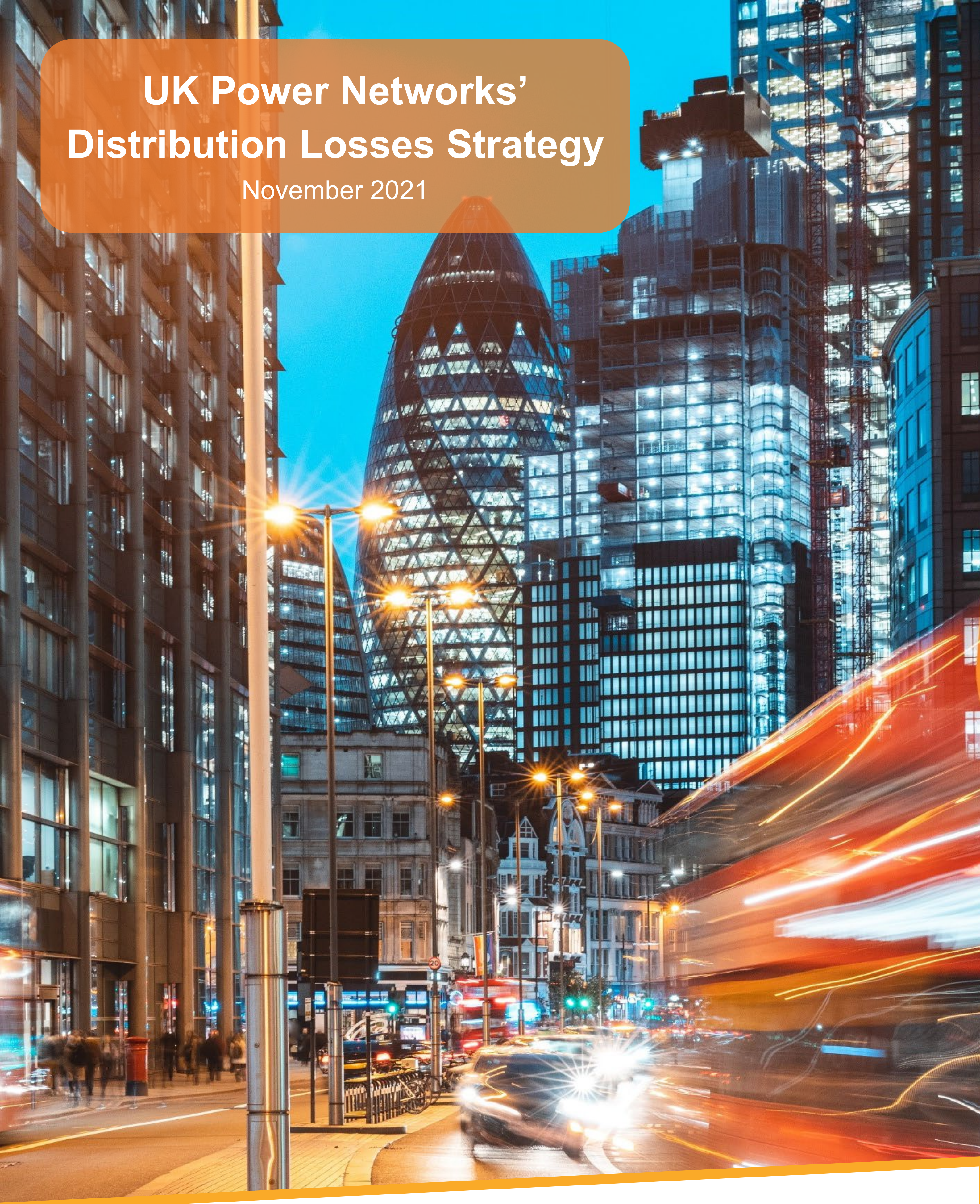
UK Power Networks' Distribution Losses Strategy

November 2021



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UK Power Networks

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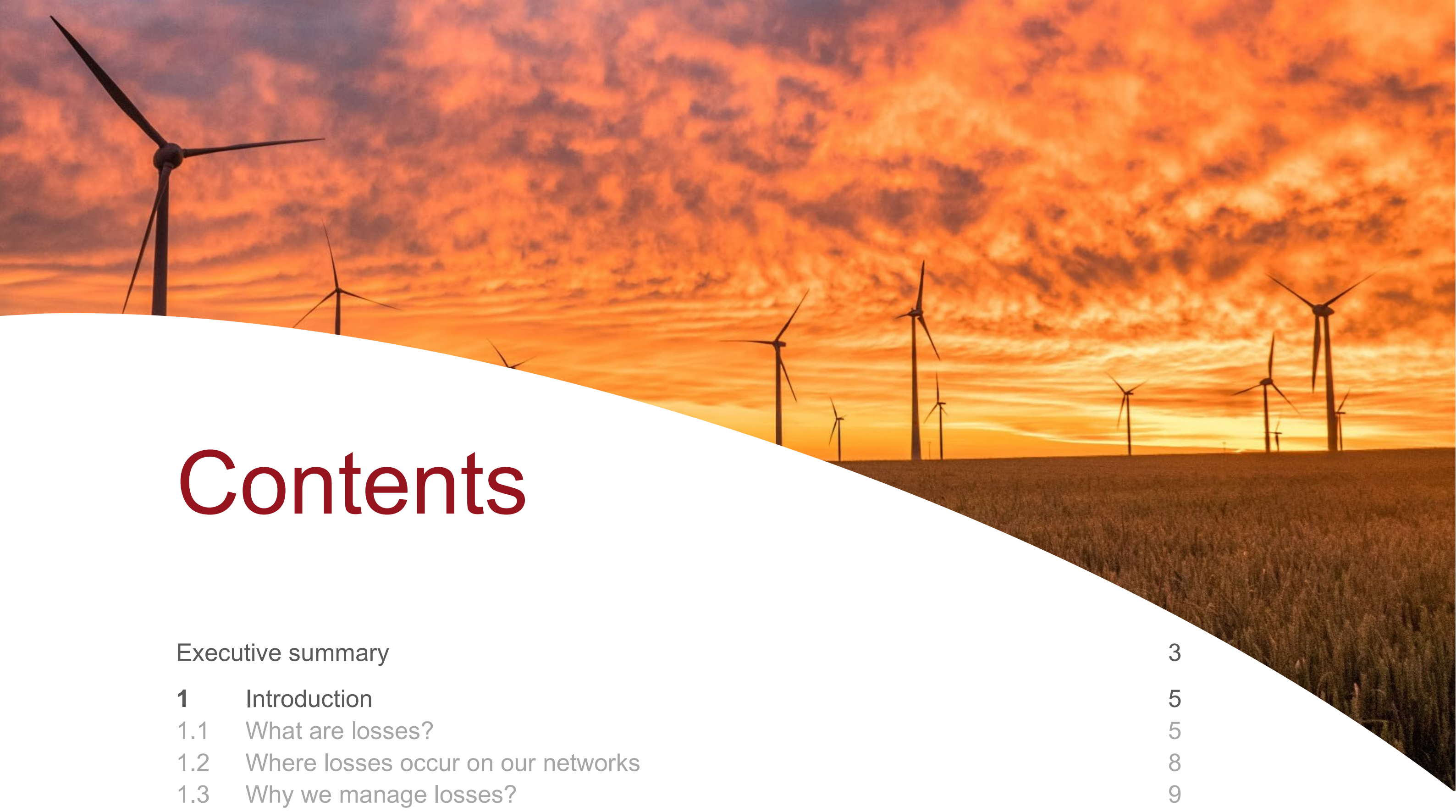

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Executive summary

Electrical losses are an inevitable consequence of transferring electricity across the distribution network. Losses have a significant financial impact on customers as well as an associated environmental cost. As part of UK Power Networks' wider company vision to be a Respected and Trusted Corporate Citizen, and in line with our statutory and licence obligations, we have prepared this strategy document describing what we are doing to manage losses on our distribution network. We discuss the technical state-of-the-art understanding of network losses and how we have contributed to that learning.

Throughout RIIO-ED1, we have continued to identify new ways in which we can reduce losses on our network. UK Power Networks was the first DNO to establish a dedicated losses engineering capability at the beginning of the RIIO-ED1 (2016 – 2023) period to drive losses improvement projects. We are proud for our achievements to date including the pioneering demonstration of the Mobile Asset Assessment Vehicle (MAAV) technology that was used in our London network in a UK-first to deliver electricity losses and health and safety benefits. We are delighted to see other DNOs such Scottish Power Networks to adopt the learnings and including the MAAV technology into their RIIO-ED2 plans.

Our strategy for RIIO-ED2 is to embed these in our wider work programme while we continue to explore new technologies and approaches. Where the initiatives we identify throughout the period demonstrate a long-term benefit to customers, we will adopt them to achieve further reduction in losses.

Our Distribution Losses Strategy sets out our vision and objectives for energy loss management:

- Maximise the amount of energy we save every year for our customers.
- Integrate losses management into all our existing processes and systems.
- Engage with stakeholders to promote loss-inclusive design, collaborate, share knowledge, and in this manner, enable other DNOs to produce similar benefits for their customers.

