Environment Report 2022/23

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NES NATIONAL EQUALITY STANDARD

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Contents

1 Introduction

1.1 Executive Summary

We are pleased to present UK Power Networks' Environment Report for 2022/23, the final year of the RIIO-ED1 price control period. This document fulfils an annual requirement under standard condition 47 (Environment Reporting) of the Electricity Distribution Licence and has been prepared on behalf of our three licensed distribution companies: Eastern Power Networks plc (EPN), London Power Networks plc (LPN), and South Eastern Power Networks plc (SPN). It updates stakeholders on our performance across the key environmental measures we work to and our efforts to deliver environmental benefits for our customers and the wider communities in the regions we serve.

Protecting the environment is a core area in our aim of being a respected and trusted corporate citizen – a key part of our vision to be consistently the best-performing Distribution Network Operator (DNO) and Distribution System Operator (DSO) in the UK. We strive to have a positive effect on the environment in which we operate, working closely with communities and their representatives to identify where we can play an active, beneficial role.

Our environmental performance and key activities in 2022/23 are summarised below and covered in more detail in the following sections. We have indicated where these activities are related to the environmental commitments in our RIIO-ED1 Business Plan. These are listed in section 1.3.

- We continued to work closely with stakeholders to identify schemes that would benefit from the undergrounding of overhead lines to improve visual amenity. We are currently progressing 22 undergrounding schemes of varying sizes. For more information, please see section 2.2.

- Our RIIO-ED1 commitment was to reduce cable fluid losses by 2% per annum – this has been achieved, with an overall 34% improvement recorded over the period 2014/15 to 2022/23. However, our RIIO-ED1 commitment also used an assumed starting point of 207,000 litres, which was taken from actual performance earlier in the DPCR5 period. As such, whilst we have delivered a 34% improvement over the RIIO-ED1 period, we have not reached the implied performance level of 176,107 litres in 2022/23, with actual fluid filled cable leakage of 188,355 litres in the year. For more information, please see section 2.3.

- We set ourselves an overall target to reduce our business carbon footprint (BCF) by 2% for each year of the RIIO-ED1 price control period, amounting to a 16% total reduction against our baseline year of 2014/15 by 2022/23. As of 31 March 2023, we are pleased to report a reduction of 35.9% in our BCF which is significantly ahead of this target. For more information, please see section 2.4.1.

- We comfortably met our 2022/23 target for the RIIO-ED1 period of emitting less than 0.2% of the total amount of sulphur hexafluoride (SF_6) in service. During the year SF_6 leakage overall was 0.05% of the SF_6 in service. We continue to invest in SF_6 leak reduction projects in order to reduce the impact on the environment. For more information on our plans, please see section 2.4.2.

- We continued with our programme of upsizing or replacing network assets to manage distribution losses. On our HV and LV networks, upsizing main line conductors in 2022/23 will yield annual improvements of 1,090 MWh and 521.1 MWh, respectively. Over the last 12 months we have increased the size of the distribution transformers at 510 of our sites, yielding an annual improvement of 2,140.6 MWh. We also replaced 695 distribution transformers and 14 primary and grid transformers with Ecodesign specification units, yielding further annual improvements of 3,493.6 MWh and 4,606.5 MWh, respectively. For more information, please see section 2.4.3.

- In 2022/23 our programme of work to tackle theft in conveyance led to 480 cases being resolved across our three licence areas. During the year we continued to work with the industry, including electricity suppliers, to promote more effective electricity theft reduction. For more information, please see section 2.4.4.

- We continued to invest in our flood protection programme to ensure that customer supplies are protected from flood risk. In 2022/23 we successfully flood-protected a further nine substations serving almost 100,000 customers. This brings the total number of substations mitigated in RIIO-ED1 to 80 – exceeding our commitment to protect 78 substations from the impact of flooding during the eight-year price control period. For more information, please see section 2.5.1.

- In 2022/23 UK Power Networks generated 4,083 tonnes of office and depot waste, a reduction of 113 tonnes on the previous year. Of this, 471 tonnes (11.5%) of non-recoverable waste ended up in landfill. The remaining 3,612 tonnes (88.5%) were diverted from landfill and were either recycled or used for energy recovery. This is significantly ahead of our annual RIIO-ED1 commitment of 70% diversion from landfill. We continued to invest in and install energy efficiency measures within our estate, and to upgrade our office welfare facilities with water saving devices when refurbishments are undertaken. The delivery of in-house environmental awareness training was also a continued, important area of focus. For more information, please see section 2.5.2.

- Over the course of the RIIO-ED1 price control period we have worked hard to embed innovation in our business. During the 2022/23 regulatory year we focused on supporting the development and scale-up of existing solutions to maximise their potential. Our 58 business-as-usual solutions have delivered £508 million of savings since 2015. As we move into RIIO-ED2, we remain committed to playing a leading role in the energy transition towards net zero and ensuring that the benefits of the transition are accessible to all. Some of our projects include facilitating the reliable connection of increased Distributed Energy Resources (DERs) to power distribution networks, as well as increasing the resilience of the LV network with greater visibility, monitoring and control. For more information on our innovation strategy, project portfolio and the innovation benefits we have delivered into business as usual, please see section 3.1 onwards.

Over the last eight years of RIIO-ED1 our targets have driven significant change within our business to address our environmental responsibilities and identify opportunities for improvement. Where our performance has exceeded our targets we have set new stretching objectives to ensure we continue to make environmental improvements. The overall success of our actions and initiatives to date has created a solid foundation as we enter the next price control period. In RIIO-ED2 we will maintain our focus on carbon emissions, resource use and circular economy, pollution abatement and prevention, biodiversity enhancement, and in tandem, climate adaptation. We will also review our targets and programmes annually and once again, where we are exceeding existing targets, set new stretching objectives where appropriate and practical to do so. Throughout RIIO-ED2 we will continue to innovate and seek out new opportunities to reduce our environmental impact at the lowest cost to our customers.

1.2 Our business/who we are

At UK Power Networks we manage the distribution of electricity from the National Grid and locally connected generation to 8.4 million homes and businesses via our networks in London, the South East and the East of England. Our licensed companies EPN, LPN and SPN are responsible for operating and maintaining these networks, ensuring we provide safe, reliable and efficient electricity supplies to existing customers and timely, cost-effective connections to new ones. We are purely a network operator. We do not generate or buy electricity, nor do we sell it to customers.

Our operating area (see Figure 1) covers 29,250 square kilometres and includes most of London as well as large areas of rural and agricultural land and over 500 miles of coastline around the south east of England. It has many environmental landscape features that are of great importance – Areas of Outstanding Natural Beauty, National Parks, Sites of Special Scientific Interest, unique waterways such as The Norfolk Broads, and Central London which is rich in archaeological significance.

Figure 1: Our operating area

As a provider of an essential service we occupy a privileged position in society and also have an important role to play in safeguarding the environment in which we operate. We must consider the design and construction of our infrastructure, the use of oil and other insulation products on our network, and the factors which contribute to our BCF from the energy used to light and heat our offices and depots to the vehicles we use. When installing new equipment on our network we ensure that we consult with relevant statutory authorities and other appropriate bodies at the earliest possible opportunity. Every effort is made to identify potential environmental impacts at the earliest planning and design stage of projects and to mitigate any harm.

Our greatest contribution to protecting the environment lies in how we facilitate our customers' journey towards a decarbonised world and develop our future DSO capabilities to deliver a secure, reliable low carbon energy system that addresses their evolving needs. As an electricity network operator, we are at the heart of enabling net zero because of the crucial role we play in both connecting renewable energy and facilitating the uptake of new low carbon technology. Our customers in London, the South East and the East of England rightly expect us to lead the way in achieving a greener future for all. We are actively working with industry and policymakers to facilitate the change.

To learn more about how UK Power Networks is supporting the UK's transition to a net zero carbon economy, please see section 3.1.2.

