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Losses Strategy

RIIO-ED2

nationalgrid

Introduction

Losses are the difference between the electrical energy that is input into the electricity network compared to the electrical energy that reaches the consumer.

This document explains what losses are, what National Grid Electricity Distribution (NGED) has been and is doing to reduce losses, and how this approach may need to change in the future.

Sohn Associates-Imperial Report

Initial losses work was navigated using a report commissioned by NGED and United Kingdom Power Networks (UKPN), the Sohn Associates-Imperial Management of Distribution Losses Report, which outlined 26 recommendations to address losses.[2]

NGED has made improvements in all 26 areas, and will continue to use this report and other recent works to approach losses in a considered manner.

There are four key reasons that a focus on losses is important within NGED:

Customer
The customer is our priority at NGED.

Customers pay for the cost of the network through the standing charge on their bills and it is therefore vital that we deliver an efficient network which delivers value for money.

Financial
There is a financial cost for losses where electricity that could otherwise have been utilised is wasted.

This has implications for several stakeholders including our customers.

Environmental
The electricity network is not fully decarbonised and losses therefore currently have an environmental cost.

The government has a target for the UK power system to have been decarbonised by 2035, however, until then losses will have associated carbon emissions.

Obligation
Although there will always be a degree of losses on the network, it is stipulated in our license conditions that we must ensure that Distribution Losses on our network 'are as low as reasonably practicable'.[1] We must also maintain an up-to-date Losses Strategy on our website, which we will act in accordance with, to ensure that we meet our responsibility for managing losses.

[1] Ofgem, Standard Conditions of the Electricity Distribution License, Condition 49, p.291

[2] Sohn-Associates and Imperial College, Management of Electricity Distribution Network Losses, 2014

NGED vision for losses

Our vision for losses during the current price control period, RIIO-ED2, is dominated by the journey to net zero by 2050 and the mechanisms that are needed to facilitate it.

The benefits of energy efficiency are sizeable, but the pace of decarbonisation and the cost of immediate traditional upgrades and reinforcement mean that we must use flexibility and alternative means to deliver net zero. This higher utilisation of the network will lead to an increase in losses. Our focus must therefore be how we can manage losses to be as low as practicably possible in a highly utilised network.

Our losses vision statement:

> **To proactively manage losses, minimising them where possible, to ensure that we deliver value to our customers alongside the action needed to facilitate net zero.**

[3] United Nations, For a Liveable Climate, net zero Coalition | United Nations[2092098774]

[4] GOV.UK, Plans Unveiled to Decarbonise UK Power System by 2035, Plans unveiled to decarbonise UK power system by 2035 - GOV.UK (www.gov.uk)

Net zero

In 2019, the UK amended the 2008 Climate Change Act, setting a legally binding target of net zero by 2050. There are now over 70 countries with net zero targets, representing 76% of global emissions. One reason to pursue net zero is to align with the 2015 Paris Agreement ambition to limit global warming to 1.5°C above pre-industrial levels.[3]

As a major UK business as well as a key actor in the energy sector, NGED has a significant role in enabling the net zero transition. There are two key elements to this: achieving our own business goal of net zero by 2043, and facilitating the necessary infrastructure to meet the government target of a net zero electricity system by 2035, as well as the wider 2050 net zero target.[4]

A net zero business

The parameters of our business net zero target have recently changed to become more stringent.

NGED is now striving towards a science-based target of net zero by 2043, to include scope 1 and 2 emissions.

This means losses will also be included in the net zero business target.

However, since the government has set the target for a decarbonised electricity system by 2035, the environmental cost of losses should decrease as the power system decarbonises.

There will of course always be a waste and financial cost to losses, which will require monitoring and management.

Our Environment and Innovation report can be found **here.**

A net zero facilitator

More significantly, NGED must consider its role in enabling the wider UK energy system to become net zero. This includes facilitating an increase in Distributed Generation (DG) as well as Low Carbon Technologies (LCT) like Heat Pumps (HP) and Electric Vehicle Charging Points (EVCP), all of which could increase levels of losses on the network.

As essentially wasted electricity resource, losses represent energy which might otherwise have been used elsewhere. Since 2014 and the publication of the Sohn Associates-Imperial report, NGED has sought to complete the 26 losses recommendations given.

We have outlined how we have met these recommendations in the appendices. However, we are now working in a different energy landscape and NGED will maintain a proactive approach in order to push towards a net zero power system. An important and ever-increasing part of this is flexibility, an approach which will have a significant impact on losses.

Flexibility

Under the Climate Change Committee (CCC), the Sixth Carbon Budget was passed into law in December 2020. Each Carbon Budget operates carbon limits under a five-year timeline, however, they also elaborate on the wider pathway that the UK needs to follow in order to reach net zero by 2050.[5]

The Sixth Carbon Budget outlined that electrification is the biggest change that lies ahead, with heating, transport and industry all expected to electrify to some extent. This, when combined with the transition to intermittent renewables means that flexibility will be crucial to the success of net zero. At present, National Grid Transmission and Distribution are both working to reinforce the network to provide the additional capacity that is needed to meet demand growth, which is expected to triple globally between 2022 and 2050 and to at least double in the UK.

It does not, however, make sense for the electricity distribution network to be reinforced to the capacity of peak demand. A key reason for this is that energy demand varies. These variations may be over time, throughout the day, and over different seasons, or they may vary due to other factors including price variations in global commodities or significant events such as the Covid pandemic.

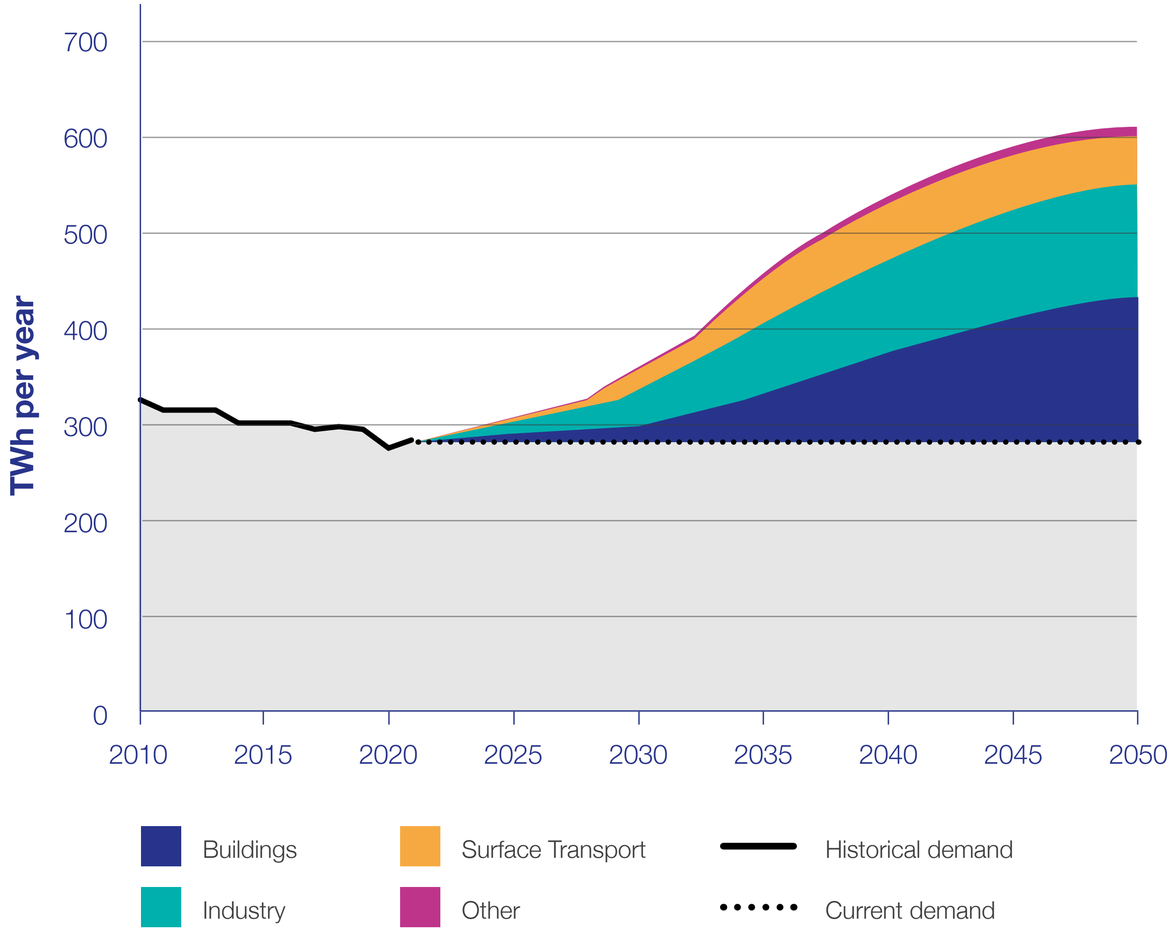
Furthermore, increased electrification and renewables cannot rely on the same energy systems and governance that were effective for easily stored vectors such as gas and petroleum. There is the need, therefore, for an adaptable network and this can be realised through flexibility.[7]

The rise of flexibility presents a significant opportunity but will increase losses, as loads will be higher for extended periods of time, until reinforcement is actioned.