Over RIIO-ED1 we have already delivered tangible loss reductions for customers. Initiatives already implemented include:

- Upgrading LV and HV cables by installing larger cross-section conductors in underground feeders, with a cost benefit approach driving a focus on main lines given the higher currents involved yield higher benefits in terms of losses reduced.
- Installing amorphous steel pole-mounted transformers (50 kVA), with a cost benefit approach to target a reduction in constant losses.
- Optimising distribution transformer sizes to benefit losses using a cost benefit approach.
- Normal Open Point optimisation (HV).
- Surveyed central London with Mobile Asset Assessment Vehicle (MAAV) to identify Contact Voltage Losses (CVL).

We anticipate that the following initiatives will also be implemented before the end of RIIO-ED1:

- Upgrading 33kV and 132kV EHV Cables with a cost benefit approach could drive significant benefits. The replacement of these assets requires bespoke costs and benefit analysis to be carried out on case by case basis.

- Installing amorphous steel pole-mounted transformers (25-200 kVA) with a cost benefit approach to target a reduction in constant losses.

Our plans for RIIO-ED2 are designed to deliver our Distribution Losses Strategy objectives, as outlined above, however, the following key themes form a common thread:

- Introduce efficiencies by optimising our asset replacement and touching the network once.
- Exploiting new sources of data including smart meters and new ways of analysing it.
- Dynamic management and control of networks based on the granularity that smart meter data brings.
- Whole system approach to understanding and managing losses. We endeavour to stretch the influence of our strategies and actions across the boundaries of our networks to benefit the wider interests of the UK and its people.
- Optimising our physical networks and the efficiency of individual assets embedded in these networks.
- Maximising the loss reduction opportunities from using flexible distributed generation and in moving to a distribution system operation model.
- Effective collaboration with our peers, across the energy system and internationally.
- Continuous learning and collaboration.
- Robust processes and better decision-making tools to deliver benefits in the shortest time possible.
- Work driven by a genuine concern for society and the environment.

Historically, we predominantly designed the network with thermal and voltage considerations in mind to deliver the lowest-cost solutions to customers. Following LDR-driven research, we now understand that we can achieve the lowest long-term cost by designing for losses instead. In our proposed arrangement, customers pay more upfront, but receive better value for money in the longer term.

It should be noted that in order to make better use of available capacity and keep costs low to the customers, network utilisation must be increased, which in turn may increase losses. This strategy aims to minimise the increases in these losses by using more energy efficient materials, larger capacity circuits and equipment, optimising network topology and tackling latent CVL losses in our LV underground cable network.

In summary, in this revision of our Losses Strategy we have applied the learning and experience we have gained during the price control to date. We have updated the strategy based on the RIIO-ED2 proposals and will be further updated when the results of the consultation period have been received.

1 Introduction

Losses can never be eliminated completely and the management of losses requires long-term investment and focus to make a significant impact. Losses are complex and require extensive analysis in order to implement cost-effective measures.

A loss-mitigation gain is a reduction in losses as a result of an action taken by UK Power Networks. They are a saving in energy relative to what would have happened if we had not undertaken that action. These actions benefit our customers in the form of lower electricity bills.
This Losses Strategy and the actions embedded within it is reviewed periodically to ensure that it remains current and continues to incorporate new technologies and approaches.

1.1 What are losses?

Distribution network losses are the difference between the electrical energy that enters our distribution network and the energy that is delivered to our customers. Losses are the unavoidable consequence of transferring electricity across the network; but can be minimised using appropriate strategies, assets, and systems.

Our losses strategy combines the following two distinct areas:

- Technical network losses
- Non-technical losses

1.1.1 Technical losses

Technical losses are inherent to the distribution of electricity and cannot be completely eliminated. As energy passes through our network a small proportion of this is lost as heat. Technical losses can be categorised into fixed losses and variable losses. Fixed losses exist whenever the network is energised or “switched on”. Variable losses arise when energy is transferred over the system and are a non-linear function of the system utilisation. The level of the technical losses within a system will depend on several factors, but for a typical distribution network around 30% of its technical losses will be due to fixed losses and around 70% will be due to variable losses[1].

These categories are explained hereby:

Technical losses types	
Variable or Copper (Cu) losses:	These losses are due to the electrical resistance of conductors and hence have a non-linear (quadratic) relationship with the current passing through the conductor.
Fixed or Iron (Fe) losses (also known as ‘no load’ losses):	These are incurred as a result of the magnetising forces involved in transforming electricity. They are present and virtually constant so long as the transformer is energised, even when supplying no load.

[1] https://www.ofgem.gov.uk/sites/default/files/docs/2003/01/1362-03distlosses.pdf

Contact voltage losses (CVL):	Contact voltage losses are a new category of losses, discovered by UK Power Networks through our Losses Discretionary Reward (LDR) work. Contact voltage losses occur due to defects in low voltage cables. These defects can be caused through aging, chemical corrosion or third-party damage. They cause energisation of the metallic cable sheaths with consequent losses through heating. Contact voltage loss magnitudes are considerable, but typically masked by existing load as they are not significant enough on their own to operate protective devices.

Technical losses also include the energy involved in running network ancillary equipment such as transformer cooling fans and pumps and other auxiliary energy supplies directly associated with electricity distribution (battery charging, substation heating, lighting, Air Blast Circuit Breaker air compressors, tunnel cooling systems, etc.). We are increasingly deploying metering equipment at our substations so we could account for this type of losses.

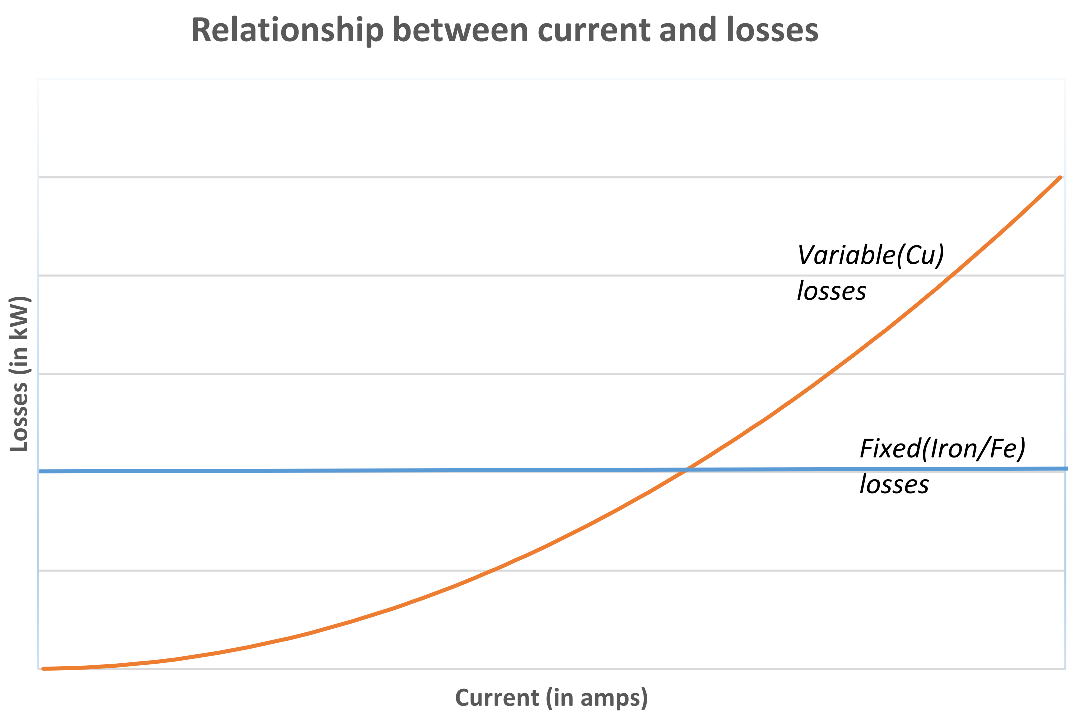

Figure 1 - The relationship between current and losses is non-linear: as current increases the losses increase by the square of the current, i.e. a quadratic relationship. Fixed losses are related to magnetising forces and remain the same regardless of current.

1.1.2 Non-technical losses

Non-technical losses arise where electricity is delivered and consumed but that usage is not properly measured and accounted for. Electricity theft is a key component of non-technical losses and adds to the costs borne by legitimate customers; it may additionally create dangerous situations risking fire or electrocution. Also contributing are data issues with unmetered supply equipment inventories and certain records held by electricity suppliers.

To explain these broad categories in more detail:

Non-technical losses types	
Theft from suppliers	This arises where the occupier seeks to avoid charges by tampering with their meter, installing hidden bypasses or simply wiring their consumer unit directly to the cut-out assembly.
Theft in conveyance	These are situations where a premise has no supplier associated, illegal services are installed, or existing services are split and self-energised with rogue meters or direct-to-main connections.
Under-declaration of unmetered supplies	Certain items such as streetlights, advertising hoardings and telecommunications infrastructure are not individually metered since they represent modest and predictable loads[2]. Energy bills are based upon the declared inventory of equipment connected to our network and electricity may be "lost" where the customer has not kept up to date a list of what is installed.
Supplier Data Issues	Accurate accounting of energy depends on suppliers ensuring that they have the correct registration and energisation status for every customer.