1.3 Purpose of this report

This report presents our activities in relation to environmental matters during the 2022/23 regulatory year. It includes information on:

- Improving visual amenity
- Reducing oil leakage from our fluid filled cables
- Managing and reducing our BCF
- Minimising SF_6 emissions from our assets
- Reducing technical and non-technical distribution losses from our network
- Protecting our substations from flood risk
- Promoting biodiversity
- Addressing noise pollution from our assets
- Environmental awareness training for our staff
- Managing and preventing waste
- Embedding innovation in our business and supporting the transition to net zero
- Exploring and realising the benefits of smart metering

Where applicable, we present progress against the environmental targets in our RIIO-ED1 Business Plan. These are:

- Underground the equivalent of 80 km of HV overhead line in SPN and 96 km of HV overhead line in EPN in Areas of Outstanding Natural Beauty and National Parks
- Reduce cable fluid leakage of 207,000 litres by 2% per annum
- Reduce our BCF by 2% per annum
- Maintain SF_6 leakage at less than 0.2% as a proportion of SF_6 in service
- Continue to recycle 70% of office and depot waste and 98% of street works spoil
- Investigate all noise issues and address all non-compliant sites
- Protect 78 substation sites from the risk of flooding
- Innovation expenditure of 0.5% of allowed revenues and win largest market share of the NIC

2 Managing Our Environmental Impact

2.1 Introduction

We play an important role in safeguarding the environment in which we operate and have robust policies and procedures in place to ensure we comply with all relevant environmental legislation and industry codes of practice. The Electricity Act specifically requires us to consider natural beauty, flora, fauna and geological or physiographical features of special interest, and sites, buildings and objects of architectural, historic or archaeological interest, and do what we reasonably can to mitigate any effects. All other environmental legislation is assessed for relevance to our activities as a DNO. Relevant activities include environmental permitting, pollution prevention, waste management and the preservation of historic and natural habitats.

Where practicable and achievable, we seek to surpass the basic level of environmental compliance and work to enhance our positive impacts on the environment, whether that be improving biodiversity opportunities at suitable locations, minimising waste and maximising recycling, or working with our supply chain to improve our environmental performance. Our Environmental Action Plan provides a suite of targets focused on energy use, carbon emissions, waste, water, biodiversity and pollution. We have also completed our carbon footprinting in line with the Green House Gas (GHG) protocols and had our carbon targets verified by the Science Based Targets initiative (SBTi). We are also facilitating the societal transition to net zero to ensure that we can accommodate electric vehicles (EVs), low carbon heat and distributed energy while at the same time developing plans to reduce our own operational carbon footprint.

We have Environment Agency permits to operate three waste transfer stations and seven waste oil storage facilities. Electrical insulating oil removed during routine maintenance is reprocessed and reused, thereby reducing demand for new oil to be extracted. Through training and monitoring, high levels of compliance with our environmental permits are maintained. When working in protected habitats such as Sites of Special Scientific Interest or where protected species may be impacted, we consult with Natural England and where appropriate, apply for relevant licences. Suitably qualified ecologists are engaged to help us with these activities. We also consult English Heritage if our work might have an impact on scheduled monuments or other protected historic sites.

Environmental governance is provided by our Health, Safety and Environment Committee, which is chaired by our CEO. This is cascaded through the organisation via local and business Health, Safety and Environment Committees. Our Environmental Management System meets the ISO 14001:2015 standard requirements and is subject to external verification and audit by DNV-GL. This system is implemented by relevant business leads and appropriate managers within our organisation who are responsible for identifying and mitigating their respective environmental risks, with guidance and assurance from our Environment team. In 2021 we formed an Environmental and Social Governance (ESG) committee that reports to the board of UK Power Networks Holdings Ltd. This committee meets three times a year and receives reports of progress against core ESG KPIs, as well as reports on specific projects and initiatives that support the delivery of these KPIs.

We consult with stakeholders, including statutory authorities and other appropriate bodies, to help mitigate the impact of our operations on the environment. At a local level, we seek to build good relationships with local authorities and work collaboratively on initiatives to help reduce the impact of issues such as noise pollution and litter, which can be a source of concern for local communities. We also work with the industry to identify areas of best practice and ensure continuous improvement. Members of our Environment team represent UK Power Networks on the Electricity Networks Association (ENA) Environment Committee, helping to ensure that best practice is implemented from knowledge shared across the electricity and gas sectors.

The following subsections present our 2022/23 performance in relation to visual amenity, oil leakage, our BCF, SF_6 emissions, and technical and non-technical distribution losses, plus key activities in other environmental areas.

2.2 Visual amenity

UK Power Networks is a member of a long-established Steering Group that nominates schemes to underground overhead lines within Areas of Outstanding Natural Beauty (AONB) and National Parks (NP) in the EPN and SPN licence areas, observing funding criteria specified by Ofgem.

The group consists of landscape experts (representatives of the AONB and NP boards within UK Power Networks' footprint) acting as stakeholder representatives and is chaired and facilitated by Natural England who hold the national remit to advise on the management of designated landscapes. The group meets every three months to promote and manage the portfolio of work.

UK Power Networks holds the position of a non-voting member within this group, providing the necessary technical guidance to support scheme assessment. The level of support provided varies from scheme to scheme but will always include the provision of a route for the new cable network, a substation position and the estimated cost of carrying out the work.

A majority voting process determines approval of schemes with the Chair holding the deciding vote in instances where there is a tie. All new schemes proposed by Steering Group members must undergo a two-stage approval process:

- Stage 1: This is an outline of the scheme which includes indicative routes and budget costs for consultation with stakeholders. The scheme budget is ring-fenced
- Stage 2: This is triggered once stakeholders (landowners) have been consulted, the final cable route/extent of the scheme has been determined and the scheme has been assessed in terms of applicable scoring criteria (see below) and costs

Projects are assessed against scoring criteria prior to being considered for selection. Factors such as the impact on a landscape's character, the impact on visual amenity and the potential impact of undergrounding on features in the landscape (either its biodiversity or rural heritage) are taken into account. As part of this process the proposer will identify whether the scheme is linked to any proposals to seek additional local/national government/industry funding to improve accessibility to a region and increase visitor numbers to a protected landscape.

Schemes are nominally capped at a cost of £200,000 per kilometre. In some instances, because of technicalities in the delivery of the scheme, the upper limit may be exceeded and the Steering Group retains the discretion to waive this cap. During the Stage 2 process, changes to the cable route or positioning of substations may impact on the overall cost of a scheme and where this cost increases by more than 20% of the initial estimate the proposer must seek the Steering Group's approval to continue. In 2022/23 no schemes were withdrawn on this basis.

Approved schemes (those that have completed Stage 2) are referred to UK Power Networks to acquire the necessary consents to deliver the works. During the consenting and delivery phases we continue to work closely with the scheme's proposer on any material issues that arise, such as the rerouting of a proposed cable or the relocation of a substation.

Table 1 identifies 22 schemes of varying size and complexity that are being progressed through the various stages of the consultation process. A number of these schemes involve lines operating at differing voltages. For such schemes, the benefits increase as the removal of only one voltage (line) would further highlight the impact of the remaining line(s) on the landscape. This encourages the Steering Group to identify whole distribution system schemes that focus on locations that have the potential to maximise the visual amenity improvement to the greatest number of visitors to the protected landscape.