This is where we must balance our four losses considerations: our customers; the financial cost; the environmental cost; and our business license obligations. This will be assessed using our cost-benefit analyses (CBAs).

Losses will still be kept as low as practically possible, but an effective losses strategy is no longer only about reducing losses but more about how to best manage losses.

Figure 1 – A graph to show the estimated growth in electricity demand by 2050[8]



[5] CCC, The Sixth Carbon Budget, The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf (theccc.org.uk)

[6] McKinsey & Company, Global Energy Perspective 2022, Global-Energy-Perspective-2022-Executive-Summary.pdf (mckinsey.com)

[7] ESO, Flexibility, Flexibility | ESO[2092098777] (nationalgrideso.com)

[8] CCC, 2023, Delivering a reliable decarbonised power system, Delivering a reliable decarbonised power system - Climate Change Committee (theccc.org.uk)

Making it happen

In order to make our losses vision happen, we need to be proactive in our approach to managing losses. A high level outline of how we will achieve this is detailed below:

Data

Our data team collects, processes, analyses and presents data from across the business.

Data gives us the knowledge that we need to make the best decisions for customers, business and the planet.

Research

We must use this data to continue to learn about losses, how we can manage them and maintain regular CBAs.

This includes research from various teams including Innovation and Distribution System Operator (DSO) as well as collaborating with academia, business and other Distribution Network Operators (DNOs) to find a balanced approach.

Create

From our learnings, we must ensure that we are creating loss inclusive policies. The assets that we are connecting to the network now are those which will be in place long after the 2050 net zero deadline.

We must therefore ensure that our policies are forward-looking and appreciate what our network may look like not just in five or 10 years but in 20, 30, 40 years time.

Whenever a new initiative is introduced in the Losses Strategy, the relevant Policies and Standard Techniques are updated.

Train

NGED is known for its excellence in training.

We must ensure that staff know and appreciate the importance of policy and the context behind its implementation and that staff are alerted to significant changes to our Losses Strategy and relevant policies.

Engage

We must listen to staff, customers and stakeholders to ensure that we continue to do the right thing for managing losses.

Understanding losses

As stated, losses are the difference between the electrical energy that enters the distribution network and the electrical energy that reaches the customer. These losses are typically classified as either technical or non-technical losses.

At present, losses are reported through the GB Settlements arrangements. This is a process used by suppliers to determine the amount they have to pay generators for their energy and is defined in the Balancing and Settlement Code (BSC). Distributors obtain information about the electricity entering and leaving the system by reference to the industry-standard data flows.

This is also how they bill suppliers for distribution charges.

The reported losses are the difference between the units entering and the units leaving the network. This is a large number and any inaccuracies or errors within this reporting methodology, such as meter reading problems or inaccurate records for unmetered supplies, will have a magnified impact.

Figure 2 – An illustration to show the impact of losses on energy received by the end-consumer

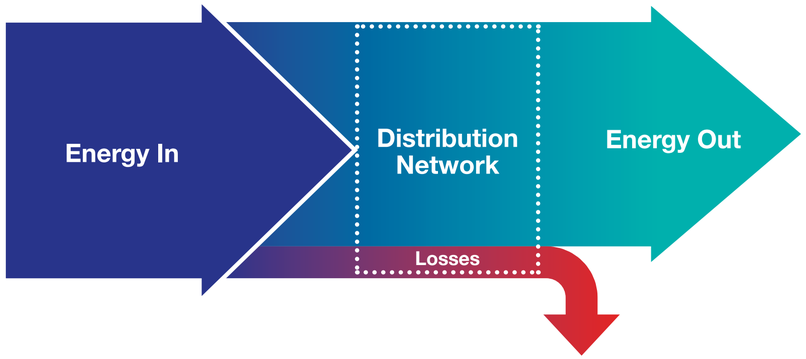
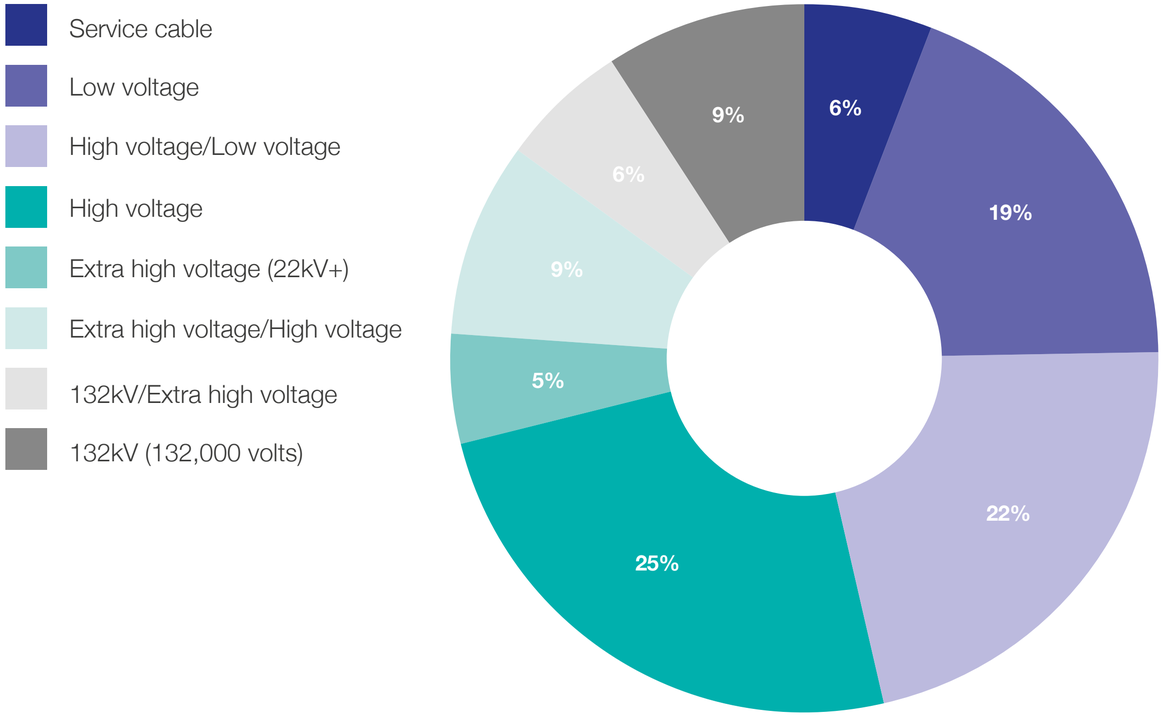


Figure 3, an extract from the Sohn Associates-Imperial report, shows a breakdown of GB distribution network losses, calculated using representative network models. Annual losses are estimated to be between 5.8% and 6.6% of energy delivered. Three quarters of losses occur in LV and HV networks, a consequence of higher current flows in these circuits.

Figure 3 – Percentage of losses found in electricity distribution networks.



Technical losses

The individual physics of our assets coupled with the square of the energy flowing through the network dictate the technical losses that will be seen on the network. The total amount of technical loss is made up of a fixed component (a function of the network itself, independent of the load on the network) and a variable component which is dependent on the level of load on the network. Variable losses may also be impacted by power factor, network imbalance and the effects of harmonics.

