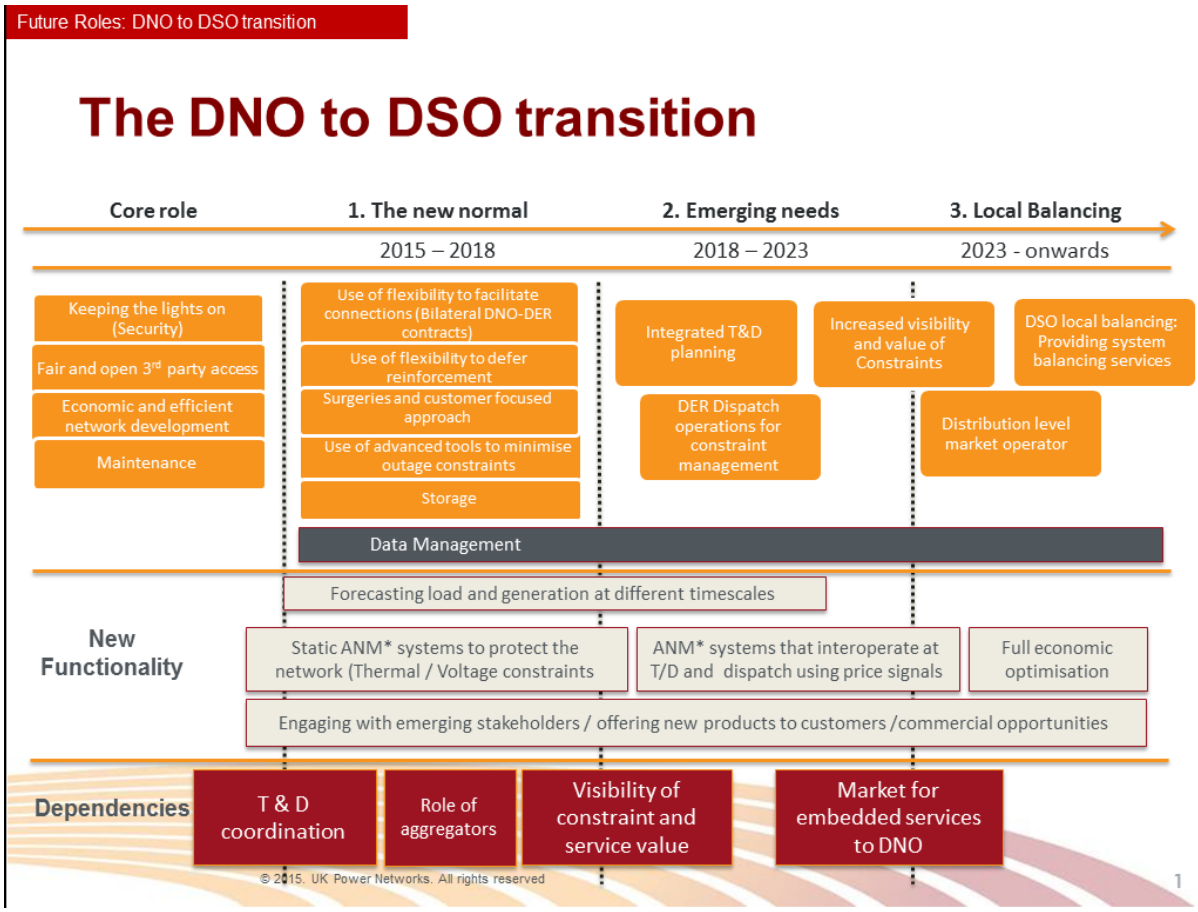
In search of a method to pinpoint system deficiencies, from aging and damaged underground cable and equipment, on the low voltage network, we partnered in early 2015 with Power Survey Company. Power Survey Company uses extremely sensitive electric field measuring equipment integrated into their fleet of mobile contact voltage detectors (Mobile Asset Assessment Vehicles or MAAVs) to identify contact voltage conditions. They have performed field testing in over 60 US cities. This is essentially a tailor made solution to the problem of pin-pointing defects on the LV network.

To prove the concept, a pilot scan was initiated in areas of our LV network. During the survey technicians traversed the streets searching for instances of voltages on street level objects such as pavements, street lamps and bus shelters.

The pilot demonstrated that the MAAV is effective at identifying sites where LV cables are damaged and discharging voltage into the surrounding environment. In every case where voltage was measured on the surface and a site investigation was conducted the source of the voltage was determined to be a damaged LV underground cable. The ability to quickly and accurately locate defected assets represents a paradigm shift in underground asset surveys and fault detection/prevention strategies.

http://www.powersurveyco.com/services/gridhealth/

A4.2 Transition to DSO



*Active Network Management

A5 Glossary

Term	Definition
ANM	Active Network Management
APRS	Automatic Power Restoration System
BAU	Business as Usual
CBA	Cost Benefit Analysis
CIGRE	Conseil International des Grands Réseaux Électriques / International Council on Large Electric Systems
CIRED	Congrès International des Réseaux Electriques de Distribution / International Conference on Electricity Distribution
CKI Group	Cheung Kong Infrastructure Holdings Limited
DCC	Data and Communications Company
DECC	Department of Energy & Climate Change
DG	Distributed Generation
DMS	Distribution Management System
DNO	Distribution Network Operator
DSO	Distribution System Operator
DSR	Demand Side Response
ENA	Energy Networks Association
ENMAC	UK Power Network's control room system to view and monitor the network in real time
EPN	Eastern Power Network
EU	European Union
FDG	Flexible Distributed Generation
FPP	Flexible Plug & Play
FUN-LV	Future Urban Networks – Low Voltage
GB	Great Britain
HV	High Voltage
HVDC	High Voltage Direct Current
ICL	Imperial College London
IET	Institution of Engineering and Technology
IFI	Innovation Funding Iniative
IUWG	International Utility Working Group
KASM	Kent Active System Management
KPI	Key Performance Indicator
kV	Kilo-Volt
LC49	Licence Condition 49
LCL	Low Carbon London
LCNF	Low Carbon Network Fund
LCT	Low Carbon Technologies
LDR	Losses Discretionary Reward
LPN	London Power Network
LV	Low Voltage
MPAN	Meter Point Administration Number
NIA	Network Innovation Allowance
NIC	Network Innovation Competition
OFR	Optimal Feeder Reconfiguration
PNDC	Power Networks Demonstration Centre
RIG	Regulatory Instructions and Guidance
SCADA	Supervisory Control And Data Acquisition
SNS	Smarter Network Storage
SPN	Southern Power Network
SSEPD	Scottish and Southern Energy Power Distribution
TSO	Transmission System Operator
TWh	Terawatt hour
UK	United Kingdom
WS7	Work Stream 7 of Smart Grid Forum