Scheme	Protected landscape	Licence area
Potter Heigham	Broads	EPN
Blyth	Suffolk Coast & Heaths	EPN
Stoke by Nayland	Dedham Vale	EPN
Felixstowe	Suffolk Coast & Heaths	EPN
Brett Valley	Suffolk Coast & Heaths	EPN
Latimer	Chilterns	EPN
Elham Valley	Kent Downs	SPN
Bedgebury Pinetum	High Weald	SPN
Chilham	Kent Downs	SPN
Preston Hill	Kent Downs	SPN
Malling Hill	South Downs	SPN
A27 Corridor	South Downs	SPN
Olantigh Park	Kent Downs	SPN
Lees Court	Kent Downs	SPN
Swanborough	South Downs	SPN
Littlington South	South Downs	SPN
Royal Military Canal	Kent Downs	SPN
Telscombe	South Downs	SPN
Sheffield Park	High Weald	SPN
Littlington North	South Downs	SPN
Bodsham	Kent Downs	SPN
Swingfield	Kent Downs	SPN

Table 1: Undergrounding schemes in progress in UK Power Networks' operating area

Charge Restriction Condition (CRC) 3J of the Electricity Distribution Licence allows DNOs to spend up to 10% of their allocated expenditure on undergrounding lines which extend beyond the boundaries of Designated Areas. Within these requirements we continue to work with Steering Group members to develop two such schemes in our SPN licence area – Sheffield Park and Royal Military Canal.

Undergrounding these cables has been challenging given the complexity of the schemes and the associated governance process. UK Power Networks has an advisory role within the Steering Group to support nominated schemes from a technical and consent perspective; it is not able to promote its own schemes. Nevertheless, changes have been made to the Steering Group constitution to streamline the selection and adoption of schemes. Other interested parties, in particular large landowners, have been invited into the Steering Group who have schemes that sit within their footprint, and this has accelerated the approval process and helped to build a bank of approved schemes for RIIO-ED2.

Achievements in the 2022/23 regulatory year are shown in the E1 – Visual Amenity worksheets (please see the Annexes and Appendices). In EPN no achievement was claimed but there were costs in relation to ongoing works on the schemes at Latimer and Potter Heigham. In SPN we claimed an achievement for part of the scheme at Telscombe. The majority will be claimed during the 2023/24 regulatory year.

The 2022/23 regulatory year signals the end of the RIIO-ED1 allowance period. In terms of achievement over the eight-year period against the allowances:

- 12.90 km of lines were removed in SPN for £2.43 million (16% of allowance used)
- 32.19 km of lines were removed in EPN for £8.24 million (59% of allowance used)

2.3 Oil leakage

Fluid filled cables account for 35% of all cables running at 33kV, 66kV and 132kV in our three licence areas by length. Leaks from fluid filled cables occur for various reasons, including the failure of ancillary oil equipment (e.g. pipework, monitoring gauges and oil tanks), cable joint failure, cable damage due to third-party excavations, and incorrect installations.

In our RIIO-ED1 Business Plan we committed to reduce oil leakage from fluid filled cables by 2% per annum for the duration of the RIIO-ED1 price control period from a starting point of 207,000 litres. This section provides information on our strategy for reducing oil leakage from fluid filled cables, a summary of 2022/23 performance and details of the work we have undertaken both independently and with key stakeholders.

Key reasons to reduce cable fluid loss include:

- Complying with environmental legislation where the operating code states that the DNO "will take all reasonably practicable steps to prevent pollution of controlled waters", taking advice from the Environment Agency as required[1]
- Ensuring a continuous supply to customers by reducing instances of power loss caused by leaking cables
- Ensuring the network operates as efficiently as possible by reducing the cost to customers of cleaning up oil leakages

Our strategy is to reduce cable fluid loss by investing in the network to refurbish and replace poor condition circuits. Where circuits develop new leaks we ensure we are at the forefront of new technology and best practice to identify and repair damage as swiftly as possible. For the last few years we have used perfluorocarbon tracer (PFT) for leak location. This technology is based on introducing a controlled volume of chemical tracer which is mixed into pumped cable fluid. Once it has reached the point of the leak this 'tagged' fluid becomes detectable in the atmosphere or through bore-hole sampling using either a static detector or a vehicle-mounted vapour analyser.

Where leaks occur we have thorough procedures in place to manage, report and address them to minimise the amount of fluid lost and its associated environmental impact.

2.3.1 2022/23 performance

Cable fluid loss is measured by the total amount of fluid used to top up cables less any fluid recovered. A summary of 2022/23 cable fluid loss is provided in Table 2 below. The 2022/23 values have been extracted from the E2 – Environmental Reporting worksheets for each of our licensees and should be read in conjunction with the notes below. For more information, please see the Annexes and Appendices.

Licensee	Average annual cable fluid losses – DPCR5[2]	Cable fluid losses – 2022/23[3]	Difference (volume)	Difference (%)
EPN	54,239 litres	49,186 litres	-5,053	-9%
LPN	126,623 litres	98,559 litres	-28,064	-22%
SPN	54,298 litres	40,609 litres	-13,689	-25%
Total	**235,160 litres**	**188,355 litres**	**-46,805**	**-20%**

Table 2: Comparison of cable fluid lost in 2022/23 to historical performance in DPCR5

[1] https://www.ena-eng.org/ENA-Docs/D0C3XTRACT/ENA_EREC_C135_Extract_180902050412.pdf
[2] The data in this column represents the average amount of cable fluid lost and not recovered in each year of DPCR5, the price control period from April 2010 to March 2015.
[3] Cable fluid losses are measured by the total fluid used to top up cables less the total fluid recovered for all three of UK Power Networks' licence areas.

Figure 2 presents our overall RIIO-ED1 performance.

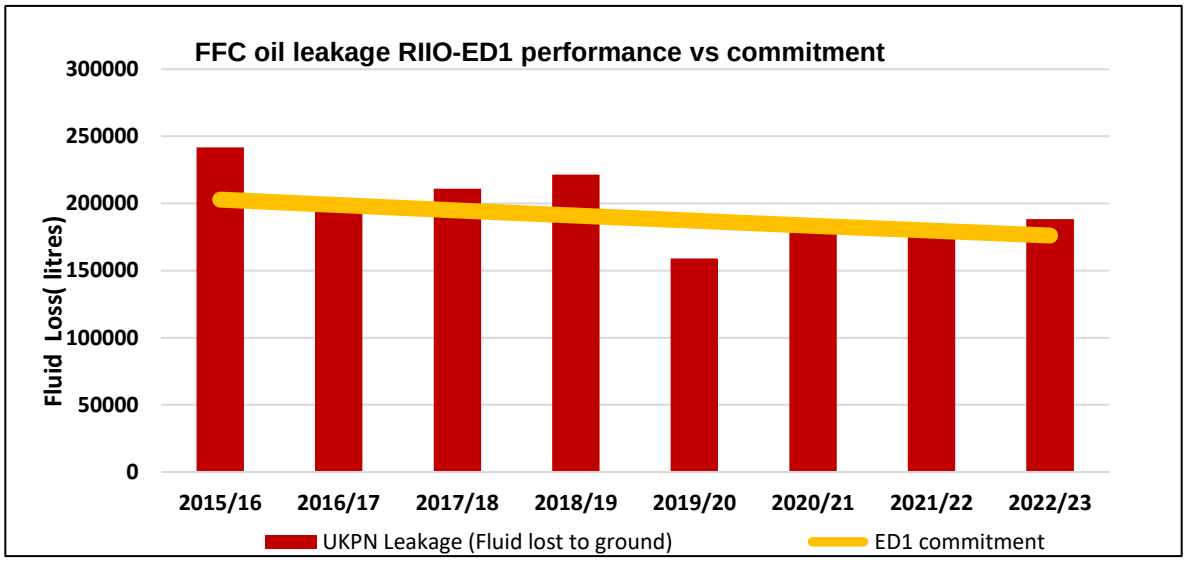

Figure 2: UK Power Networks' overall RIIO-ED1 performance

Our RIIO-ED1 commitment was to reduce cable fluid losses by 2% per annum – this has been achieved, with an overall 34% improvement recorded over the period 2014/15 to 2022/23. However, our RIIO-ED1 commitment also used an assumed starting point of 207,000 litres, which was taken from actual performance earlier in the DPCR5 period. As such, whilst we have delivered a 34% improvement over the RIIO-ED1 period, we have not reached the implied performance level of 176,107 litres in 2022/23, with actual fluid filled cable leakage of 188,355 litres in the year.