Fixed Losses

Some electrical energy is dissipated by network components and equipment such as transformers or conductors as a result of being connected to the network and being energised. Even if no power is delivered to customers, if the system is electrically energised then there will be losses. These losses take the form of heat and noise and are called ‘fixed losses’ or ‘no-load losses’, because they are independent of how much electrical energy the network delivers.

Most fixed losses can be exhibited within transformers from both the iron and copper losses. Besides inherent transformer losses, another source of fixed losses is the electrical insulation in network equipment. Imperfections in electrical insulation lead to the flow of very small currents across them in transformers, overhead lines, underground cables, and other network equipment.

These types of fixed losses are called ‘dielectric losses’ or ‘leakage current losses’ and vary with the voltage level, the physical wire diameter, and with weather conditions such as rain and fog.

While fixed losses do not change with current, they depend on the applied voltage. However, as the applied voltage is relatively stable while the network equipment is energised, they are essentially fixed.

Therefore, fixed losses are a function of the network itself and depend mainly on the number of energised components.

In general, fixed losses contribute roughly to between a quarter and a third of the total technical losses on distribution networks.

Variable Losses

The variable component of losses is created by the heating effect of electricity passing through the cables and windings. All conductors, whether windings in transformers; the aluminium or copper wires in overhead lines, underground cables, switchgear, fuses, or metering equipment, those various conductors all have an internal electrical resistance which causes them to heat up when carrying electric current.

As a result, the variable losses change as power flows increase and decrease (proportionally to the square of the current). Distribution networks experience a higher level of losses because at lower voltages a higher current is required to transmit the same amount of electric power. Additional factors such as the effect of network imbalance, harmonics, and power factor and power quality can also have an impact on variable losses, as they influence the value of the currents flowing through the conductors.

Additionally, variable losses are dependent on the length and the cross section of the network line as they vary in proportion to the conductor resistance. The resistance of a conductor decreases as its cross sectional area increases. Therefore, the effect of losses is reduced with larger cable sizes. A similar principle also applies to the variable losses in transformers, where the cross sectional area of windings, and the materials used in them, influence the variable losses.

In general, variable losses contribute roughly between two-thirds and three-quarters of the total power system technical losses. Solutions to high variable losses are to lower the system power flows and resistance of the transportation paths; reduce the utilisation levels of network assets and to upgrade assets. However, any capital investments required for loss reduction must show a positive lifetime CBA.

A significant change on the network which may affect variable losses is the rise of LCTs. This is because they are a disturbing load which generates harmonics. As a result, there is a requirement for customers/installers to either apply or notify for any such changes. The rise of LCTs and their effect on the network is being closely monitored in order to ensure that we are able to put any necessary mitigations in place.

Non-technical losses

Non-technical losses are caused by actions that are external to the power system. They refer to lost energy that is not directly related to the transportation of electricity and occur independently of the physical and technical characteristics of the network (technical losses). Cases of non-technical loss cannot be fixed by upgrading equipment or altering network design. Instead investigations, audits and collaborations with other bodies are required. These kinds of losses involve the abstraction of electricity with a loss of revenue to both the network operator and the supplier, and are categorised as follows.

Theft in conveyance

Theft and fraud generally account for the majority of non-technical network losses.

These are important challenges for the DNO, and require a concerted effort from a range of stakeholders to mitigate them.

It is difficult to gauge the exact extent of this type of loss as a large proportion of it is likely to go undetected.

When a property does not have a meter installed or a registered supplier, it is referred to as theft in conveyance.

Unmetered supply

Not all supplies in distribution networks are metered. There are many items of electrical equipment where it is neither practical, nor cost-effective, to measure energy consumption using conventional meters. In these circumstances, there are legitimate unmetered supplies whose energy demand is estimated rather than accurately metered. All unmetered connections can be treated as any other type of load, provided that it is registered, properly estimated and accounted for.

Moreover, customer-related unmetered connections (e.g. public lighting) or some of the DNO's own consumption (e.g. auxiliary services of substations) can be adequately contracted from an energy supplier and paid for by regular tariffs as any other normal consumption. Therefore, unmetered consumption, whether related to customers or the DNO, can be excluded from non-technical or technical losses, respectively, provided they are adequately contracted. Only the difference between the real and estimated unmetered consumptions is part of non-technical losses.

In the case of equipment such as street lighting, traffic lights and road signs it is not practical to meter every unit. Instead bills are estimated using the power rating of the equipment, the approximated time of use and the number of units. It is not uncommon for these estimates to be inaccurate or an inventory of equipment to be out of date.

In order to reduce these losses, DNO's must work alongside customers with unmetered supplies to improve the accuracy of inventories, to produce more accurate bills.

Regulation

External

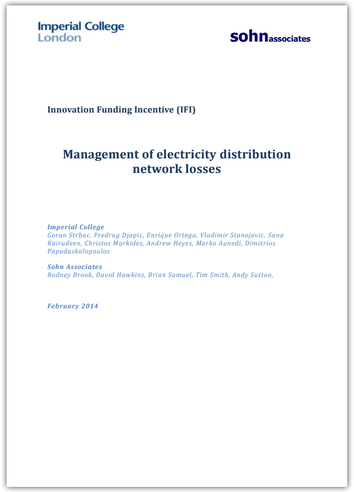
The key external regulation on Losses is governed by Ofgem and the Standard Conditions of the Electricity Distribution License. Within this, DNO obligations for Losses are defined under Condition 49 and are stipulated as follows:

- Maintain a Losses Strategy which is kept under review and modified from time to time.
- Ensure that losses are as low as is reasonably practicable.[9]
- Maintain an up-to-date cost-benefit analysis.
- Keep our website up-to-date with the latest Losses Strategy, as well as providing a record of any modifications made, and justifications for those changes.

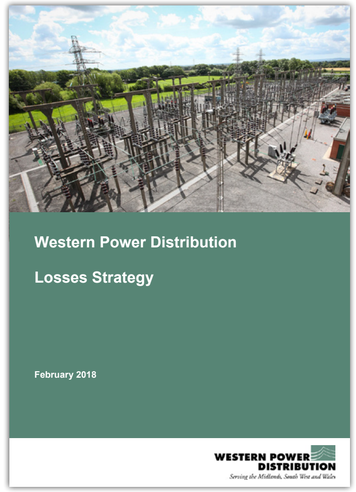
Internal

To ensure that we meet the external regulation set by Ofgem, since 2014 numerous reports including an annual Losses Strategy have been published. The reports below are those which relate directly to losses. This is not exhaustive as NGED takes part in numerous research and innovation projects where there are learnings for losses, although losses may not be the primary topic. There is more information on this research within the Innovation section.

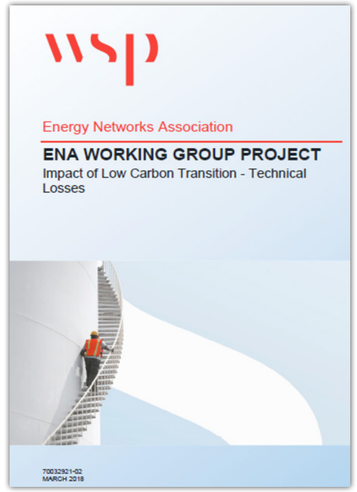
Figure 5 – An illustration to show NGED loss specific research projects



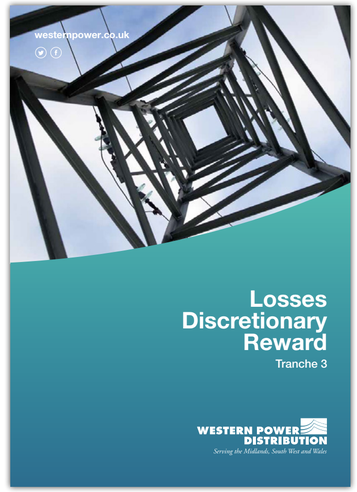
2014
Management of electricity distribution network losses (Sohn Associates Imperial Report).