[2] http://www.legislation.gov.uk/uksi/2001/3263/contents/made

1.2 Where losses occur on our networks

Losses on our distribution networks are estimated[3] to occur on the following component parts of our networks:

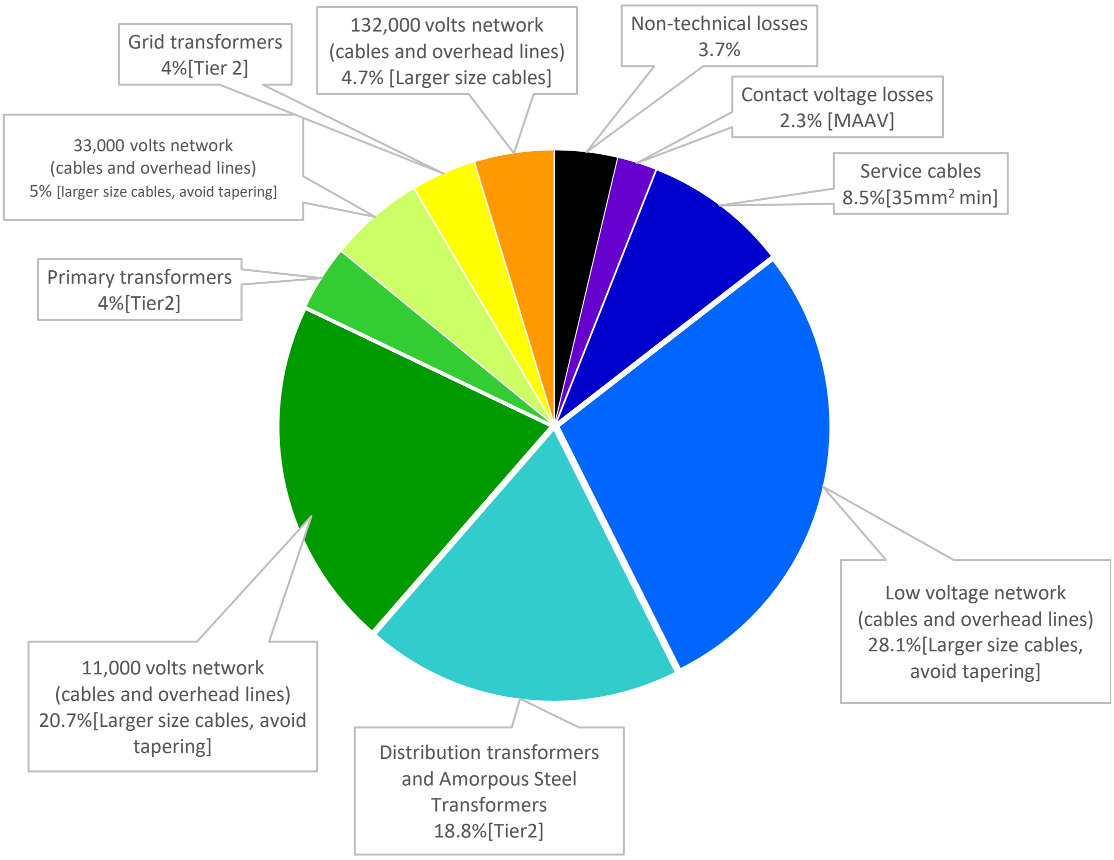

Figure 2 - Estimated breakdown of distribution losses at UK Power Networks. A detail explanation of our solutions (presented in brackets [ ] above) is given in section 3.

Technical losses represent the highest stake, 96.3%, while non-technical represent only 3.7% of the total estimated losses.

Figure 3 shows the losses on our network over the RIIO-ED1 period compared to the total amount of energy distributed. It is useful to note that during the regulatory year 2020/21, the total demand of the GB network was reduced compared to previous years because of COVID-19.

[3] https://www.ukpowernetworks.co.uk/losses/static/pdfs/strategies-for-reducing-losses-in-distribution-networks.d1b2a6f.pdf

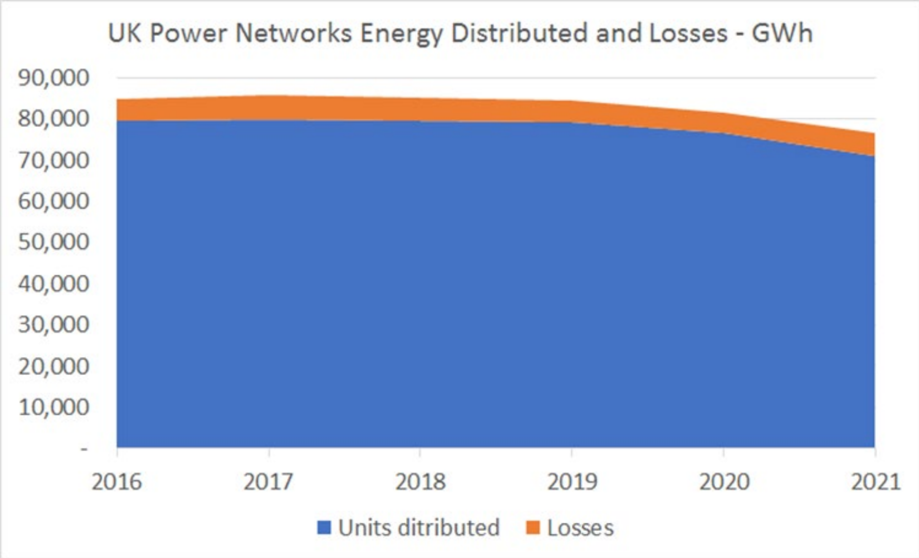

Figure 3 - Comparison between the energy distributed to the customers and energy losses in RIIO-ED1

1.3 Why we manage losses?

The electricity distribution network, taken as a whole, represents one of the largest consumers of energy in the country.

The benefits of loss mitigation are wider than the direct financial benefit of the energy saved. When losses are reduced:

- Less generation is required to sustain losses, and therefore reducing overall carbon footprint and cost;
- The ability of our network assets to deliver useful energy is maximised; and,
- The cost of connecting to our network is reduced as less reinforcement is required.

We have a social responsibility to reduce the financial cost of these losses to our customers and a moral duty to reduce the impact that losses have on the wider environment. We have legal obligations imposed by legislation (such as section 9 of the Electricity Act) and licence conditions set by Ofgem, our regulator. We also need to anticipate the likely impact of the transition to a low carbon economy.

Financial: The financial impact extends beyond the additional generation required to feed losses. Reducing losses to the most economic level maximises the available capacity of plant and equipment to deliver useful energy (i.e. rather than supply losses) so keeping costs to our existing and future customers low. If losses are minimised, then lower levels of capital and operational expenditure will be incurred in providing, maintaining and reinforcing generation, transmission and distribution assets. There is also a benefit in terms of avoided material extraction, manufacturing and construction costs through not having to install generation to feed losses.

Environmental: Carbon emissions attributed to losses from distribution networks across the UK represent approximately 1%[4] of the national total. Reducing losses to the most economic level reduces the amount of generation required purely to supply network losses. A disproportionate level

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[4] In 2020 losses represented 8% (26.4 TWh of the total 330 TWh) of total annual demand according to the Digest of UK Energy Statistics: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/736152/Ch5.pdf.

26.4 TWh equates to 4.76 $MtCO_2e$ of a UK total of 414.1 $MtCO_2e$ or 1%. See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/972583/2020_Provisional_emissions_statistics_report.pdf and https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2011 of less efficient (and generally higher carbon footprint) generation will be called upon to compensate for variable losses at times of peak demand. Reducing this reliance on fossil-fuelled power stations, therefore, has a direct carbon benefit. Even though the carbon intensity of electricity is reducing the environmental impacts extend to issues such as visual amenity or preventing land from being used for other purposes.

Regulatory: At the start of the RIIO-ED1 regulatory price control Ofgem recognised that a keyway to improve the efficiency of network infrastructure is to reduce its losses. This aligns with the Energy Efficiency Directive (EED) which imposes a set of binding measures to help EU nations reach energy efficiency targets[5]. In addition, sections of the Electricity Act and our Distribution Licence Conditions require us to develop and maintain an efficient, co-ordinated and economical system ensuring losses are as low as reasonably practicable.

Future: As we move to a low carbon economy, the electricity demand on our network is expected to grow as a result of the ongoing electrification of heat and transport[6]. Therefore, the need for efficiency grows ever more important given the non-linear relationship between load growth and losses (i.e. losses = I^2R: where I represents current and R represents the resistance of the conductor) as seen in Figure 1. Moreover, with the increase in demand, we require an increase in the number of deployed transformers. Therefore, it will become more important to reduce fixed losses.

[5] EED target originally set in 2012 requiring a 20% reduction by 2020. This was updated in 2018 to a 32.5% target by 2030.

[6] National Grid System Operator: Future Energy Scenarios. http://fes.nationalgrid.com/

1.3.1 Regulatory and Legal Framework

UK Power Networks operates within a regulatory and legal framework, which it needs to abide to when delivering the Losses Strategy. The key components of this framework are the regulator Ofgem, the Electricity Act 1989, environmental legislation, and the LDR.

1.3.1.1. Ofgem

Ofgem is the Office of Gas and Electricity Markets. They are a non-ministerial government department, and their principal objective is to protect the interests of existing and future customers of electricity and gas. They are independent of government, the energy industry and other stakeholders.