Performance was on track until the summer of 2022. From August onwards the monthly leak rate increased. This was due to the following substantial leaks:

- Bromley Grid – Orpington (SPN) – approximately 6,245 litres in the 2022/23 regulatory year. The leak location was challenging due to the complex location of other utilities and diversions. This was resolved and repairs were carried out in March 2023 to prevent further oil loss
- Wimbledon to Wandsworth circuits 1 and 2 (LPN) – approximately 5,900 litres in the 2022/23 regulatory year. Work is under way to install two new 132kV cable circuits utilising existing tunnels between Wimbledon and Wandsworth. The new routes are set to replace existing worst performing fluid filled circuits which will be decommissioned by March 2024 (circuit 1) and March 2025 (circuit 2) respectively
- Deptford – Bengeworth (LPN) – approximately 9,000 litres in the 2022/23 regulatory year. This was resolved and repairs were undertaken in November 2022. A further condition assessment is under way to explore the option of replacing this circuit section to prevent further oil loss and improve network resilience

In addition, further progress has been made on the installation of pressure transducers to actively manage the pressure within cables, as well as further innovative work to develop a self-healing cable fluid additive (see below). The latter remains at the development stage.

As we move into RIIO-ED2 we will continue to look for new ways to improve oil leakage reduction in all three of our licence areas.

2.3.2 Initiation of Network Innovation Allowance (NIA) projects

In previous Environment Reports we have provided updates on innovation projects which if successful will directly contribute to a reduction in cable fluid loss. An update for the 2022/23 regulatory year is provided below.

- **Self-Healing Cables (registered for NIA as 'Development of Oil-Filled Cable Additive – Phase 2')**

  UK Power Networks is leading this project in collaboration with Northern Powergrid to identify new additives to cable fluid that would seal leaks where they occur without the need for leak location and excavation. The first and second phases of the project are registered under the NIA project NIA-UKPN0030, which started in March 2016 and concluded in March 2020.

  The project has resulted in several significant developments in regard to the self-healing cables themselves, the testing methods, and the facilities required for the technology to move to both fluid filled cable and network demonstration. Building on this initial success, a programme has been developed to investigate whether it is possible to move the technology to the next readiness level, i.e. closer to commercialisation.

  Phase 3 of the project was launched in March 2023. This will focus on assurance and further work required in a practical environment, assessing the potential for the self-healing cable additive (Anagen) to be deployed into the cable in the same way as a standard cable oil (i.e. top-up fluid). The results of this work have the potential to significantly lower the volumes of Anagen required for its successful deployment to business as usual. Specifically, to ensure that the formulation is electrically compatible over a longer period, we are exploring a further live circuit trial on a fluid filled cable circuit.

  The project will be split into stages 3a and 3b which are to be stage-gated with a break clause. This will enable UK Power Networks to discontinue the project if the outputs from stage 3a are unsatisfactory. Both project phases will focus on the assurance required to ensure that the formulation is electrically compatible over a more extended period at a threshold of 10 years and does not negatively affect the cable system. This will include further development of procedures for safe handling and formulation performance, which will build on those currently in place for existing electrical insulation fluids.

  Learnings and outputs from the circuit trial for rapid leak mitigation will build further confidence in Anagen. DNOs will be able to adopt the technology as business as usual if it is proven to be electrically and operationally consistent with the relevant standards ENA TS 09-04 and IEC 60141-1 and fully compatible with standard fluid filled cables.

  Further work has been carried out to develop test rigs for the trialling of Anagen using a progressive top-up method. If phase 3a is successful, the plan is to proceed with HV testing at Kinetrics' test facility in Canada.

  Experience gained during this trial will provide further information for the review of UK Power Networks' policy and standard operating procedures; this will give us more assurance in adopting the technology for a wider network. If successful, we expect that it will provide benefits from reduced cable fluid loss in RIIO-ED2.

- **Pressurised Cable Active Control and Monitoring**

  This project reviewed the operating systems for fluid filled cables so that cables can be operated at lower pressures to reduce leakage without the risk of customer interruptions, extending their operational life. The project is registered under the NIA project NIA-UKPN-0012. It started in September 2015 and concluded in 2019.

The project developed and trialled a new device, an Active Pressurised Control Unit (APCU), to avoid fluid leakages from cables. An APCU is operated by a variable speed pump and pressure valve to create a pressure differential across the unit, and sensors on either side of the unit to control the flow of oil into and out of the APCU. This allows the pressure of oil inside the cable to be maintained at a constant value, which is expected to avoid cable degradation versus simply operating them within their designed pressure.

APCU units have been successfully developed and trialled as part of this project. The findings largely suggest that the APCU could be permanently deployed on the fluid filled cable network with confidence in its safe long-term operation.

In 2022/23 we made further progress in rolling out the project to business as usual. During the year we installed three APCU units in our network and also identified suitable circuits for installation in 2023/24.

We anticipate that this solution will provide benefits from reduced cable fluid loss in RIIO-ED2, as indicated in our E6 – Innovative Solutions worksheets.

The learning from these projects is being shared with other DNOs so that areas of best practice can be identified to support others in meeting similar commitments. This has been added to the Engineering Recommendation ENA_EREC_ C135_ Issue 2 (2022) which is due to be issued later this year.

As the above projects are funded through workstreams that require project specific reporting in the RIGs (e.g. the NIA), they are not recorded under costs or volumes within the E2 – Environmental Reporting worksheets. It is therefore not possible to compare or analyse the costs and volumes included with this worksheet.

2.3.3 Stakeholder engagement

As outlined in the previous sections, we take a proactive approach to identifying leaks through monitoring cable pressures and utilising perfluorocarbon tracer (PFT), enabling us to identify leaks rapidly. We use active pressure control units (APCUs) to ensure we reduce pumping pressures where needed to prevent cable joint failure and oil loss to the surroundings. We also have dedicated teams whose primary role is to minimise the impacts of any leaks with immediate interventions, protecting vulnerable receptors such as water courses and water abstraction points, as well as recovering the majority of any oil lost and remediating the soil. These teams are fully supported by our contract partners, RSK, who are leading experts in managing spill and leak incidents. Our contractors and teams engage directly with all relevant statutory stakeholders, landowners and interested parties during cable interventions. At the same time, we are constantly innovating to preserve the life of the cables and reduce the risk of leaks through actions such as the self-healing cable initiative, and we have a rolling programme of replacement, targeting the worst performers.

We have a partnership agreement with the Environment Agency outlining how we should report, notify and manage cable leaks across the network. We also work with key stakeholders to share best practice and target the poorest performing circuits in our network. In 2022/23 this included:

The environmental impacts of cable fluid loss must be managed effectively, and we have a partnership agreement with the Environment Agency outlining how we should report, notify and manage cable leaks across the network. We also work with key stakeholders to share best practice and target the poorest performing circuits in our network. In 2022/23 this included:

- Regular updates to the Environment Agency on the mitigation in place on specific projects and on the progress of capital replacement and refurbishment of fluid filled cables more generally
- Ongoing engagement with the Environment Agency at six-monthly meetings of the ENA Fluid Filled Cable Liaison Group where performance is reviewed and best practice is shared with other DNOs
- Enduring consultation/knowledge sharing with other DNOs, on a six-monthly basis or as required. These meetings focused on sharing new technologies and further improvements to reduce the environmental impact where there were opportunities to share learning
- Discussions of individual poorly performing circuits with local stakeholders including Thames Water, the Canal and River Trust and local authorities (as required), enabling UK Power Networks to hear and take account of their views

2.4 Carbon impact and climate change

2.4.1 Our business carbon footprint

This section describes our BCF reporting process, the various elements of our BCF and how they are measured, and how we track our carbon emissions throughout the year.

In our RIIO-ED1 Business Plan we set ourselves an overall target to reduce our BCF by 2% for each year of the RIIO-ED1 price control period. This amounted to a 16% total reduction against our baseline year of 2014/15 by 2022/23. The RIIO-ED1 price control period has now ended and we achieved a reduction of 35.9% (see Table 3) which is significantly ahead of this target.