2015
First Western Power Distribution (WPD)/NGED losses strategy.



2018
WSP Impact of the low carbon transition on technical losses report.

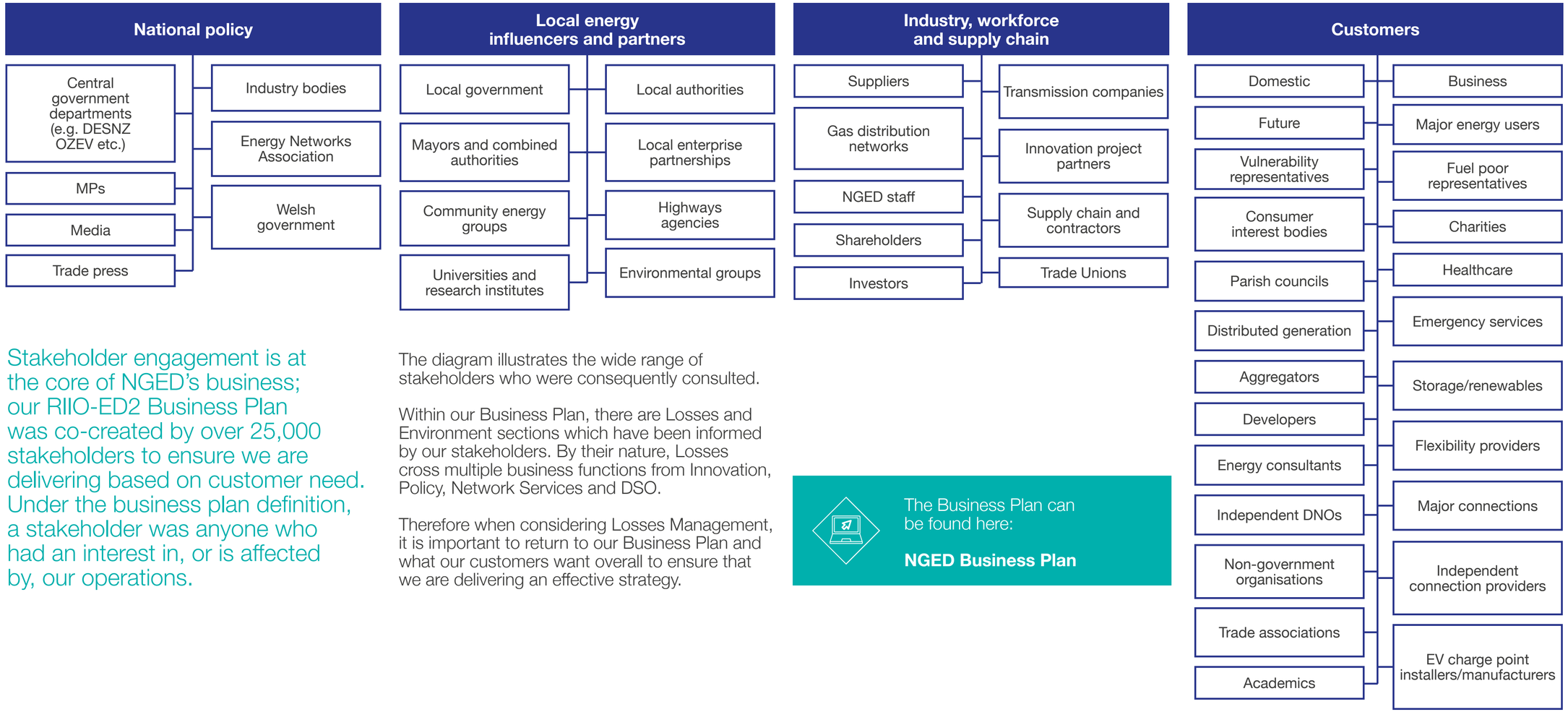


2020
WPD/NGED Losses discretionary award.

[9] Ofgem, Standard Conditions of the Electricity Distribution License, Condition 49, p.291

Business Plan stakeholder engagement

Figure 6 – An image to show the variety of stakeholders consulted in the RIIO-ED2 Business Plan



Stakeholder engagement is at the core of NGED's business; our RIIO-ED2 Business Plan was co-created by over 25,000 stakeholders to ensure we are delivering based on customer need. Under the business plan definition, a stakeholder was anyone who had an interest in, or is affected by, our operations.

The diagram illustrates the wide range of stakeholders who were consequently consulted.

Within our Business Plan, there are Losses and Environment sections which have been informed by our stakeholders. By their nature, Losses cross multiple business functions from Innovation, Policy, Network Services and DSO.

Therefore when considering Losses Management, it is important to return to our Business Plan and what our customers want overall to ensure that we are delivering an effective strategy.

The Business Plan can be found here:

NGED Business Plan

Losses stakeholder engagement

When the first edition of the Losses Strategy was published in 2014, NGED carried out a stakeholder engagement process to ensure that the Strategy was formed on the basis of what our stakeholders wanted.

Since then we have conducted four further formal stakeholder events to gather insight into losses.

Engagement has included input from more general stakeholders as well as stakeholders with greater technical awareness and a specific interest in losses.

General learnings were that although stakeholders were interested to hear progress, those with a greater technical awareness were more engaged with the topic of losses. Updates on innovation projects as well as collaborations with other DNOs were found to be effective ways of maintaining engagement. Based on feedback, we believe that the frequency of both stakeholder engagement events and the update of the Losses Strategy can be limited to whenever there is a significant update to discuss and report.

The feedback from these stakeholder engagement events has been used to inform our Losses Strategy and to ensure that we have considered stakeholder opinions and values in developing our strategy for managing losses.

Innovation

As stated in the Regulation section, since we began our Losses Strategies, we have conducted several research projects pertaining specifically to losses. The projects opposite are managed by our Innovation Team and are investigations into how we can use our network most effectively, which will often have implications for losses.

Funding has previously come from the Past Low Carbon Network Fund (LCNF) and Network Innovation Allowance (NIA). These have been used to construct NGED's Losses Strategies and will continue to inform future Losses Strategies. Furthermore, the information learnt from NIA funded projects such as the Losses Investigation are used to develop new standards for Business as Usual (BAU) implementation. This has resulted in NGED funding upgrades to the network which are outside of core RIIO-ED2 and innovation funding.

As well as the Losses Strategy, the Innovation Strategy shows a great deal of the work that NGED have carried out at an industry level. It highlights numerous interesting projects and initiatives, which help us to understand both what will and what won't help improve the efficiency and running of the network, as we transition towards net zero.

The ultimate goal is that successful innovation projects become BAU and a standard part of our policy.

The Innovation Strategy can be found here:

NGED Innovation Strategy

Sohn Associates-Imperial Report

What has been done?

The Sohn Associates-Imperial report was commissioned by NGED and UKPN under the Innovation Funding Incentive (IFI) to provide an assessment of all the ways in which losses could be reduced. The report was written in partnership by Sohn Associates and Imperial College London to provide an academic viewpoint on the range of the losses problem.

The scope of the investigation was very broad, as the intention was to develop multiple potential solutions to reduce losses. We have included the Sohn Associates-Imperial Report in both our list of internal losses reports and our list of innovation projects as it is the cornerstone of our Losses Strategy and Policy.

How does it help NGED manage losses?

Using a network modelling tool designed by Imperial College London and intelligent forecasting for future demand, potential approaches to reducing losses were identified. The report looked at possibilities such as heat recovery, active network management and asset replacement. These possible approaches led to 26 recommendations for DNOs to consider.

These recommendations have formed the basis of the NGED losses strategies and have been addressed over the course of RIIO-EDI. As we move forward into RIIO-ED2, there is scope for further research in order to assess whether the dramatic changes in the cost of electricity and how much losses cost means that replacements which were previously not economically justifiable now might be.

This will ensure that NGED stays up to date with the best ways of managing losses and demonstrates our continued committed to reducing losses in all areas that it makes sense to do so.

Losses investigation

How does it help NGED manage losses?

This project was funded by the NIA and attempted to better understand technical losses on the LV and HV networks. It also sought to determine the minimum information required in order to accurately predict losses. A previous piece of work, the LV templates project, created an overall profile of a distribution substation but didn't obtain data on individual flows. The Losses Investigation therefore set out to monitor all the in-feeds and out-feeds to a case study area of the network. From this, a losses model was created to test understanding against the measured values. The idea being that if we can understand the effects of different loading types and patterns on the various networks, we will then be able to predict and estimate the effect on losses in parts of the network where there is limited data.