1.3.1.2. Electricity Act 1989 & Distribution Licence

We hold three distribution licences enabling us to distribute electricity in compliance with the Electricity Act.

Within the distribution licences, the terms relating to losses are:

- Section 9 of the Electricity Act 1989 that requires us to "develop and maintain an efficient, co-ordinated and economical supply of electricity distribution"; and
- Condition 49 of our Licence Conditions that requires us to "to ensure that Distribution Losses from our Distribution System are as low as reasonably practicable, and to maintain and act in accordance with our Distribution Losses Strategy".

1.3.1.3. RIGs & Environment Reports

Under our licence conditions we are required to report annually to Ofgem on the progress of our losses activities through the Regulatory Instructions and Guidance (RIGs) report.

The reporting guidelines require that only activities where all or some of the costs that are incurred relate to managing losses are reported. We refer to these activities as "reportable".

Other activities undertaken often reduce losses, but no additional costs were incurred that relate to losses. We refer to these activities as "non-reportable".

Although in the RIGs report we only state losses savings attributable to "reportable" activities we also calculate losses savings for "non-reportable" categories wherever possible. Both categories are stated in our Annual Environment Report[7] which is available on our website[8].

1.3.1.4. Losses Discretionary Reward

The Losses and Discretionary Reward (LDR) is a regulatory mechanism aimed at encouraging and incentivising DNOs to undertake additional actions to better understand and manage electricity losses.

The LDR required a submission of three tranches where we explained the latest losses environment over the eight years of RIIO-ED1 and we included lessons learnt and stakeholder feedback. The LDR process together with the knowledge gained from various innovation projects have enabled us to undertake a number of significant initiatives, see section 3.1.

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[7] https://www.ukpowernetworks.co.uk/internet/en/about-us/documents/Annual%20Environment%20Report%202019-20%20v1.0.pdf

[8] https://www.ukpowernetworks.co.uk/internet/en/about-us/sustainability/

2 Our approach to managing losses

2.1 Summary of our strategy

Our Losses Strategy was first published in 2014 and sought to provide a comprehensive overview of the technical and non-technical losses on an electricity network, and suggested approaches that could be taken to minimise these losses. Over the course of RIIO-ED1, our Losses Strategy has evolved, notably thanks to the LDR process. This 2021 version captures a comprehensive view of the latest changes and progress.

Our strategy for managing losses includes four main activities:

1. Understand Losses	2. Plan and Design	3. Build and operate
Implement top-down and bottom-up approaches to improve our understanding of losses on our network, where they are most prevalent, what causes them and how they can be best determined, quantified, managed and finally optimised.	Test outputs from Phase 1, design solutions, quantify benefits, identify timescales, confirm cost-efficiency and prioritise options. Adapt policies and standards where required.	Deploy the changes on the network to manage technical and non-technical losses, according to the plan developed in Phase 2. Complete BAU economic assessment of the changes implemented to validate assumptions and track benefit.
4. Stakeholder Engagement		

2.2 Understand Losses

Our strategy is primarily supported by the understanding of losses on our network. The reduction of losses and the optimisation of our network efficiency requires a deep understanding of both technical and non-technical losses, to assess the impact of various factors and target relevant areas for improvement.

By definition, losses cannot be measured and can only be:

- Calculated via the difference between infeeds and consumption,
- Or modelled.

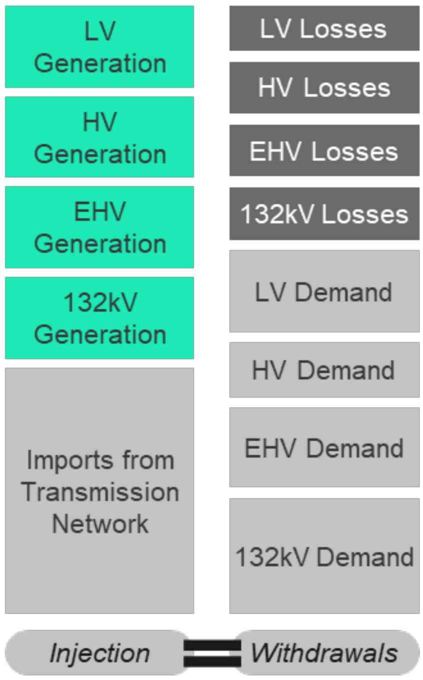

Figure 4 - Losses are equal to the difference between total generation and total consumption

We are continuously working on improving our understanding and assessment of losses, through a three-step approach:

1) **Top-Down approach**: calculation of total losses at each voltage level using energy flows, and modelling of losses with simple polynomial functions (see Figure 5), which can be refined with local case studies (e.g., on rural vs urban assets, LV feeders, feeders with embedded generation or heat pumps etc.)

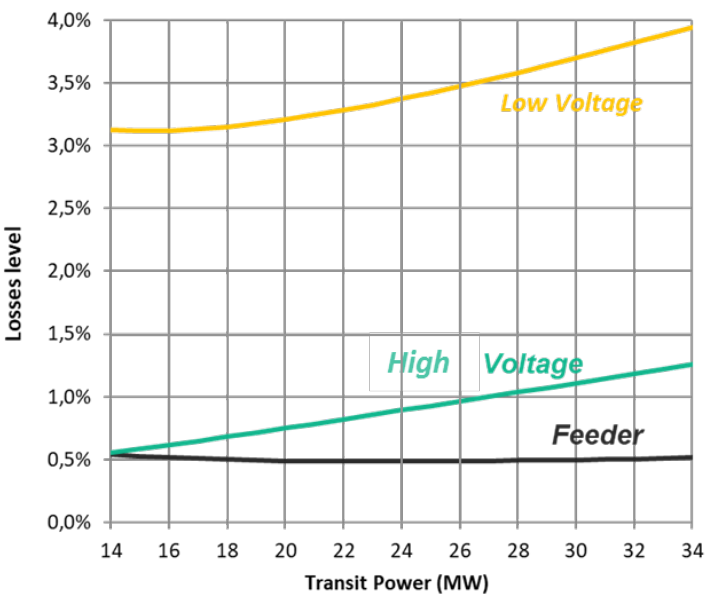

Figure 5 - Examples of losses models
Source: Sia Partners, Study from European DSO

2) **Bottom-up approach:** calculation of losses at various network levels by stacking and subtracting users' consumption and generation. Levels of the network where this can be performed depend on the analogues deployed, down to individual users thanks to smart meters. This can also be conducted on restricted scopes if monitoring equipment is deployed on specific areas only, to work on high losses areas for example. By difference, this can also allow to refine losses models on other areas, where analogues are not available.

3) **Consolidation of the two approach**: combining the top-down and bottom-up results to refine models and assumptions.

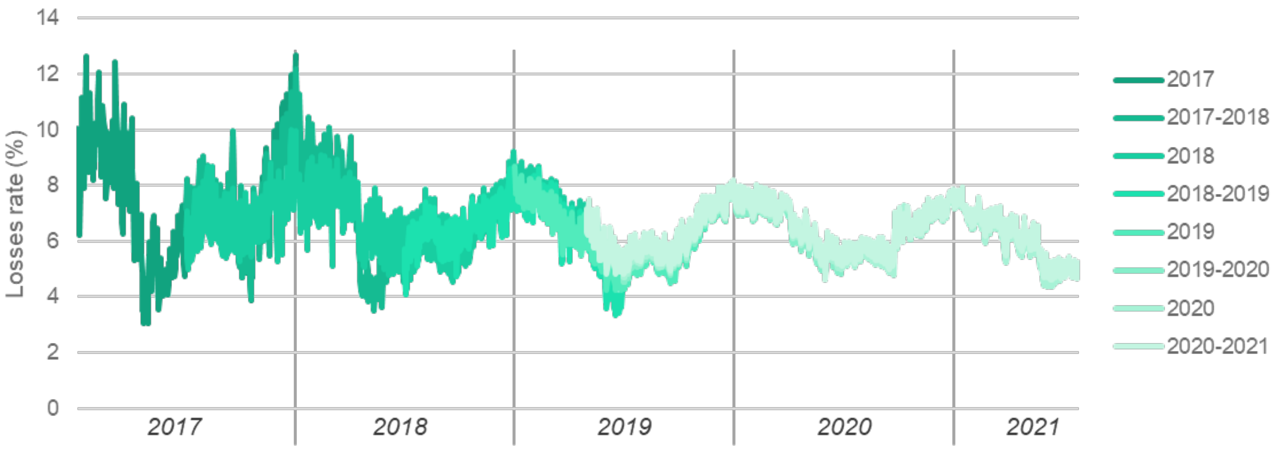

Figure 6 - Example of improvement in losses calculation thanks to smart meter data
Source: Sia Partners, Study from European DSO

2.3 Plan and design

Accurate understanding of losses allows us to simulate outcomes of losses activity.

When considering a potential losses activity, we

- test outcomes with scenario modelling,
- and make sure that it is cost effective. To do this in a consistent manner we use the Cost Benefit Analysis (CBA) method developed by Ofgem for RIIO-ED1. The CBA puts monetary values to the costs and benefits and these are then considered over the life of the asset or activity. The CBA shows if and when an activity becomes cost-effective. This CBA process allows a consistent and comparable analysis of potential activities.