Our BCF reporting to Ofgem is done under the rules of the Greenhouse Gas (GHG) Protocol; however, it splits carbon into subject areas rather than the three scopes which the protocol defines.

The GHG Protocol scopes are:

- Scope 1: direct emissions from sources owned or controlled by UK Power Networks
- Scope 2: indirect emissions from consumption of purchased electricity, heat and steam and in a DNO's case, network losses
- Scope 3: upstream and downstream emissions which are as a result of our activities but outside UK Power Networks' ownership and control, such as those embedded in our supply chain, purchased goods and services, waste disposal and transportation in vehicles not owned or controlled by UK Power Networks

Figure 3 shows how the categories reported to Ofgem map to the GHG Protocol scopes.

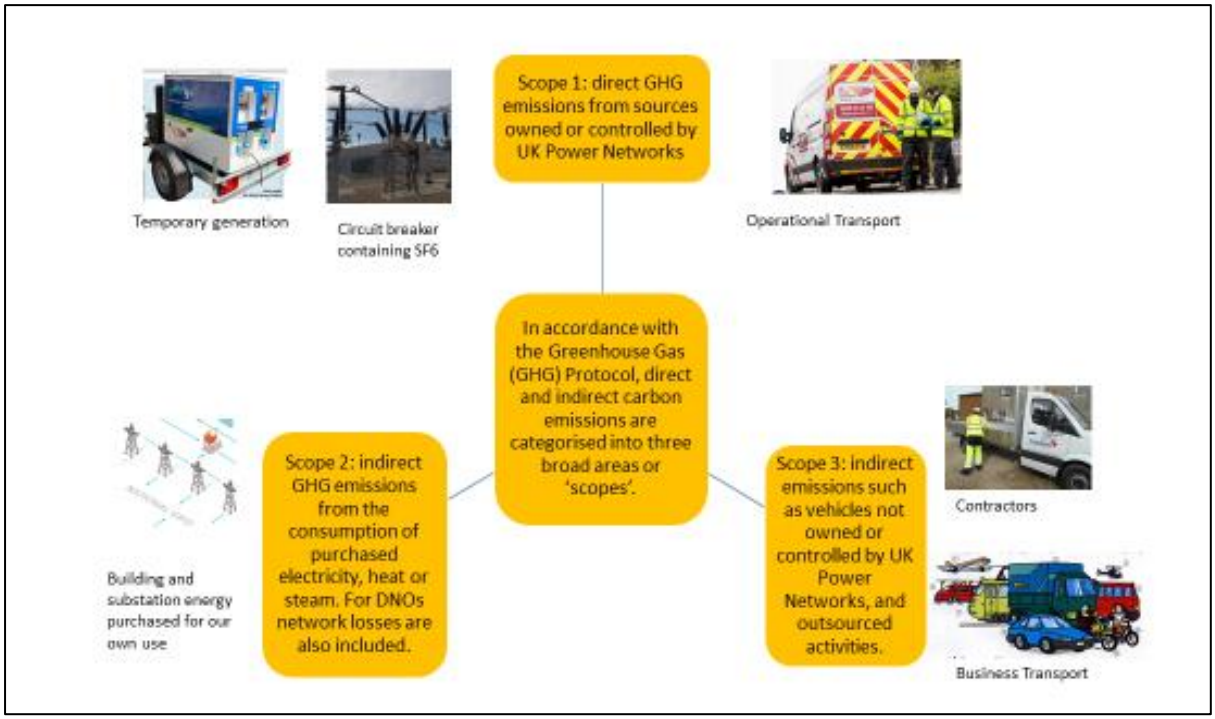

Figure 3: GHG Protocol scopes

Our BCF methodology

The processes described in this section are used to calculate the BCF for EPN, LPN and SPN. Where data is collected centrally it is apportioned between the three DNOs based on headcount as of 31 March 2023. If we apportioned based on geographical area, as opposed to headcount, LPN would only be allocated 2% of the shared footprint, which would result in an unrealistically small value.

All data provided is for the regulatory reporting year from 1 April 2022 to 31 March 2023. The reductions reported below are measured against a baseline of 2014/15, the last year prior to RIIO-ED1.

Unless stated otherwise, the UK Government GHG Conversion Factors for Company Reporting (last updated in September 2022) have been used in all calculations. This approach complies with Defra guidance to use these factors for any April to March reporting as well as calendar year reporting. Our results for the 2022/23 regulatory year are shown in the E3 – Business Carbon Footprint worksheets (please see the Annexes and Appendices).

Our BCF reporting process

Distribution losses account for 94.5% of our total BCF and are the focus of a separate strategy; please see section 2.4.3. Focusing on our BCF without losses highlights the potential for sustainability improvements in other areas. Excluding distribution losses, in 2022/23 the largest element of our BCF was operational transport (28.4%). Temporary generation is now the second largest element, accounting for 23.4%. This is followed by building and substation energy usage (21.6%), business travel (5.8%) and fugitive (SF_6) emissions (3%). We also include contractor fuel used directly on UK Power Networks projects, contractor fuel used in plant and equipment, and contractor travel which account for 17.7% of our footprint. These elements are illustrated in Figure 4 which provides a breakdown of our BCF excluding distribution losses over the last nine years.

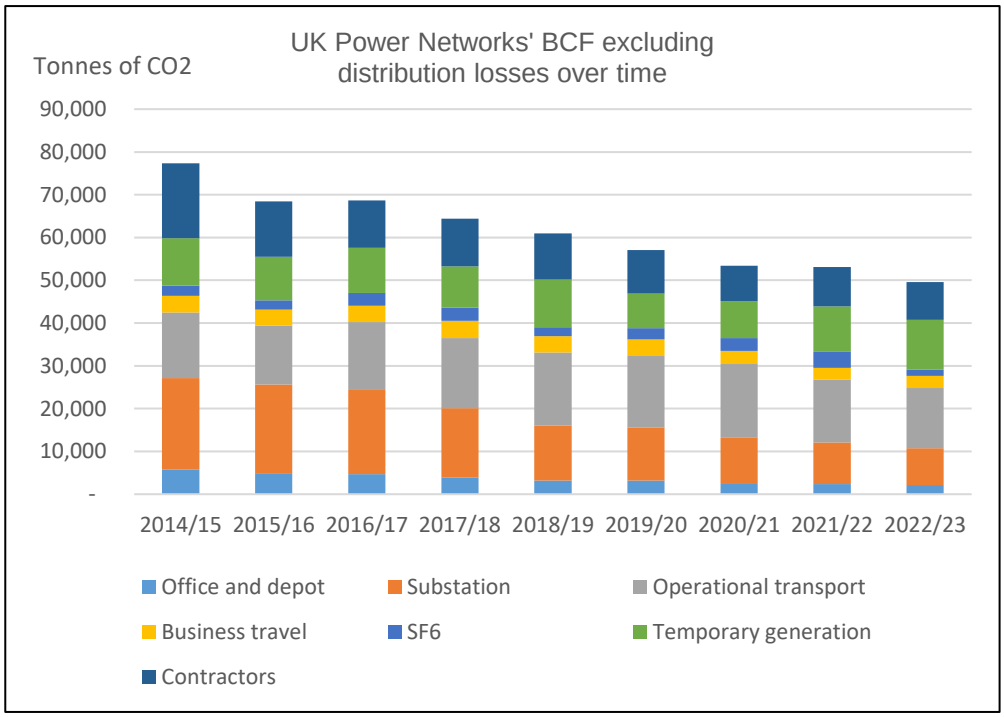

Figure 4: UK Power Networks' BCF breakdown excluding distribution losses over time

Table 3 shows our overall BCF excluding distribution losses for the regulatory years 2014/15 (our baseline year as set by Ofgem) and 2022/23. Details of the individual components of our BCF excluding losses are also reported below.