What has been done?

For HV feeders, one minute resolution logging equipment was installed at the primary substation on the source breakers of the sample feeders, and at each load connection point along the feeder. This provides comprehensive information about the power flows for a complete HV feeder, allowing actual losses to be assessed for a specific feeder. For LV feeders, one minute resolution logging equipment was installed at distribution substations, monitoring the entry/exit of power onto LV feeders with one minute data being logged at all connection points along the sample LV feeders. As with HV feeders, this instrumentation provided comprehensive information about power flows for a complete LV feeder, and allows actual LV losses to be assessed for a specific feeder.

The LV field work was carried out on the Isle of Man in collaboration with Manx Utility Authority, as NGED are not allowed access to individual customer data in their own regions. The development of the HV feeder loss estimation process has been completed and feeder-specific annual mean loss estimates have been generated for three of the four regions of NGED.

Findings and learning from the HV loss estimation work can be found **here**.

Innovation

New and Retrofit Housing Projects in Wales

What has been done?

NGED are working with Pobl Living, Sero Energy and Loughborough University at Parc Eirin in Tonyrefail, South Wales, where 225 new homes are being built, each installed with PV, ES, HP, EVCP and smart white goods. The devices are connected to an Energy Management System (EMS) or Program Logic Controller (PLC) and the homes are supplied via three phase service cables and dark fibre. To date, Loughborough University have modelled the estate and provided NGED with analysis of the site.

In a second project, NGED are again working with Pobl and Sero in Blaen-y-maes, Swansea where circa 700 homes are being modified and retrofitted with PV and ES, with each device being connected to a PLC. Each home will be supplied via three phase service cables and some on street EV charging. In the same format as the Parc Eirin project, the long-term goal is that NGED will be able to monitor the substation which supplies the 11kV LV mains feeders and each home. It is expected that the data and outcomes will be very similar to Parc Eirin.

In both projects the data gathered will help produce updated ADMD information which will be required for designing future networks to the correct standard, such as the potentially improved diversity of three phase versus single phase EVCPs. This data has also fed directly into Innovation projects including the Equitable Novel Flexibility Exchange (EQUINOX) which seeks to trial how the dispatch of smart heat could benefit the network and consumers.

How does it help NGED manage losses?

By monitoring each home and the 11kV mains feeders in both projects, a comparison can be drawn between the benefits of three-phase compared to single phase, which was monitored in the Isle of Man Losses Investigation. NGED envision that the new and retrofitted homes would benefit from a reduction in losses in the LV service cables, LV mains cables and in the 11/0.4kV unit substation which supplies the housing estate. It was expected that three phase service cables would reduce imbalanced loads in the LV mains cables and on the 11/0.4kV transformer. This was confirmed by Loughborough University in their analysis.

As the utilisation of EVCPs and heat pumps increase, the trend towards loss reduction is likely to increase as each EVCP is a three phase device and thus does not cause phase imbalances. These projects have helped develop an understanding on the effective design of three phase housing in order to ensure that export and import via different phases do not cause imbalances. There is the potential for further modelling and innovation to develop from these projects.

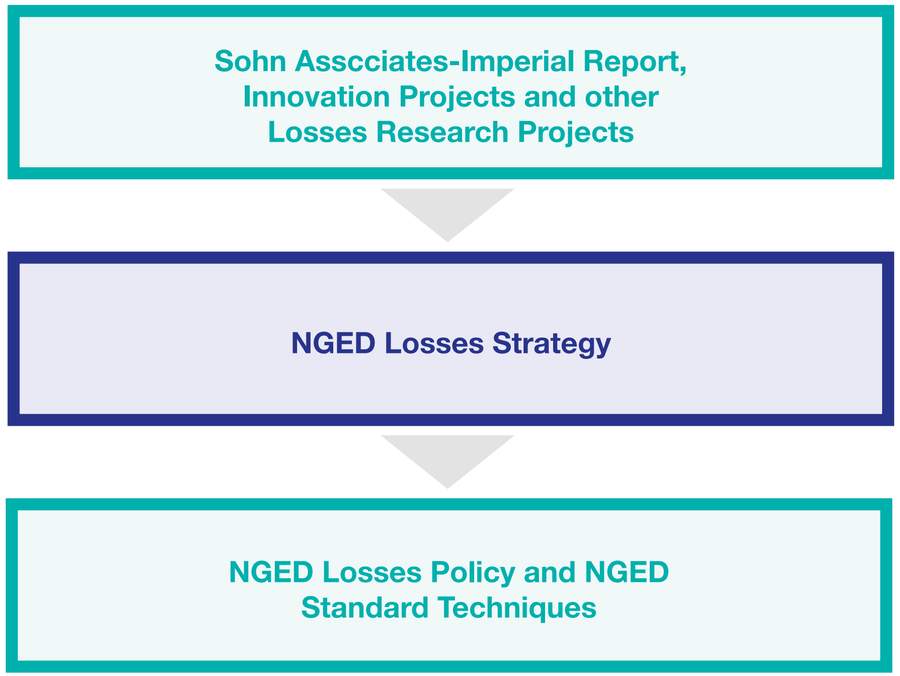
Policy and actions

Policy implementation

As stated, the Sohn Associates-Imperial Report, along with other research and Innovation projects, has enabled us to develop well-informed Losses Strategies.

Our Losses Strategy in turn enables us to develop effective internal policies which deliver the necessary action. The graphic below demonstrates the process of transitioning from research to policy to implementation into business-as-usual activities.

Figure 7 – A flowchart to show the process from research to BAU activities



Policy actions

Since the publication of the Sohn Associates-Imperial Report, NGED has completed a work package to ensure that we have researched, evaluated and, if appropriate, actioned the 26 recommendations that were outlined in the report. Below is a summary table of the recommendations.

This outlines what measures we have adopted, reviewed or discounted in the 9 years since the report was published, as well as the current status of the recommendation. Keys of what is meant by the categories within 'Action Since 2014' and 'Current Status' are detailed below. The table gives a high level summary of the progress made. For specific actions that have been taken please see the appendices.

Action Since 2014 Key:	Current Progress Key:
Discounted After review, it has been determined that under current conditions it is not viable/effective to fulfil the recommendation.	**Discounted** After review, it has been determined that under current conditions it is not viable/effective to fulfil the recommendation.
Reviewed When reviewed, there was a potential benefit to the recommendation but a barrier/challenge means that adoption has not yet been possible.	**Research** There has been significant changes in the context of the recommendation which means that previous action is no longer relevant and further investigation is needed as to what course of action to take.
	Consider There is a challenge which has prevented us from making this recommendation BAU. It should therefore be reviewed at regular intervals.
Adopted Measures or actions have been taken based on the recommendation given. However, there may still be scope to expand or develop the action taken.	**Completed** This recommendation has been fully acted upon and no further work is possible.
	Continue This recommendation has been acted upon but is something that we can review at intervals and continue to work on.
	Expand Action has been partially executed but it may be that it could be expanded. For example, it has been applied at one voltage level but not another.