Once an activity has been modelled, analysed and deemed cost-effective we capture the volume of the activity, costs and benefits and make changes to our Engineering Standards[9].

Changing our Engineering Standards is an effective means of ensuring that high volume activities have loss inclusive design built into their design considerations by default.

For some low volume but high-cost activities, such as major projects replacing power transformers, we undertake site-specific losses calculations and assessment of the options. For these major projects we have well-established BaU processes to review project options, designs, costs and progress. We have extended this

[9] G81 standards: https://g81.ukpowernetworks.co.uk/

governance process so that it captures the value of losses to ensure that losses are included as one of the many considerations in our major projects.

2.4 Build and operate

Once designed and tested, actions are finally deployed and if relevant integrated into BaU activities.

Benefits and cost assessment are performed regularly to validate assumptions and improve further actions.

As part of Regulatory Instructions and Guidance (RIGs) annual report, we submit the losses snapshot and commentary (E4 table). We have developed a robust process and governance to gather the data required from our core systems, model and quantify the losses, and prepare the regulatory outputs.

2.5 Stakeholder engagement

We recognise that effective engagement is a two-way dialogue that benefits both parties. As such we continuously seek input from our stakeholders to inform our decisions and evaluate our performance, while encouraging the sharing of knowledge to help shape industry-wide understanding of ‘best practice’ for managing electricity losses with the aim of helping the UK meet its carbon objectives. At the 3 November 2020 Sustainability Critical Friends Panel, it was noted that we can, and should, do more on controllable losses such as unmetered supplies in substations (which are considered separately). It also noted that forecast reductions in carbon emissions are largely driven by the decarbonisation of the grid and that the associated losses reductions should not count towards our work to reduce losses.

Key elements of our stakeholder engagement consist of:

- **Building best practice:** Over the course of RIIO-ED1 we have collaborated with our peers internationally and nationally to understand actual and best practice in other networks. We have also formed productive partnerships with top universities and consultancies to discover, research and validate new and emerging ideas, technologies and strategies for reducing losses on our and others’ networks. We actively participate in bi-monthly meetings at the ENA technical losses task group comprising other DNOs, TOs and the TSO. This task group seeks to encourage discussion, sharing of knowledge and to help build consensus around best practice for the benefit of customers. It has played an important role in helping us decide to follow a CBA-driven approach for losses in RIIO-ED2. We will continue to collaborate with our peers at this forum to develop an Engineering Recommendation for Losses; and

- **Knowledge sharing with the public:** we have created an interactive losses website[10] that aims to explain distribution losses to a wider audience. On this website we also publish the reports we have produced or commissioned so we can share our learning with others. We continue to work with academia, equipment manufacturers, suppliers, customers and the wider industry at every opportunity.

- **Knowledge sharing with the other DNOs:** We are collaborating and sharing our knowledge with the other DNOs to maximise the value for society. For example, Scottish Power Energy Networks are considering the use of MAAV to survey their network in order ￼them￼. draft business plan￼.

[10] https://www.ukpowernetworks.co.uk/losses/index.html

3 Our solutions to managing losses

3.1 Technical losses

Losses actions have been undertaken following our Losses Strategy approach, over the course of RIIO-ED1. The actions that have been completed are described in the table below.

The LDR process together with the knowledge gained from various innovation projects have enabled us to undertake a number of significant initiatives.

The solutions that have been adopted as BaU are subject to annual review to ensure they remain cost-effective and that we apply learning from the LDR and our other activities to these established categories.

Type of action	Past actions - Description	Adopted as BaU?
LDR initiative	A major research project involving holistic network modelling with Imperial College London[11], resulting in the publication of a report on strategies for reducing losses on distribution networks.	
	Integration of losses consideration in Kent Active System Management[12] (an Innovation funded project developing a contingency analysis tool to facilitate connection and manage curtailment of distributed generation on part of our 132kV network).	X
	Detailed analysis of the potential benefits of reducing losses on LV networks through voltage optimisation.	
	Development and adoption as BaU of 50kVA single-phase pole mounted amorphous steel transformers (see 3.1.1.1).	X
	Report on International benchmarking[13].	
	Report on the use of smart meter data[14].	
	Report on cross-border collaborative works with SSEN[15].	

[11] https://www.ukpowernetworks.co.uk/losses/static/pdfs/strategies-for-reducing-losses-in-distribution-networks.d1b2a6f.pdf

[12] https://www.ukpowernetworks.co.uk/losses/static/pdfs/kasm-distribution-network-losses-and-strategies-for-reducing-losses.4781973.pdf

[13] https://www.ukpowernetworks.co.uk/losses/static/pdfs/managing-losses-international-best-practice.78dda2a.pdf

[14] https://www.ukpowernetworks.co.uk/losses/static/pdfs/smart-meters-and-losses-best-practice-review.bbbb974.pdf

[15] https://www.ukpowernetworks.co.uk/losses/static/pdfs/uk-power-networks-collaboration-project-with-scottish-and-southern-energy.6048377.pdf

	Development of the theory of contact voltage for losses reduction resulting in a report by Princeton University[16]. This resulted in the development of the mobile asset assessment vehicle, building our systems and processes and adopting this activity for reducing losses as BaU (see 3.1.1.2). We surveyed central London Network with MAAV.	X
Non-reportable	Adoption of Ecodesign transformers for distribution networks (see 3.1.1.3).	X
Asset replacement	Pragmatic approach for cable replacement including standardisation of minimum size and avoiding cable tapering (see 3.1.1.4).	X
	Standardisation of minimum size of larger capacity transformers (see 3.1.1.3).	X

3.1.1.1. Amorphous steel-cored transformers

Amorphous steel-cored transformers have an even lower level of fixed losses than standard transformers. However amorphous steel is difficult to manufacture in large plate sizes (not least because it is brittle) and is generally available only for smaller distribution transformers. In addition, the cost is considerably higher than for laser etched/cold rolled conventional steel-cored transformers.

Our analysis with Imperial College London highlighted that the fixed losses are disproportionately high on small lightly loaded transformers such as rural pole mounted transformers.

We developed a specification for a 50kVA single phase amorphous steel transformer where the increased cost is outweighed by the long-term losses benefits. Accordingly, we now purchase and install these transformers as BaU.

We will always ensure that we are providing value-for-money for our customers. The relative cost of AMT and Cold Rolled Grain Oriented (CRGO) transformers has fluctuated and will continue to fluctuate. AMTs have generally, historically been more expensive than CRGO transformers, this is not always the case, and may change as demand for energy efficient transformers increases and we purchase AMTs in larger quantities.

Figure 6 - Amorphous Steel-cored pole mounted transformer

We are currently exploring the feasibility of deploying different AMT pole-mounted and ground mounted transformers. There are challenges in terms of size and weight of higher than 200kVA AMT transformers and we continue working with our Technology Sourcing & Standards team to identify the most suitable options.

[16] ttps://www.ukpowernetworks.co.uk/losses/static/pdfs/analysis-of-contact-voltage-losses.f7e1d56.pdf

3.1.1.2. Contact Voltage Losses

Contact Voltage Losses are a new category of network losses that we discovered through our LDR-funded work with Princeton University. CVL was discovered as a positive side-effect of the Mobile Asset Assessment Vehicle (MAAV) Innovation project that focussed on safety. Based on our work surveying Central London, Princeton University's Andlinger Centre[17] calculated that CVL account for 590 GWh of losses in Great Britain every year. This is the most significant change in our industry's understanding of network losses to have occurred in recent times. Importantly, because these defects are not necessary for the functioning of the network so there is no reason they cannot be wholly mitigated through intensive scanning and repair programmes.

The Mobile Asset Assessment Vehicle (MAAV) is a vehicle equipped with advanced electromagnetic wave sensors. It drives through urban environments and detects defective underground cables. While these cables have not 'faulted' in the traditional sense of triggering a fuse or other protective device, they are defective in the sense that a conductor is exposed to the general mass of the earth in a way that is contrary to the intended operation of the network. In some cases, these defective cables have metallic sheathes. When the sheath comes into contact with the live phase conductor, the entire length of sheath is energised at system voltage. As well as being a safety hazard, this results in energy leakage in the form of dissipated heat.

Working with Princeton University and the manufacturer of the MAAV, we have developed a BaU process to conduct surveys to detect faults and instigate cable repairs. Since the MAAV became a BaU activity for UK Power Networks, we have mitigated over 5,000 MWh of network losses. This was mainly driven by de-energising faulty lighting columns. It also makes the conservative assumption that the energised lighting columns would only have remained in their defective state for a single year, in the absence of our intervention. We have evidence to suggest these defects can in fact sustain for a much longer span of time.

We have surveyed the central London network using the MAAV and we are pleased to introduce this as a BaU activity to our Losses Strategy and will continue to gain further understanding from the results. For RIIO-ED2, we propose surveying the full extent of our low voltage underground cable network. We feel the discovery of CVL demonstrates a perfect case study for how innovative analysis from the LDR and other Ofgem Innovation funding streams can drive genuine and significant benefits for our customers and the wider public. This method is currently being used by Consolidated Edision company in New York and has been recognised by the council of European regulators in their 2nd report on power losses[18] and other UK DNOs[19].