Licensee	2014/15 (tCO_2e)	2022/23 (tCO_2e)	% change
EPN	32,539.49	22,669.68	-30.3%
LPN	19,776.50	11,231.25	-43.2%
SPN	25,025.12	15,678.38	-37.3%
Total	**77,341.11**	**49,579.31**	**-35.9%**

Table 3: Our 2014/15 and 2022/23 BCFs excluding losses

To check progress against our RIIO-ED1 target we prepare monthly BCF reports, at a company-wide as opposed to an individual DNO level, using data received from internal and external sources. Any anomalies in the data are closely examined and corrective actions implemented where necessary.

Monthly reports are received from various sources and cover:

- Fleet fuel usage
- Business mileage, transport expense claims and transport credit card expenditure
- SF_6 top-ups
- Headcount
- Electricity and gas meter readings
- Generator and bowser fuel usage

Key operational contractors supply details of their own fuel usage for fleet, plant and equipment and provide business mileage on UK Power Networks' contracts. In this report, the values representing UK Power Networks' and contractors' emissions are shown both separately and as a combined figure.

We compile an annual report on non-technical distribution losses; please see section 2.4.4.

For elements such as the purchase of fuel for temporary generation, SF_6 top-ups, substation energy use and some of our building energy, data is apportioned directly to each of our three DNOs where possible. The use of common systems in all three of our licence areas means that some data is captured centrally. Where this is the case, we apportion the data between the DNOs on a headcount basis.

The individual elements of our BCF

There has been a shift in the relative proportions of the elements of our BCF since 2014/15, with the most significant change being the proportional decrease from 46% to 21.6% in building and substation energy usage. A contributing factor is the UK's grid decarbonisation. The closure of coal fired power stations and increasing amounts of renewable energy connected to the UK electricity network have led to a marked reduction in the carbon intensity factor for UK electricity. This was 0.49426 $kgCO_2e$ per kWh in 2014/15 and has fallen by 60.1% to 0.19338 $kgCO_2e$ per kWh in 2022/23.

Our challenge going forward is that a significant element of our BCF is based on transport or diesel fuelled generation. The carbon intensity of diesel is not likely to decrease so ultimately a switch to an alternative fuel source for our operational fleet will be required. Currently there is not an electric alternative with sufficient range and weight carrying capacity for the large vans which make up the majority of our operational fleet. However, an EV pilot is due to launch at the end of the regulatory year for car derived vans (Class B), and a small trial for Class C vehicles (small vans). Policies, incentives and support schemes have also been set up for company cars, cash allowance schemes and employees' own cars to encourage the uptake of EVs. We are also working on introducing hybrid engines and battery packs into our temporary generator fleet, as well as exploring and trialling lower carbon fuels.

Operational transport

This element of our BCF represents the fuel used by our fleet of vans, trucks and specialist vehicles which work directly on our electricity networks. We also report on the fuel used by our contractors' operational vehicles when working on our behalf. Fuel purchased for UK Power Networks' fleet vehicles is captured centrally using fuel cards. Contractor transport data is obtained from contractor fuel figures submitted via a manual reporting process. A small quantity of diesel for temporary generation is also purchased using fuel cards, but this is recorded separately and reported later in this section as part of our temporary generation carbon footprint.

Table 4 shows the levels of tCO_2e emitted by UK Power Networks' operational fleet and contractors when working on our networks. As previously mentioned, we apportion fuel usage on a headcount basis as we believe this is a more accurate method than geographical apportionment which is based on square kilometres.

Licensee	Direct operational staff	% of staff	2014/15 total (tCO_2e)	2022/23 – UK Power Networks' fleet (tCO_2e)	2022/23 – contractor (tCO_2e)	2022/23 – combined (tCO_2e)	% change
EPN	1,144	44.5%	11,450.84	6,262.27	3,759.26	10,021.53	-12.5%
LPN	749	29.1%	9,284.47	4,099.40	2,460.88	6,560.29	-29.3%
SPN	680	26.4%	10,212.92	3,721.59	2,234.08	5,955.67	-41.7%
Total	**2,573**	**100%**	**30,948.23**	**14,083.26**	**8,454.22**	**22,537.49**	**-27.2%**

Table 4: Levels of tCO_2e emitted by our operational fleet and contractors working on our networks

Overall, operational transport emissions have reduced from 30,948.23 tCO_2e in 2014/15 to 22,537.48 tCO_2e in 2022/23. This represents a 27.2% reduction and is due to the modernisation of our operational fleet and the roll-out of more sophisticated communications technology enabling staff to access cable plans and other documents in the field.

After showing a pandemic-related increase as additional vehicles were hired in to prevent vehicle sharing, the downward trend shown last year has continued. In 2022/23 our operational transport footprint was 3.7% down on the previous year.

Temporary generation

This element of our BCF covers emissions from plant and equipment, such as temporary generators used during fault repairs and planned work on our networks. Data for such emissions is captured from the following sources:

1. Monthly fuel usage reports from external providers of standby diesel generators – though provided on an as needed basis, these generators are in direct use on our networks and under our operational control and are therefore classified as scope 1 rather than scope 3 emissions
2. Fuel cards capturing the amount of fuel used by company owned plant and equipment
3. Invoices submitted by the tanker company that fills the bowsers at several of the sites used to fuel our own generators

With the exception of contractor generation, no headcount conversion needs to be applied to the above as the source data is captured by region.

We use temporary generation to minimise the time that customers are off supply. Severe weather can add significantly to this element of our BCF as we restore customers' power supplies as quickly as possible, often using temporary generation whilst repairing storm damage. The LPN network is least affected by bad weather as it is almost entirely underground.

Table 5 shows the levels of tCO_2e emitted from temporary generators and plant and equipment used on our networks. Across all three networks, 2022/23 represents a 4.4% reduction from our baseline year.

Licensee	2014/15 total (tCO_2e)	2022/23 – UK Power Networks (tCO_2e)	2022/23 – contractor (tCO_2e)	2022/23– combined (tCO_2e)	% change
EPN	4,321.55	4,749.67	91.56	4,841.24	+12.0%
LPN	1,717.71	775.75	59.94	835.69	-51.3%
SPN	6,328.58	6,086.62	54.42	6,141.03	-3.0%
Total	**12,367.84**	**11,612.04**	**205.92**	**11,817.96**	**-4.4%**

Table 5: tCO_2e emitted from temporary generators and plant and equipment used on our networks

Building and substation energy usage

We collate data on building and substation energy usage from the electricity and gas bills received for each of our sites. Gas and electricity usage is billed in kWh then converted into tCO_2e using the appropriate carbon factors. In most cases, geographical location determines the apportionment of energy usage per licensee. For shared buildings, apportionment is determined by overall UK Power Networks headcount.

Savings have been introduced through the consolidation of staff into fewer buildings and energy saving initiatives such as the introduction of LED lighting and occupancy sensors in many offices.

Under the GHG Protocol, we are able to use both location-based and market-based methodologies to report our scope 2 emissions. We follow a location-based method of reporting using the UK's annual electricity conversion factor, regardless of the type of tariff purchased. Since 1 January 2018, all of UK Power Networks' purchased electricity has been on a 100% renewable tariff. Under a market-based reporting methodology, all of our electricity could therefore be discounted from our BCF.

The footprint of our building electricity using a location-based methodology represents a 64.7% reduction on our baseline year, while our gas footprint has reduced by 22.6%.

For the first time we have recorded EV energy usage in the E3 worksheets (see the Buildings Energy section). The combined total for all three licensees is 11.83 tCO2e which is classified as a Scope 3 emission.

Table 6 shows the levels of tCO_2e emitted from energy usage at our sites.