Policy and actions

Recommendation No.	Category	Recommendation	Action since 2014	Current status
1	Network modelling and analysis	Establish the capability of modelling and evaluating loss performance of present and future networks, under different future development scenarios.	Adopted	Continue
2	Power factor	Conduct systematic data gathering associated with power factors to develop a business case for power factor correction.	Adopted	Continue
3	Phase imbalance	Conduct further research on imbalance and develop policies to avoid excessive imbalance in the future.	Adopted	Continue
4	Non-diversified loading in loss calculations	Recognise the inaccuracy of loss calculation using half-hourly data at the edges of the LV network when conducting network studies.	Discounted	Discounted
5	Peak demand	Assess opportunities for alternative smartgrid techniques.	Adopted	Continue
6	Voltage control	Assess opportunities for active voltage control in reducing losses.	Adopted	Continue
7	ANM	Consider losses when evaluating ANM solutions.	Adopted	Continue
8	Loss inclusive network design	Review cable and overhead line ratings to ensure that future loss costing has been included.	Adopted	Continue
9	Early replacement of assets	Factor in the need for resources to facilitate the early asset replacement of transformers.	Adopted	Continue
10	Low-loss transformers	Invest in low-loss transformers.	Adopted	Continue
11	Transformer density	Consider installing additional distribution transformers.	Discounted	Discounted
12	Rationalising HV and EHV voltage levels	Reconsider long-term distribution network design in light of LCTs. Consider a strategic view of future voltages and include consideration of losses in decision-making.	Adopted	Continue
13	Cable tapering	Review LV tapering policy.	Adopted	Completed
14	Loss inclusive network design	Review network modelling and analysis tool and capabilities for ability of applying new policies and processes relating to loss-inclusive network design.	Adopted	Expand
15	Heat	Learn from other DNOs, National Grid and the rest of Europe on waste heat recovery installations.	Reviewed	Consider
16	Heat	Conduct an innovation project, building from the learnings in the Sohn Associates-Imperial report.	Reviewed	Consider
17	Heat	Maintain an awareness of the potential for heat recovery when planning the installation of EHV transformers and consider more systems where recovered heat could be of commercial use.	Discounted	Discounted
18	Heat	Further work on heat storage may be integrated with work on recovery of heat to improve the economics of more basic heat recovery systems.	Reviewed	Discounted
19	Business Plans	Develop a loss-inclusive network design strategy which should include modelling capability for 'what-if' questions.	Adopted	Continue
20	Business Plans	In collaboration with DESNZ* and Ofgem, a common basis could be developed by DNOs in relation to losses.	Reviewed	Research
21	Long term electricity and carbon prices	Establish a basis for assumptions on future electricity costs and carbon prices.	Reviewed	Research
22	Monitoring and reporting	Develop more accurate means of measuring and reporting of distribution network losses.	Adopted	Expand
23	Monitoring and reporting	Review the disparity in losses between loss reporting from DUKES** and Ofgem which may cause a distorted view of GB DNO losses.	Reviewed	Discounted
24	Monitoring and reporting	Take opportunities to influence loss reporting in other countries to ensure GB DNO loss management performance i.e. presented accurately.	Reviewed	Research
25	Heat	In collaboration with industry, government and regulators consider developing regulatory and commercial frameworks to facilitate loss-generated heat schemes.	Reviewed	Consider
26	Barriers to implementation	Consider 'stress testing' losses strategy to show that it is capable of delivering an economic level of losses based on avoid loss valuation, engineering costs and future network demands.	Adopted	Continue

*Department for Energy Security and net zero **Digest of UK Energy Statistics

Key policy summaries

Within NGED there are numerous policies in place to ensure that we are managing losses. Our Losses Strategy aims to give an overview of some of the policies that we have in place to facilitate losses management.

Greater network visibility - creation of DSO

In recent years, significant work has been undertaken to understand losses on the network. One example is the aforementioned Losses Investigation project.

One of the main aims of this project was to see whether we could monitor losses on the LV and HV networks before extrapolating this and using it to estimate losses across all feeders. This has proved incredibly useful but we continue to seek greater understanding of losses on the network, particularly in light of the development of Low Carbon Technologies and Distributed Generation.

In recent years, the Distribution System Operator (DSO) team has emerged and expanded.

This team is responsible for many of the areas which are necessary for the transition to net zero, including anticipating future demand and generation on the network, as well as the operation of flexibility.

With the coordination of DSO, Data and Digitalisation and Network Services, our understanding of losses on the network continues to grow.

Across the business there is a growing demand for network visibility and teams are working together to deliver this need which will enable us to better understand the actions needed to manage losses effectively.

Positive CBA outcomes and oversized assets

As outlined in the 'Making it Happen' section of the report, we conduct CBAs which are based on an Ofgem established methodology. If the outcome of the CBA for any particular asset type is positive, then we are able to replace or upgrade assets ahead of schedule.

By conducting our CBAs, we have been able to take the following actions/ interventions:

- A minimum LV and HV cable cross sectional area (CSA) of 185mm^2 when used as a mains cable.
- A minimum service cable CSA of 25mm^2 Cu or 35mm^2 Al.
- A minimum ground mounted distribution transformer size of 500 kVA.

As part of our RIIO-ED2 Business Plan, under the Engineering Justification Papers (EJP) we also successfully applied for funding to:

- Have a minimum pole mounted distribution transformer size of 25kVA (single phase) and 50kVA (three phase).
- The proactive replacement of all ground mounted transformers manufactured before 1958.
- Increase the minimum size of LV and HV cable CSA to 300mm^2.

Through the forecasting and future energy system modelling of the DSO team, we know that in many situations, it makes sense to deploy oversized assets. Whilst oversized assets cannot be deployed to the detriment of other assets, our teams are able to factor losses into their planning decisions at all voltage levels. This forward-looking approach is crucial as the assets that we install now will often have a lifespan of between 40 and 80 years, meaning they will be in place far beyond 2050.

It is also the civil-works including digging and roadworks which represent the largest proportion of our upgrade costs rather than the capacity of the equipment itself.

It therefore makes sense to upsize assets where we know there will be future constraints. These issues all feed into our loss-inclusive design policy which is about factoring in the cost of losses as we are designing the network rather than at a later date.

Thinking ahead - three phase and the rise of LCTs

As previously outlined in the 'net zero' section, we are anticipating significant growth in the demand on our network. At a LV level, key reasons for this will be the electrification of heating and transport with government reports including the Heat and Buildings Strategy and the Decarbonising Transport plan, both outlining growth in heat pumps (HP) and electric vehicles (EV). By 2030, government targets state that there shall be 600,000 HP installations per year, whilst in 2022 we processed over 30,400 domestic EV charger installations.[10]

One of the policies that we have introduced at a domestic level is to install three phase service cables and three phase meter boxes as standard. This is an essential part of facilitating net zero, as having an electric vehicle charging point (EVCP) and HP installed represents a significant demand pressure on service cables.

Properties will generally need to have three phase installed to have an EVCP and HP in order to avoid a single phase being overloaded, creating excessive losses on the service cable or causing imbalance on the network. By creating a policy whereby three phase service cables are installed as standard, we are building a network which will be suitable for many years to come and avoiding additional work in the future. It also ensures that we are minimising the amount of losses at the service cable level, which the Sohn Associates-Imperial Report attributed to 6% of total losses.

In order to support the growth of LCTs and Distributed Generation on our network, we have developed specific polices and standard techniques so that we can integrate best practice with BAU.

For example, where there is any new or substantially modified connection to a domestic property, a 32A EVCP will be included with the customer installation. We will continue to evolve and develop these policies as the adoption of LCTs and Distributed Generation grows and accelerates.

[10] HM Gov, 2021, Heat and Buildings Strategy, HM Government – Heat and Buildings Strategy (publishing.service.gov.uk)

Future policies and conclusions

Under RIIO-ED2, NGED will continue with the policies outlined above which are effective and balanced mechanisms to support our mission to 'proactively manage losses'.

Using the table above, we are able to identify which recommendations from the Sohn Associates-Imperial we should prioritise for further investigation or immediate policy change and which we may need to consider further.

As network visibility improves and we continue to increase the amount of monitoring on the network, we will focus our efforts on managing the parts of the network where losses are highest and where our CBAs are most likely to be positive.

As the energy network is changing and evolving rapidly, losses has become an iterative process.

That is to say that we must continuously review and monitor our work on losses so as to ensure that we are managing them effectively.

A recommendation which might not have been viable a few years ago, may now be worth re-investigation and equally a policy that may have made sense at one point, may no longer be adding value.

This relates back to our original vision statement for losses, to be proactive in their management and to ensure that the policies that we have in place deliver best value to our customers and support the UK on its way to net zero.

We hope that this has helped you, the reader, understand NGED's approach to losses and we look forward to working with you and the wider energy sector to continue to develop knowledge of losses and the best ways of managing them.