3.1.1.3. Replacing transformers

The three main categories of transformers on our networks are grid, primary, and distribution transformers and there are common elements when considering losses that apply to all three.

Transformer losses comprise of fixed and variable losses. Given the diverse range of networks and utilisation levels the ratio between fixed and variable losses varies considerably and needs to be factored into any assessments. Newer transformers typically have lower losses than older transformers. It is interesting to note that there have been significant advances in transformer efficiency over the

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17 https://www.ukpowernetworks.co.uk/losses/static/pdfs/analysis-of-contact-voltage-losses.f7e1d56.pdf

18 https://www.ceer.eu/documents/104400/-/-/fd4178b4-ed00-6d06-5f4b-8b87d630b060

19 SPEN_RIIOED2_DraftBusinessPlan_1JULYWeb.pdf (spenergynetworks.co.uk)

course of many decades. These developments continue with the Ecodesign[20] 2015[21] (Tier 1) specifications and 2021[22] (Tier 2) specifications. These advances lead to a significant reduction in losses as assets are replaced.

EU Directive 2009/125/EC[23] mandates the adoption of Ecodesign transformers for distribution networks in two phases from 2015 to 2021. We have implemented the Ecodesign 2021 specification ahead of legislative requirements. It should be noted that where existing transformers are replaced with Ecodesign 2021 transformers of the same size there are typically considerable losses savings but as Ecodesign is a legislative requirement, this activity might be deemed as non-reportable.

Given the high cost of any transformer replacement it is unlikely to be cost-effective with losses as the primary driver. We therefore have to seek opportunities where there are other primary drivers such as connections, replacement or reinforcement and consider whether losses can cost-effectively warrant a change in the specification or size of the transformer.

Grid & primary transformers

We have over 2,300 grid and primary transformers on our networks with significant ranges in voltage, size, condition and age. In a typical year we would expect to replace or install around 30-40 grid and primary transformers.

The low volume but high value allows us to make site-specific losses calculations and undertake CBAs where these assets are being installed or replaced. There are considerable losses savings especially when replacing older transformers but there is unlikely to be a direct cost attributable to losses. For this reason, the vast majority of this activity is non-reportable.

As assets are replaced in RIIO-ED2, our policy will be to increase the capacity of the units to cater for the future load growth, where the capacity of the existing units is forecasted to be exceeded before 2050.

Distribution transformers

We have over 120,000 distribution transformers on our networks ranging from small single phase pole mounted transformers supplying electricity to a single dwelling to 1MVA three phase ground mounted transformers supplying electricity to hundreds of homes and businesses. In a typical year we would expect to replace or install over 1,000 distribution transformers based on condition, age, load, fault or to accommodate new connections.

Our analysis with Imperial College London[24] showed the significance of losses on distribution transformers with an estimated 20% of losses on our networks occurring on these assets.
As the older assets are likely to exhibit higher losses than the average it follows that making an informed decision about transformer specification and replacement is important. This importance is elevated as transformer life expectancy is 45-70 years and made more relevant with the anticipated uptake of electric vehicles[25] and other low carbon technologies that are expected to increase network utilisation.

When replacing existing transformers there will be a significant reduction in losses due to the on-going development of transformer specifications and efficiency. However, given the RIGs guidance from Ofgem although replacing these transformers on a like for like basis will reduce losses this is a non-reportable activity as there are no incremental costs.

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[20] http://ec.europa.eu/growth/industry/sustainability/ecodesign_en

[21] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R0548

[22] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02014R0548-20191114&from=EN

[23] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0125

[24] https://www.ukpowernetworks.co.uk/losses/static/pdfs/strategies-for-reducing-losses-in-distribution-networks.d1b2a6f.pdf

[25] https://innovation.ukpowernetworks.co.uk/wp-content/uploads/2021/02/Market-Intelligence-Report-February-2021.pdf

For all transformer installations and replacements, we specify Ecodesign 2021[26] transformers as a minimum.

We have developed a detailed analysis which makes site-specific recommendations to our asset replacement programme. This analysis selects a transformer size for each site where losses are minimised to the most-cost effective level.

Now that we have proven the effectiveness of this analysis, we have embedded this in our Engineering Standards so that all transformer selection and installation include loss inclusive design by default.

3.1.1.4. Cables

In the past we have rationalised our range of cable sizes particularly at low voltage (LV) and 11kV. This has both commercial benefits due to economies of scale when purchasing from suppliers as well as loss reduction benefits. Limiting the range of available options will naturally lead to larger overall cable sizes hence lower resistance and losses.

On cable installation projects the costs of the civil works for installation and reinstatement typically outweigh the cost of the actual cable. In many cases installing a larger cable has no impact on the costs of the civil works. Hence, our strategy with cables is to analyse the incremental cost difference and losses between the minimum standard cables size (which meets thermal ratings etc.) and larger cables with lower resistance.

This is a pragmatic approach and given the current value of losses, it is unlikely that losses will be the primary driver on any cable replacement programme at any voltage level.

Low voltage cables

We estimate that between 36-47% of losses[27] on our networks occur on our low voltage networks. This estimate highlights the importance and value of installing lower loss LV cables.
The challenges with LV networks are the sheer scale and the availability of data. We have over 90,000 km of LV underground mains cables, 7 million underground LV service cables and limited visibility of load at the LV feeder level at present. There is also a very wide range of utilisation on our LV networks, but we have analysed and found that increasing standard cable sizes is cost-effective. We have adopted and changed our Engineering Standards[28] [29]specifying 300mm^2 aluminium cable as our standard size for LV mains cables for all but a very limited number of exceptions. We also specify a minimum size of 35mm^2 aluminium for all LV service cables.
When changing the Engineering Standards, we also prohibited the tapering of cable sizes, a practice which has been shown to increase losses. We also sought to promote balancing of load across phases.

11kV cables

We estimate that between 17-27% of losses[30] on our networks occur on 11kV networks.
The challenges with 11kV networks are very similar to those on our LV networks. We have over 46,000 km of 11kV underground mains cables but benefit from some additional load data compared to LV.
Again, there is also a very wide range of utilisation on our 11kV networks, but we have analysed and found that increasing standard cable sizes is cost-effective.

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[26] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R0548

[27] https://www.ukpowernetworks.co.uk/losses/static/pdfs/strategies-for-reducing-losses-in-distribution-networks.d1b2a6f.pdf

[28] https://g81.ukpowernetworks.co.uk/library/design-and-planning/lv/eds-08-2000-lv-network-design

[29] https://g81.ukpowernetworks.co.uk/library/design-and-planning/lv/eds-08-2100-lv-customer-supplies

[30] https://www.ukpowernetworks.co.uk/losses/static/pdfs/strategies-for-reducing-losses-in-distribution-networks.d1b2a6f.pdf

We have adopted and changed our Engineering Standards[31] specifying 185mm^2 aluminium cable as our minimum standard size for 11kV mains cables for all but a very limited number of exceptions. With the benefit of additional data and analysis we are investigating the potential to increase this minimum size further to 300mm^2 aluminium.

EHV cables

We estimate that around 9% of losses on our network occurs on EHV cables. We have over 6,600 km of EHV cables. The replacement of these assets requires bespoke costs and benefit analysis to be carried out on case by case basis. The cable core size and material will depend upon installation conditions and rating requirements while taking account of future network development plans. The power losses in a cable circuit are proportional to the currents flowing in the metallic sheaths of the cables. Therefore, by reducing or eliminating the metallic sheath currents through different methods of bonding, it is possible to increase the cable rating[32].

We have updated our Engineering Standards accordingly. Where reasonable and feasible, UK Power Networks shall maximise the use of the highest distribution voltage possible within an area and minimise the use of lower voltages to customer connections and low load density areas. In addition, for cable distances under 5km, the largest feasible cross section of conductor available shall be used regardless of load requirements.

3.1.2 Ongoing losses actions

The below activities are currently under assessment and review either as part of the LDR process or through our licence condition obligations.

If these activities are deemed cost-effective they will proceed through our project governance process with the aim that they are ultimately adopted as a BaU activity.

The academic and LDR outputs are being subjected to scrutiny using network impedance data, measured load data and robust cost-benefit analysis. Some of these outputs are in the process of being implemented as BaU activities. Some outputs require further data or implementation of systems beyond the direct control of losses. It is anticipated that many of these actions will result in benefits in the remainder of RIIO-ED1, throughout RIIO-ED2 and beyond.

Topic	Ongoing actions - Description
LDR initiative	Expanding the range of kVA ratings of amorphous steel transformers
	Review of the potential benefits and cost-effectiveness of power factor correction on 11kV feeders (see 3.1.2.1).
	Active Response project including development and analysis of systems for optimisation of normally open points on 11kV and LV networks[33].
	LV monitoring project continue to roll-out LV monitoring equipment. This will increase visibility of LV network utilisation and losses allow us to understand, plan and deploy loss reduction solutions.