Licensee	2014/15 – total (tCO_2e)	2022/23 – total (tCO_2e)	% change
EPN	13,574.67	5,333.95	-60.7%
LPN	6,942.63	2,865.61	-58.7%
SPN	6,648.78	2,543.52	-61.7%
Total	**27,166.08**	**10,743.08**	**-60.5%**

Table 6: Energy usage at our sites

Business transport

This section refers primarily to employees' mileage and public transport (attending meetings, etc.), which constitute indirect operational emissions. Some of these emissions will be directly related to operational work (e.g. visits to project sites) due to the data being combined. We convert source data available as costs only into kilometres or litres before applying the GHG conversion factors.

Transport records for shared services (IT, HR, etc.) related to our unregulated business, UK Power Networks Services, are not recorded separately and therefore all data is included within the calculations. This is consistent with previous submissions.

Data is captured from four sources:

1. Our financial management system which enables us to determine business mileage and travel claimed through staff expenses
2. Our external travel provider
3. Corporate credit cards
4. Fuel cards

Data is recorded by type of travel (e.g. air, rail and road). Business travel data is not recorded by licence area and is apportioned based on the number of indirect staff employed per area. To improve the quality and accuracy of data, all claims for business mileage now use the actual CO_2 rating.

In 2022/23 rail and air travel was approximately half of what it was compared to pre-pandemic levels and business travel by car reduced also. This is due to many more meetings taking place online.

Contractor mileage was included in our baseline year footprint for business transport. Combining these elements for 2022/23 represents a 33.1% reduction on our baseline year.

Table 7 shows the levels of tCO_2e emitted by our staff and contractors when travelling on company business.

Licensee	Indirect staff	% of staff	2014/15 – total (tCO_2e)	2022/23 – UK Power Networks (tCO_2e)	2022/23 – contractor (tCO_2e)	2022/23 – combined (tCO_2e)	% change
EPN	1,123	45.3%	1,651.60	1,320.80	55.18	1,375.98	-16.7%
LPN	654	26.4%	1,339.13	678.74	36.12	714.87	-46.6%
SPN	702	28.3%	1,473.05	863.99	32.79	896.78	-39.1%
Total	**2,479**	**100%**	**4,463.78**	**2,863.53**	**124.09**	**2,987.63**	**-33.1%**

Table 7: Business mileage summary showing the levels of tCO_2e emitted by UK Power Networks' staff and contractors when travelling on company business

Fugitive emissions

SF_6 is an electrical insulating gas which is commonly found in modern electrical switchgear. It can have a significant impact on the environment, being 22,800 times more harmful to global warming than CO_2.

SF_6 can leak following faults or from old equipment. We continue to actively monitor our assets and have a number of procedures to minimise the escape of SF_6 to the environment. We measure the SF_6 that is lost in terms of top-ups required.

From a BCF perspective, we measure and record the quantities of SF_6 lost as fugitive emissions.

Table 8 shows the levels of SF_6 emissions reported by our three licensees in 2014/15 (our baseline year) and 2022/23. The current year represents a 37.7% reduction on our baseline year.

Licensee	2014/15 – total (tCO_2e)	2022/23 – total (tCO_2e)	% change
EPN	1,540.83	1,096.98	-28.8%
LPN	492.56	254.79	-48.3%
SPN	361.80	141.38	-60.9%
Total	**2,395.19**	**1,493.15**	**-37.7%**

Table 8: Levels of tCO_2e emitted from leakage of SF_6 from switchgear

For more detail on our procedures and annual performance, please see section 2.4.2.

Distribution losses

These calculations measure units exiting our distribution network compared to units entering from Grid Supply Points and any other sources. Estimated data can have a big impact on network losses. These estimates are based on historical data, which has fluctuated enormously in recent years. During the pandemic, this historical data was based on a time when people were not working from home and therefore is generally an underestimate of electricity consumption. As the additional energy used has not been accounted for yet, it sits as network losses. This meant we saw a significant increase in network losses during the pandemic.

To date we have seen the lowest network losses reported this year. The exact cause of this is difficult to identify but is likely to be due to a significant overestimate of supply volume being corrected in this reporting year. During the pandemic meter reading ceased, increasing estimates, and volumes of consumption would have shifted from business sites to homes, affecting standard estimates. It is likely that these overestimates have now been corrected with actual reads. In addition, more smart meters may have been installed and consumers may also be much more careful with their energy use, given the current high costs.

Our results for the 2022/23 regulatory year are shown in our E4 – Losses Snapshot worksheets; please see the Annexes and Appendices. The figures were correct at the time of submitting our E4 figures (31 July 2023) but may be subject to further updates given the standard reconciliation cycle in the settlements process.

Table 9 and Table 10 present overall losses performance for the 2022/23 regulatory year. We have achieved a 69.3% reduction on our baseline year across all three networks. This is largely driven by extensive grid decarbonisation in the UK. The carbon intensity factor for UK electricity in 2014/15 was 0.49426 kgCO_2e per kWh and has fallen by 60.1% to 0.19338 kgCO_2e per kWh in 2022/23.

Licensee	2014/15 – total (tCO_2e)	2022/23 – total (tCO_2e)	% change
EPN	1,178,315.84	359,902.86	-69.5%
LPN	913,866.74	290,718.05	-68.2%
SPN	663,791.18	196,685.39	-70.4%
Total	**2,755,973.76**	**847,306.30**	**-69.3%**

Table 9: Levels of tCO_2e emitted from direct losses as the electricity travels through our networks

Licensee	2014/15 (tCO_2e)	2022/23 (tCO_2e)	% change
EPN	1,210,855.33	382,572.54	-68.4%
LPN	933,663.24	301,949.30	-67.7%
SPN	688,816.30	212,363.77	-69.2%
Total	**2,833,334.87**	**896,885.61**	**-68.3%**

Table 10: Our overall BCF including distribution losses in tCO_2e

Distribution losses are covered in detail in sections 2.4.3 and 2.4.4 of this report.

2.4.2 Sulphur hexafluoride (SF_6) emissions

Reducing SF_6 leakage from our network assets is key to our vision of being a respected and trusted corporate citizen. In our RIIO-ED1 Business Plan we signalled our commitment to maintain SF_6 leakage at less than 0.2% as a proportion of SF_6 in service throughout the RIIO-ED1 price control period in all three of our licence areas.

We use SF_6 in our switchgear as an insulation medium, an arc extinction method or for both functions, from 6.6kV up to 132kV. SF_6 leakage is measured in kilogrammes as the amount of SF_6 that is used to top up our gas-filled switchgear. The total capacity of SF_6 utilised in electrical assets on our network is just under 127,000 kilogrammes across our three licence areas; please see the corresponding breakdown in Table 11 below.

Licensee	SF_6 bank (kg)
EPN	51,756
LPN	49,183
SPN	26,016
Total	**126,955**

Table 11: SF_6 bank per licensee

In Table 11, the SF_6 bank for each licence area is a summation of the amount of SF_6 in the assets on the network and the stock of SF_6 cylinders kept for topping up any leaking circuit breakers. The measurement of SF_6 leakage as a percentage of installed capacity is more reflective of the performance of the assets. By omitting the SF_6 stock from the calculation, we eliminate the diluting effect that high stock levels may have on the perception of leak performance. The leakage percentage figure can be found in the table in section 2.4.2.1. The SF_6 bank figures have been included here because they are the figures we report to Ofgem.