Appendices - appendix 1 - detailed policy actions

Recommendation No.	Category	Recommendation	Action since 2014	Current status	Our actions
1	Network modelling and analysis	Establish the capability of modelling and evaluating loss performance of present and future networks, under different future development scenarios.	Adopted	Continue	• The DSO team is responsible for the Distribution Future Energy Scenarios (DEFES) which, using the same four scenarios as the Electricity System Operator (ESO) in their Future Energy Scenarios (FES), offers an insight into what demand and generation may be on the distribution network in the future. This is reassessed every year and gives an insight into the factors that may affect losses. • Modelling for losses is now BAU up to and including 11kV. In addition, the upgrades to policy including increasing underground cable size and removing cable tapering means that these upgrades are now largely uniform. • At HV/EHV, PSS/E can be used to produce loss calculations. At HV/EHV, all designs are bespoke. NGED has therefore created templates which can be used for generation connections in order to incorporate losses impacts.
2	Power factor	Conduct systematic data gathering associated with power factors to develop a business case for power factor correction.	Adopted	Continue	• Since 2010, WPD has been including an excessive reactive power charge for HV and LV half hourly metered, via the Use of System Charge, with a power factor of 0.95 lagging. • A digital project, Distributed Power Flow, is in development. This project would run analysis on the network and show if any analogue information was at abnormal levels. Similarly, the Integrated Network Model is a product that will interface with multiple systems and in the future will be able to calculate the network usage from analogue data. As a business, we are committed to developing ways to systematically gather data from our network and our Digital Grid team are a key part of making this happen.
3	Phase imbalance	Conduct further research on imbalance and develop policies to avoid excessive imbalance in the future.	Adopted	Continue	• NGED has completed several projects where imbalance has been investigated/addressed. These include the LV Templates Project, which used monitoring to create ten distinct LV templates to help understand how the rise in LCTs could cause imbalances in different parts of our network, as well as the Losses Investigation project where the feeders and services on the LV and 11kV systems were fully monitored and subsequently assessed for imbalance by Loughborough University. • As LCTs are increasing, we are paying close attention to the issue of imbalance. One ongoing example of this is EQUINOX, an innovation project which is looking at technical and commercial considerations for a network with the widespread adoption of heat pumps.
4	Non-diversified loading in loss calculations	Recognise the inaccuracy of loss calculation using half-hourly data at the edges of the LV network when conducting network studies.	Discounted	Discounted	• Due to the increase in underground cable size and the removal of cable tapering, upgrades are now uniform across NGED. This means that it is no longer necessary to recognise the inaccuracy of loss calculation at the edges of the LV network.
5	Peak demand	Assess opportunities for alternative smartgrid techniques.	Adopted	Continue	• With a growing amount of data available on the network, our network is able to be increasingly ‘smart’. Some of the characteristics we consider as part of a smart grid include two-way communication, self-monitoring, self-restoration and islanding. With regards to reducing peaks, smart grid techniques could be applied to enable demand side activities including peak shaving and shifting, voltage control, network configuration, and time-of-use tariffs. • In the last two years we have seen significant growth in the Flexibility function of our DSO. A considerable amount of work has been invested in order to create a liquid market. This means that we are now at a point where we can begin to use flexibility and demand side response in earnest. We anticipate that the use of smart grid techniques to facilitate this, as well as improved coordination between different energy actors like ESO will increase substantially during RIIO-ED2.

Appendices - appendix 1 - detailed policy actions

Recommendation No.	Category	Recommendation	Action since 2014	Current status	Our actions
6	Voltage control	Assess opportunities for active voltage control in reducing losses.	Adopted	Continue	• Our Innovation Team have done several projects to consider the opportunities for active voltage control in reducing losses. Two are listed below: Q-Flex: Investigating whether we can deliver load related efficiencies on the network by using the reactive power capability of existing generators. Early results suggest that use of reactive power may be able to create some efficiencies but more work is needed to understand the commercial viability. EQUILIBIRUM: This project was completed in 2019 and the focus was to balance voltages and power flows by using the three methods of enhanced voltage assessment, system voltage optimisation and flexible power link. The main goal is to understand how we can develop an active electricity network rather than a passive one, which will better facilitate intermittent DG and LCTs.
7	ANM	Consider losses when evaluating ANM solutions.	Adopted	Continue	• ANM will be a vital way for us to manage our network in the future. There are currently multiple primary substations which are being developed for this purpose and two which are in active use. These will develop rapidly in the next two years. As with all our network design, we have visibility of how losses may be affected which allows us to make informed decisions about losses and the future of the network.
8	Loss inclusive network design	Review cable and overhead line ratings to ensure that future loss costing has been included.	Adopted	Continue	• We have separate policies for each of the voltage levels detailing the factors that govern the rating of underground cables. These include maximum depth of lay; Soil thermal resistivity Tr (g); Ground ambient temperature (oC); Air ambient temperature (oC); Cyclic loading conditions; Maximum permissible conductor temperature; Proximity to other cables. Cable and overhead line rating have been reviewed at all voltage levels since the publication of the Sohn Associates-Imperial Report. • We also have a current innovation project, Running Cool, which is seeking to understand how we can create a new ANM architecture which could help avoid curtailment. This would be achieved by a system of short term dynamic OHL ratings (informed by real-time conductor temperatures). The project therefore seeks to view cable and overhead line ratings in a more dynamic way, whereby we can consider the cost of losses as well the factors above to make the most informed choices for the network.
9	Early replacement of assets	Factor in the need for resources to facilitate the early asset replacement of transformers.	Adopted	Continue	Since 2014, we have been undertaking the: • Pro-active replacement of distribution transformers for those with increased efficiencies; • Purchase and installation of single-phase, 25kVA 11kV amorphous pole-mounted transformers (PMTs); • Oversizing of ground-mounted transformers and pole-mounted transformers per annum; • Intervention of losses design on new installations of distribution transformers and underground cable; • Review of NGED policies to ensure losses are a priority consideration for transformer investment decisions.
10	Low-loss transformers	Invest in low-loss transformers.	Adopted	Continue	• NGED has always purchased low loss transformers since pre-privatisation and all primary and ground mount transformers meet or exceeded the Euro Eco design. In 2018 WPD purchased circa 100 amorphous pole mounted single phase transformers to install and monitor.
11	Transformer density	Consider installing additional distribution transformers.	Discounted	Discounted	• After the Sohn Associates-Imperial Report, NGED employed Sohn Associate to undertake a redesign trial of recommendation 11 using the NGED new standard of large cross sectional area cables. Part of this was to understand the effect of additional distribution transformers on losses; the result was that additional transformers did not reduce losses.
12	Rationalising HV and EHV voltage levels	Reconsider long-term distribution network design in light of LCTs. Consider a strategic view of future voltages and include consideration of losses in decision-making.	Adopted	Continue	• NGED has adopted a loss-inclusive network design policy which includes the installation of oversized asset to ensure that our network will still be suitable in decades to come. • We have created a DSO team. A major function of this team is to consider the long-term future of the network and to ensure that it is ready for what is forecasted – growth in LCTs, growth in DG and increased demand.