[31] https://g81.ukpowernetworks.co.uk/library/design-and-planning/hv/eds-08-3000-hv-network-design

[32] https://g81.ukpowernetworks.co.uk/library/design-and-planning/ehv/eds-08-4000-ehv-network-design.pdf

[33] https://innovation.ukpowernetworks.co.uk/projects/active-response/

	Envision[34] Project is developing a software based machine learning tool that will generate greater LV network insights faster and cheaper compared to traditional methods of physical monitoring.
	Vectorisation programme will continue to digitise the network assets in our GIS system. Vectorised network records are critical to improve the insight on losses particularly at LV networks
	The Hasys Phase Identification Unit (PIU) is a handheld device that can identify to which supply phase a property is connected to. This will improve the quality of phase connectivity data and consequently better understanding of phase balancing on the LV network.
	Phase Switching System project is developing a device that can reduce unbalance between phases and monitor its impact on the LV feeder or distribution transformer  Figure 7 - Phase Switching System application
	Continuation of our research with Imperial College London to review potential benefits of different network topologies and voltage. Through the LDR we have commissioned Imperial College London to undertake detailed analysis to help inform our long-term strategy. This study aims to understand the impact that Ecodesign transformers, the uptake of low carbon technologies and the potential that rationalisation of voltage levels could have on losses and on our losses strategy. We anticipate being able to publish a report on the findings in 2022.
	In 2020, UK Power Networks worked with Imperial College to understand the potential impact of Power Potential innovation project on distribution losses in a BAU application[35][36]. This identified that the Power Potential approach could reduce losses by 1.3% on the transmission or distribution networks. In the future, reactive power optimisation algorithms in DERMS could explicitly consider network energy losses and promote stronger coordination between ESO and DSO, to bring the maximum benefit of voltage and reactive power management to both distribution and transmission networks
Voltage rationalisation	We are planning replacement of legacy of the 2kV network, targeting those that are most obsolete and pose the most risk to staff, customers and reputation. Those closest to existing 6.6kV and 11kV network will also be prioritised. This initiative will provide great saving in network losses as well as health and safety, network reliability, and value for money for customers.

[34] https://innovation.ukpowernetworks.co.uk/projects/envision/

[35] UKPN_ICL_Impact-of-Power-Potential-on-Distribution-Network-Losses_Jan_2020_Final-update.pdf (ukpowernetworks.co.uk)

[36] https://www.nationalgrideso.com/innovation/projects/power-potential

Non-reportable	Expand on the work already completed on the replacement of distribution transformers and change our Engineering Standards so that all transformer selection and installation includes loss inclusive design by default.
Asset replacement	Expand the range of pole-mounted amorphous steel transformers where cost effective and will look to continue this development with ground-mounted transformers if feasible.
Optimisation of network configuration	The configuration of a network directly influences the losses that are incurred. Networks are primarily configured to meet operational and supply requirements. These requirements in many cases will ensure that losses through configuration are minimised by coincidence. Through our LDR projects with Imperial College London[37] Kent Active System Management project, and more recently Active Response, we recognised the potential for ensuring that our networks are optimised for losses taking into account other network requirements. This is a particularly appealing losses activity as the capital costs are often negligible, however the analysis can be time-consuming. As an activity through the LDR we identified an existing software platform that we can use to evaluate and reduce losses due to network configuration across all voltage levels but particularly at 11kV and LV. One important application is DPlan which we are using as primary tool for HV and LV network modelling functions. With the help DPlan, we carried out studies to optimise the location of open points in order to balance out the load and reduce losses. This task is manually intensive, so we will monitor whether this is a net benefit activity and decide further actions.
Improved use of smart meters	Smart meters present a potentially exciting opportunity to understand losses on our low voltage networks at a much more granular level than ever before. There are however, significant challenges not least of which is ensuring data privacy. We undertook a benchmarking exercise in 2017/18[38] that highlights some of these challenges and through the LDR we are looking to the market to see if there are any potential solutions to these issues that we have not considered already. We submitted our Data Privacy Plan to Ofgem and it was approved in February 2019. This is a rapidly developing area and we are collaborating with suppliers, industry and our DNO peers to find solutions to be able to access and utilise this data effectively.

3.1.3 Areas of focus for future losses actions

The below activities are currently under review. We engage with primary drivers and keep a watching brief on developments within the wider industry and it is likely that these potential activities will be subjected to further assessment.

[37] https://www.ukpowernetworks.co.uk/losses/static/pdfs/strategies-for-reducing-losses-in-distribution-networks.d1b2a6f.pdf

[38] https://www.ukpowernetworks.co.uk/losses/static/pdfs/smart-meters-and-losses-best-practice-review.bbbb974.pdf

Topic	Future actions - Description
Asset replacement	In general, the length of overhead lines at all voltage levels is gradually reducing and they are being replaced by underground cables. However, we recognise that losses are significant on these networks particularly at LV and 11kV. There are associated challenges with assessment of losses benefits as there is often little data on overhead lines or pole mounted transformers at LV and 11kV on which we can base our analysis. By comparison, installing larger underground cables is relatively simple in that the larger cable is laid in the same trench that was intended for a smaller cable. Whereas with overhead lines increasing conductor sizes often increases the strength requirements of the supporting structures (poles, ground stays etc.) to accommodate the increased mass and wind loading whilst maintaining clearances. We undertook an initial analysis at the start of the price control period and were unable to identify any clear cost-effective measures to reduce losses. Any cost-effective improvements that can be adopted as BaU will be implemented through changes to Engineering Standards. As part of our RIIO-ED2 submission we are proposing all asset replacement to be made within the context of the transition to a low carbon economy and Government targets to be carbon neutral by 2050. Specific changes to specifications are as follows: - Low voltage mains replaced will be the largest size conductor available which is 300mm^2 aluminium to facilitate the connection of heat pumps and electric vehicles. - Ground mounted distribution transformers will be upsized by one size e.g. 500kVA to 800kVA to facilitate the connection of heat pumps and electric vehicles. - Pole mounted transformers will also be upsized when they are replaced with the smallest size being installed going forward being a 50kVA three phase transformer. - When replacing conductors on tower line circuits the largest conductor that the line can support will be erected. This will result in the losses on the line being reduced lowering its carbon impact. - All newly purchased distribution, grid and primary transformers will comply with the eco-design requirements for power transformers (EU) No 548/2014. Tier 2 no-load loss requirements introduced on 1 July 2021 represent a 10% overall reduction in no-load losses when compared to the previous Tier 1 requirements. - Removal of PCB contaminated oil from electrical assets by 2025 where the concentration of PCBs is in excess of 50ppm as per the latest legislation . - AVC replacement will reduce the losses caused by circulating current .

Active Network Management	The field of wider Distributed Energy Resources Management System (DERMS) is rapidly evolving. Most of the drivers DERMS seek to increase utilisation of our existing networks. This has the potential to increase losses on our networks but will add renewable generation so a holistic view of the benefits needs to be taken. We are closely engaged with developments and seek to ensure that losses are included in any cost and design considerations. However this field also has the potential to provide losses benefits and we watch developments with interest.
Flexibility	UK Power Networks has developed a FutureSmart strategy[39] setting out a flexibility roadmap[40] for development. Flexibility programs aim to reduce demand at times when the network is constraint. As such there are wider benefits besides reducing the amount of distribution network variable losses.
Switching off transformers	Most grid and primary transformer sites have multiple transformers and due to the inherent fixed losses it has long been understood that there is a potential to reduce losses by switching out transformers during very low load conditions. There are however competing factors, such as reliability of supply, together with the costs of any control or switchgear required. Our work with Imperial College London[41] considered benefits to be negligible on all but a few sites.
Voltage management	There are potentially significant losses benefits from active voltage management as we demonstrated at LV[42] [43]. This is a potential activity that we are keen to develop but are we are currently limited by the data and the data analysis we have available. We keep a close watching brief on developments within UK Power Networks, most notably our LV visibility project, and also across our DNO peers.
Upgrade of legacy networks	Small parts of our network contain isolated legacy networks running at 2, 3.3 or 6.6kV. These legacy networks are aging and there is an asset renewal driver arising from the increasing obsolescence of these systems. Replacement with conventional 11kV networks using standard cable sizes will significantly reduce variable losses. Using Ecodesign distribution transformers will also reduce fixed and variable losses. The losses savings associated with replacement of these legacy networks will be sizeable but the losses on their own are not significant enough to effect any change to these asset replacement programmes. As part of our RIIO-ED2 plan, we have included significant investment for replacement of these networks for asset replacement purposes and as result, we will also get the losses benefit.

[39] http://futuresmart.ukpowernetworks.co.uk/

[40] http://futuresmart.ukpowernetworks.co.uk/wp-content/themes/ukpnfuturesmart/assets/pdf/futuresmart-flexibility-roadmap.pdf

[41] https://www.ukpowernetworks.co.uk/losses/static/pdfs/strategies-for-reducing-losses-in-distribution-networks.d1b2a6f.pdf

[42] https://www.ukpowernetworks.co.uk/losses/static/pdfs/lv-voltage-optimisation-for-losses-mitigation.90b33f6.pdf

[43] https://www.ukpowernetworks.co.uk/losses/static/pdfs/lv-feeder-losses-reduction-using-the-powerperfector-iq-test-report.23267b4.pdf

3.1.4 Activities requiring new technology or significant cost change

The below activities have been reviewed and although they present a potential opportunity to reduce losses, they are not deemed to be cost-effective at this time. We keep a watching brief on costs, the value of losses, new technology, or systems that may change this.