Appendices - appendix 1 - detailed policy actions

Recommendation No.	Category	Recommendation	Action since 2014	Current status	Our actions
13	Cable tapering	Review LV tapering policy.	Adopted	Completed	• Since 2012 NGED have installed link disconnecting boxes between LV substations on non-tapered LV mains cables, thereby providing the possibility of mesh connections and back feed potential under fault conditions. In addition since the start of 2015 WPD has amended the design policy and now all designs of the LV mains underground cable network are designed without cable size tapering. Networks shall be planned using either 185mm^2 or 300mm^2 Wavecon cables with an ambition for 300mm^2 to be installed as standard during RIIO-ED2. This recommendation has therefore been fully implemented.
14	Loss inclusive network design	Review network modelling and analysis tool and capabilities for ability of applying new policies and processes relating to loss-inclusive network design.	Adopted	Expand	• Since the publication of the Sohn Associates-Imperial report in 2014, the DSO team has been created. This team models the network, forecasts future constraints and demand on the network, and considers how we can use flexibility to defer reinforcement to save customer money. • At LV, cable size has been increased to 300m^2 with no cable tapering. At EHV level, NGED uses PSS/E which can create loss calculations. Furthermore, whilst all EHV designs are bespoke NGED has created template solutions for generation customers which incorporate the losses impacts. • This recommendation is listed under expand as it is part of our strategy to evolve our DSO team and ensure that we have the best modelling systems in place to ensure that we can continue to apply loss-inclusive network design to our policies.
15	Heat	Learn from other DNOs, National Grid and the rest of Europe on waste heat recovery installations.	Reviewed	Consider	• NGED maintains an interest in waste heat recovery solutions as part of our Innovation work. Since the publication of the Sohn Associates Report, we have conduced further studies into waste heat recovery but haven't found a way to use waste heat in a way that is both technically and commercially viable. • We will continue to monitor waste heat recovery which occurs in other DNOs, National Grid and the rest of Europe.
16	Heat	Conduct an innovation project, building from the learnings in the Sohn Associates-Imperial report.	Reviewed	Consider	• NGED maintains an interest in waste heat recovery solutions as part of our Innovation work. Since the publication of the Sohn Associates Report, we have conduced further studies into waste heat recovery but haven't found a way to use waste heat in a way that is both technically and commercially viable. • The Innovation team will continue to research interesting and applicable projects which may include how we can use waste heat recovery on the network.
17	Heat	Maintain an awareness of the potential for heat recovery when planning the installation of EHV transformers and consider more systems where recovered heat could be of commercial use.	Discounted	Discounted	• NGED maintains an interest in waste heat recovery solutions as part of our Innovation work. Since the publication of the Sohn Associates Report, we have conduced further studies into waste heat recovery but haven't found a way to use waste heat in a way that is both technically and commercially viable. • More specifically, commercial use was discounted based on insights from the Centre for Sustainable Energy (CSE). NGED did also consider the possibility of a mini district heating system based on its grid transformer sites, however, the distance between buildings and transformers made it unviable.
18	Heat	Further work on heat storage may be integrated with work on recovery of heat to improve the economics of more basic heat recovery systems.	Reviewed	Discounted	• NGED maintains an interest in waste heat recovery solutions as part of our Innovation work. Since the publication of the Sohn Associates Report, we have conduced further studies into waste heat recovery but haven't found a way to use waste heat in a way that is both technically and commercially viable.
19	Business Plans	Develop a loss-inclusive network design strategy which should include modelling capability for 'what-if' questions.	Adopted	Continue	• The DSO team is responsible for the Distribution Future Energy Scenarios (DEFES) which, using the same four scenarios as the Electricity System Operator (ESO) in their Future Energy Scenarios (FES), offers an insight into what demand and generation may be on the distribution network in the future. This process and subsequent decision-making methods ask the recommended 'what-if' questions and as a result NGED's DEFES includes a fifth scenario – NGED's Best View.

Appendices - appendix 1 - detailed policy actions

Recommendation No.	Category	Recommendation	Action since 2014	Current status	Our actions
20	Business Plans	In collaboration with DESNZ* and Ofgem, a common basis could be developed by DNOs in relation to losses.	Reviewed	Research	• Since 2014, NGED has engaged on the topic of losses both internally and externally and has been a part of several collaborative efforts with other DNOs as well as supporting key actors including the ENA, DESNZ and Ofgem. We continue to use their guidance on losses to help inform our own Losses Strategy.
21	Long term electricity and carbon prices	Establish a basis for assumptions on future electricity costs and carbon prices.	Reviewed	Research	• NGED carry out the Ofgem Cost Based Analysis (CBA) with any Losses project to prove the case for the particular project. NGED use the Ofgem supplied value of £48.42/MWh in the CBA calculations. In addition, when converting carbon NGED use the DEFRA carbon conversion factors for both UK electricity (kWh) and Transmission & Distribution (kWh). The 2019 values for example are 0.2556 kgCO2e for Electricity and 0.02170 KgCO2e for Transmission & Distribution. We must also report losses as part of our SBT. • In light of recent dramatic changes to electricity prices, NGED is considering whether to review the assumptions that we should make for future electricity costs and carbon prices.
22	Monitoring and reporting	Develop more accurate means of measuring and reporting of distribution network losses.	Adopted	Expand	• NGED undertook the Losses Investigation project in conjunction with the Isle of Man, Manx Utility Authority and Loughborough University. One of the key issues identified is that measuring losses is difficult because the level of losses that are being looked for are small (circa 7%) and the losses on the Smart meter for example are -3.5% to +2.5%. This is also shown by the ENA Losses Measurement Report. • NGED is in the process of developing several digital projects which will enable us to better monitor analogue data and therefore losses. Examples include the Distributed Power Flow Project and the Integrated Network Model which both look at monitoring analogue data and how we can integrate this information into our current systems. • More generally, we have increased the amount of monitoring on our network which means that over the next few years we will have a greater amount of data available to us on where losses are occurring in the network.
23	Monitoring and reporting	Review the disparity in losses between loss reporting from DUKES** and Ofgem which may cause a distorted view of GB DNO losses.	Reviewed	Discounted	• Currently DNOs and IDNOs are treated differently. DNOs are required to reduce losses but IDNOs are not. Where the IDNO network connects to the host DNO network at the Point of Common Coupling, no metering is allowed therefore all the losses incurred on the IDNO network are all added to that particular host DNO network. This then shows a discrepancy on that particular host DNO feeder.
24	Monitoring and reporting	Take opportunities to influence loss reporting in other countries to ensure GB DNO loss management performance i.e. presented accurately.	Reviewed	Research	• The Sohn Associates-Imperial report was presented to an international conference in Helsinki in 2016 and more recently a limited selection of the Innovation and D&D teams went to a conference in Rome to present on research pertaining to the efficiency of our network. As a part of National Grid, we anticipate that Losses knowledge sharing between UK transmission as well as the network of the North East of the US will be beneficial.
25	Heat	In collaboration with industry, government and regulators consider developing regulatory and commercial frameworks to facilitate loss-generated heat schemes.	Reviewed	Consider	• NGED maintains an interest in waste heat recovery solutions as part of our Innovation work. Since the publication of the Sohn Associates Report, we have conduced further studies into waste heat recovery but haven't found a way to use waste heat in a way that is both technically and commercially viable.
26	Barriers to implementation	Consider 'stress testing' losses strategy to show that it is capable of delivering an economic level of losses based on avoid loss valuation, engineering costs and future network demands.	Adopted	Continue	• The work of the DSO is very relevant to this where the team are constantly forecasting and thinking about future constraints; the costs of managing these; and whether any change to losses can be justified.

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Revision history

This section was introduced in the RIIO-ED2 edition of the Losses Strategy in order to document new changes.

Our obligation under the License Conditions is as follows:

Part B: The Distribution Losses Strategy

49.4 The licensee must maintain a Distribution Losses Strategy and must keep it under review and where necessary modify it from time to time to ensure that it remains:

(a) calculated to ensure that Distribution Losses are as low as reasonably practicable; and

(b) based upon an up-to-date cost-benefit analysis.

49.5 The licensee must maintain on its Website:

(a) an up-to-date version of its Distribution Losses Strategy; and

(b) an up-to-date record of any modifications that it has made to its Distribution Losses Strategy, including explanations of:

(i) the reasons for and effects of each such modification; and

(ii) how, in the licensee's opinion, the modification better facilitates the requirements of paragraph 49.4 compared with the previous version of the Distribution Losses Strategy'

The below table will be updated to show future reviews and updates.

Document revision and review table

Date	Modifications made	Reason for and effect of modification	How modification meets point 49.4
December 2023	Document updated with NGED branding.	National Grid purchase of WPD has been completed and is now NGED.	Shows that Strategy is up-to-date and offers reader clarity.
	Document reviewed and updated with latest strategic thinking.	Reviewed and updated the version that was published in 2022.	Ensures that we have considered how to keep Losses 'as low as reasonably practicable' and 'based on an up-to-date CBA'.
	Revision history added to document	Modifications were previously stated on the website but by providing a Revision History in the document itself, we are able to better document changes over time.	As it develops, the Revision History will show how we are keeping losses 'as low as reasonably practicable' as well as any changes to our CBA.
	New sections on Net zero, Flexibility, Policy and actions.	Provide a greater amount of context and to make it easier to understand how and why particular actions have been taken.	Ensures that we are thinking holistically about how sector changes may affect our work on losses.

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December 2023. BLU27547/PR