Topic	Description
Power quality and harmonics	It has long been recognised that power quality and in particular harmonic distortion causes a level of losses on distribution networks. Through our LDR activities Imperial College London[44] sought to study the impact of power quality and harmonics with respect to losses. On balance they concluded that the impact is likely to be low and reducing. We have increased or efforts to measure power quality and harmonics. We have started to sharing harmonics data in our Open Data portal[45]. Given this finding, at this stage we intend to keep a watching brief on developments only.
Phase balancing	Phase imbalance particularly on our LV networks presents an opportunity to reduce losses. However, we currently have limited visibility of our networks at LV feeder level and phase connectivity. Through LV visibility programme we will be able to improve our understanding of the LV network and target areas with phase balancing issues. Also by developing the Envision project we are working closely with other teams in the business that are leading improvements in data capture and visibility with a view to making full use of this data for losses purposes in due course. Another innovation project that uses high quality metering on the LV cables in SYNAPS. Whilst that project objective is to predict faults, it can have a secondary benefit of identifying phase imbalance. As mentioned above, the Phase Switching System[46] project is developing a device that can reduce unbalance between phases and monitor its impact on the LV feeder or distribution transformer after we have identified a phase imbalance.
Power factor management	The impact of poor power factor is potentially significant, and we are undertaking a project to consider power factor correction on 11kV feeders. Poor power factor is often a localised issue but potentially has implications on whole system management. We are interested in the potential of power factor correction on our LV networks and the potential that distributed generation could have on importing/exporting VARs on our higher voltage networks. We do however recognise that the value of losses is currently insufficient to warrant intervention and look for opportunities where there are other primary drivers.

[44] https://www.ukpowernetworks.co.uk/losses/static/pdfs/strategies-for-reducing-losses-in-distribution-networks.d1b2a6f.pdf

[45] https://ukpowernetworks.opendatasoft.com/

[46] https://innovation.ukpowernetworks.co.uk/projects/phase-switch-system/

3.2 Non-technical losses

Even though non-technical losses represent only 3.7% of the total estimated losses on our network, we are determined to mitigate them so far as is practicable. Our actions help ensure that we operate efficiently, avoid honest customers ‘picking up the tab’, help lessen the incidence of dangerous situations and serve to promote the efficient use of energy.

In the past, we have tackled the theft of electricity from our network and aided suppliers in meeting their theft obligations.

3.2.1 Actions implemented

3.2.1.1. Theft from suppliers

Our Service Delivery Centre provides a 24-hour/365-day emergency contact point which can receive telephone calls from members of the public, supplier agents and the emergency services. They ensure that leads are correctly re-routed to the appointed revenue protection agent or, where applicable, via the national Stay Energy Safe service. In certain emergency situations we may also dispatch a UK Power Networks field resource to site to ensure public safety.

Our staff and subcontractors identify suspected instances of theft during their daily activities. These are similarly routed back to our Service Delivery Centre for passing on to the relevant supplier.

UK Power Networks collaborates with Stay Energy Safe (also known as the Energy Theft Tip-Off Service[47] or ETTOS) operated by Crimestoppers. Where leads lack a clearly defined address and they are struggling to identify the correct premise and supplier, they refer the information to us as the distributor. With our specialist resources we can normally identify the relevant details and avoid a ‘dead-end’.

Our key commitments:

- Collate information concerning suspected theft whether from members of the public, supplier agents, the emergency services, our staff or contractors and ensure it is routed to the relevant supplier or their revenue protection agent;
- Aid the effective operation of the ETTOS by providing expert assistance in matching leads to premises permitting the identification of the relevant supplier;
- Share insight and best practice with suppliers at industry forums; and
- All activity will be in accordance with industry Codes of Practice.

[47] https://www.stayenergysafe.co.uk/report-energy-crime/

3.2.1.2. Theft in conveyance

This category of theft is much less prevalent but where it does occur it is the responsibility of the distributor to resolve. UK Power Networks has a comprehensive process to identify, investigate and resolve before ensuring that those persons who have benefitted from 'free' supplies pay back the full market value of the electricity taken.

Our key commitments:

- Pursue cases of theft in conveyance with thorough field investigations conducted in accordance with the Revenue Protection Code of Practice[48];
- Follow up with property owners and occupiers to ensure that the necessary steps are taken to enable these premises to be brought back within normal industry arrangements;
- Maintain systems to monitor the resolution of theft through new MPAN registrations;
- Robust use of distributor's statutory powers ensuring persons are charged for the electricity they have stolen and the associated costs incurred;
- Develop new and innovative approaches to maximise the identification of theft cases; and
- Detailed analysis to best understand causal and geographic trends.

3.2.1.3. Under-declaration of unmetered supplies

UK Power Networks has legally binding contractual arrangements with all unmetered supplies customers requiring the maintenance of a fully accurate inventory.

Our key commitments:

- Conduct desktop analysis to ensure that customers' submitted data meets expected standards and fully covers the electricity they consume; and
- Physical on-street audits will be undertaken if there is sufficient business justification.

3.2.1.4. Supplier data issues

This is principally an issue for electricity suppliers but we work with suppliers to support and assist where we can to ensure accurate data is recorded across all industry systems.

[48] https://www.dcusa.co.uk/Documents/Schedule%2023%20-%20Revenue%20Protection%20Code%20Of%20Practice%20v1%200.pdf#search=revenue%20protection%20code%20of%20practice

3.2.2 Future areas of focus

Detecting fraud proactively allows to mitigate safety risks and financial impacts and can be performed by using network data and Artificial Intelligence capabilities.

Considering that UK Power Networks is best placed to access the necessary network data, we will analyse the cost and benefit and feasibility to proactively detect fraud on our network.

We continue to monitor smart meter roll-out across our network and utilise this data together with low voltage monitoring data and data analytics to identify excessive consumption and network losses.

4 Appendix

4.1 Glossary of terms

Term	Definition
2009/125/EC	EU Directive – Ecodesign of Energy Related Products Directive
AMT	Amorphous Steel Transformer
AVC	Automatic Voltage Control
BaU	Business as Usual
CBA	Cost Benefit Analysis
CVL	Contact Voltage Losses are a result of defects in low voltage cables which can lead to energisation of the cable sheath and losses through heating.
CRGO	Cold Rolled Grain Oriented
DERMS	Distributed Energy Resources Management System
DG	Distributed Generation
DNO	Distribution Network Operator
DSO	Distribution System Operator
EED	Energy Efficiency Directive
EHV	Extra High Voltage (including 33kV and above)
ETTOS	Energy Theft Tip-Off Service
EV	Electric Vehicle
HV	High Voltage
I^2R	Losses = I^2R, where I represents current and R represents the resistance of the conductor
kV	Kilo-Volt
kVA	Kilo-Volt Amps
LCTs	Low Carbon Technologies
LDR	Losses Discretionary Reward
LV	Low Voltage
MAAV	Mobile Asset Assessment Vehicle

MWh	Mega-Watt hour
NIA	Network Innovation Allowance
Non-reportable category	Refers to RIGs reporting requirements under Section 3.3 of Annex J – Environment and Innovation. These are categories of losses activities where none of costs incurred relate to managing distribution losses but where losses benefits were coincidental.
NOPs	Normal Open Points
NPV	Net Present Value
PCB	Poly Chlorinated Biphenyl - New Poly Chlorinated Biphenyl (PCB) regulation 2019/1021 of EU Parliament – Persistent Organic Pollutants, which requires the decontamination or removal of all oil with a volume over 50ml and containing more than 50ppm of PCBs no later than 31st December 2025.
Reportable category	Refers to RIGs reporting requirements under Section 3.3 of Annex J – Environment and Innovation. These are categories of losses activities where some or all of the costs incurred relate to managing distribution losses.
RIGs	RIGs (Regulatory Instructions and Guidance) is an annual report that we submit to Ofgem containing performance data, costs and financial information. One of the RIGs reports is the E4 losses snapshot and commentary, within Annex J, where losses activities are reported.
RIIO-ED1	RIIO-ED1 is the first electricity distribution price control to reflect the new RIIO (Revenue = Incentives + Innovation + Outputs) model for network regulation. RIIO is designed to drive real benefits for customers. It provides the companies with strong incentives to step up and meet the challenges of delivering a low carbon, sustainable energy sector at value for money for existing and future customers.
TO	Transmission Operator
TRAS	Theft Risk Assessment Service
TSO	Transmission System Operator
WACC	Weighted Average Cost of Capital

4.2 Change log

November 2021:

Our Licence Condition obligations under section 49.5(b) requires us to maintain an up to date record of any modifications we have made to our Distribution Losses Strategy, to explain the reasons for and the effects of each such modification, and how the modification better facilitates ensuring losses are as low as reasonably practicable and based on up to date cost benefit analysis.

We have undertaken a wholesale revision of our Distribution Losses Strategy. Our previous Distribution Losses Strategy detailed many possible activities to reduce or manage losses. During RIIO-ED1 to date we have assessed these activities and prioritised those that are viable and cost effective. This revised Distribution Losses Strategy targets and highlights those viable and beneficial activities such as addition of EHV cables. It also sets out the potential innovative activities that we are investigating or plan to investigate further during RIIO-ED1 and beyond. We believe that these changes make it very clear to the reader what we are doing to reduce or manage losses and that these activities are based on up to date cost benefit analyses.

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