We anticipate a slowdown in the replacement of oil switchgear with SF_6 filled switchgear on our network. This is due to three factors:

1. UK Power Networks' commitment to limit SF_6 emissions involves adopting SF_6 alternatives when they become technically feasible. A policy document (Engineering Bulletin EBB 03-0130) has been published which will require an application for deviation from the standard for the installation of any switchgear containing SF_6.
2. The development and trialling of alternative gases by equipment manufacturers is gathering pace. An example of this is the landmark agreement between ABB Hitachi and GE to share intellectual property about the use of fluoronitrile-based SF_6 alternative gases in switchgear[4]. ABB Hitachi has released its Econiq live tank 132kV circuit breaker and GE has released its g-cubed insulated live tank 132kV circuit breaker. UK Power Networks has commenced deployment of the GE solution and will also review the Hitachi solution for potential adoption.
3. On 5 April 2022, the European Commission published a proposal to amend the EU F-gas regulations with specified dates for the prohibition of the marketing and sale of switchgear containing SF_6 (including parts), with lower voltages up to 24kV being embargoed by 1 January 2026, those with voltages between 52kV and 145kV by 1 January 2028, and those between 24kV and 52kV by 1 January 2030. At the 132kV voltage level, where SF_6 is the industry standard arc extinction method for circuit breakers, alternative gases and technologies such as clean air insulation combined with vacuum interruption and fluoronitrile-based solutions for insulation and arc interruption have been successfully developed. It remains to be seen if alternative gases can be used in our LPN licence area or in any other licence area where space constraints might be an issue because SF_6 filled switchgear offers space-saving advantages at installation due to its compact nature. Where alternatives can be used in such circumstances, the transition will be managed in a safe and cost-effective manner.

Although a slowdown in the use of SF_6 filled switchgear is anticipated, the timeline for widespread adoption is dependent on the technical approval of SF_6 alternative switchgear. This is a meticulous process and SF_6 switchgear will need to be used in the medium term. As a result, due to the replacement of oil and air-blast circuit breakers, the SF_6 capacity on our network increased by 2,908 kilogrammes at the end of RIIO-ED1 from the March 2022 baseline.

Based on the increased availability of SF_6 alternatives since submitting our 2021/22 Environment Report, it is anticipated that the quantity of SF_6 on the network should increase by no more than 1,000 kilogrammes by the end of 2023/24.

The decision to install air insulated (AIS) or gas insulated (GIS) switchgear is based primarily on the cost of delivery, available space and project delivery targets.

2.4.2.1. Our 2022/23 performance

The figures presented in Table 12 can be found in the E2 – Environmental Reporting worksheets (please see the Annexes and Appendices). They demonstrate that in 2022/23 our three licensees comfortably met the 0.2% target for leakage set out in our RIIO-ED1 Business Plan.

DNO licence area	% SF_6 in service emitted
EPN	0.093
LPN	0.023
SPN	0.024
Total	**0.053**[5]

Table 12: SF_6 emissions per licensee

In EPN we repaired a 33kV circuit breaker at Funthams Lane Primary 33kV and Lawford Grid.

[4] GE and Hitachi ABB Power Grids sign landmark agreement to reduce environmental impact in the electrical transmission industry

[5] The total refers to the percentage of the total SF_6 bank and is therefore not a sum of the percentages for the individual licence areas.

Going forward, we are prioritising SF_6 leak reduction projects and the evaluation and implementation of innovative measures to expedite the delivery of leak mitigation, to ensure we meet our RIIO-ED2 Business Plan commitment in all three of our licence areas.

2.4.2.2. Our strategy

We are taking action to minimise SF_6 emissions to:

- Remain compliant with the F-gas Regulations
- Minimise our impact on the environment and achieve our vision of being a respected and trusted corporate citizen
- Minimise the network outages required to top up leaking circuit breakers – reducing costs associated with the top-up and the period the network is at risk
- Reduce the probability of mal-operation or failure – improving network performance
- Minimise the risk of exposure to SF_6 for our operational staff when working on the network or handling this substance

Where SF_6 leaks occur, our current approach is to instruct the manufacturer to carry out leak detection works on the affected unit, scope out the works and complete all repair or refurbishment works required to mitigate the leak. Refurbishment can be on-site or factory based. It generally consists of a strip-down of the circuit breaker, a comprehensive clean and replacement of all worn seals or parts. Where it is not reasonably practicable or cost-effective to complete a refurbishment or repair of the circuit breaker, an immediate replacement will be considered.

Our process for recording top-ups of SF_6 is set out below:

- A low gas pressure alarm is automatically received by Network Control
- A top-up work order is raised when a low SF_6 gas alarm is detected
- A competent person (holding a valid SF_6 handling certificate) tops up the asset to within the manufacturer's recommended pressure range
- The magnitude of the top-up is recorded in an SF_6 Top-Up condition measure document, which is associated with the asset in our asset register, and the top-up work order is closed

We have produced three documents specifying the operating constraints that apply to the handling of SF_6 or the operation of any switchgear containing this substance. One of these documents is Engineering Design Standard EDS 03-0036 – Management of Switchgear containing SF_6, which offers guidance on the management of switchgear containing SF_6 from voltages of 6.6kV up to 132kV. More specifically, it details the processes followed in identifying and managing SF_6 filled switchgear that may be leaking. This policy applies to all UK Power Networks plant and staff, including contractors who work on the network on our behalf.

2.4.2.3. Our stakeholders

Our stakeholders include those who can potentially impact or be impacted by the safety, operational or environmental effects of an SF_6 leak, including customers, operational staff, and manufacturers. Correspondence is required with operational staff such as field engineers and craftsmen when ascertaining the feasibility of remedial works. For example, information about the precise source of an SF_6 leak, where known, will enable the manufacturer to decide whether the proposed remedial action is cost-effective and will prevent costly and potentially unnecessary leak detection visits. We engage regularly and openly with manufacturers on ways to enhance our SF_6 management approach.

DNOs and TOs (Transmission Operators) in the UK are also stakeholders in a broader sense. UK Power Networks will continue to work with both stakeholder groups as appropriate to assess the current and evolving state of switchgear technology with a view to charting a technological, practical and sustainable path to the reduction and ultimate elimination of SF_6 from electricity networks in the coming decades.

2.4.2.4. Our programme to reduce SF_6 emissions

Our programme adheres to the requirements of the UK's equivalent of the EU F-gas Regulations – to resolve all gas leaks without undue delay. Generally, for primary switchgear and above, a repair or refurbishment will be sought. For secondary switchgear and below, it is generally more prudent to action a replacement than to undertake remedial works, due to the associated costs.

SF_6 leakage figures are held on UK Power Networks' asset register and are reported to the senior management team in our asset management function each month. Top-up figures are also submitted to Ofgem each year as part of the commentary accompanying the E2 – Environmental Reporting worksheets (please see the Annexes and Appendices).

In 2022/23 our leak reduction programme targeted the repair of circuit breakers at Southern Cross 132kV (SPN), Trowse Grid 132kV (EPN) and March Grid 33kV (EPN). Due to network outage and original equipment manufacturer availability in 2022/23, the work will be undertaken in 2023/24, in addition to our 2023/24 plans.

Our 2023/24 plans include investment targeted at further leak reduction work at Earlham Grid and Harlow West Grid in EPN.

2.4.2.5. Looking ahead: our future strategy

Our future strategy is focused on assessing and improving our SF_6 leak monitoring and response process as well as continuing to assess the viability of SF_6 alternatives with significantly lower greenhouse effects.

The key areas that will be explored as part of our future strategy are:

- Collaborating with research organisations such as the Electric Power Research Institute (EPRI) and industry partners to develop and implement a quick and easy leak sealing technology which is not dependent on manufacturer availability and which drastically reduces the time between leak detection and repair
- Monitoring the innovation space for the development of rapid SF_6 leak detection technologies and adopting them once proven to be safe and technically acceptable
- Researching the practicality and cost-effectiveness of installing SF_6 leak detection sensors on electrical equipment with smaller amounts of gas, such as ring main units, to facilitate faster responses to smaller leaks
- Exploring the use of SF_6 alternatives, such as vacuum/clean air, and commissioning these assets on our network where safe and economically viable to do so. This will be accomplished by maintaining contact, partly through the ENA, with manufacturers, academic institutions and electricity distribution industry participants who are considering or conducting trials in order to be well positioned to take advantage of any cost-effective breakthrough product that results from such efforts
- Exploring the potential for replacing SF_6 with alternative gases (retro-filling) for carefully specified functions in electrical switchgear

We keep abreast of all innovations related to SF_6 as an insulation medium, including the exploration of SF_6 alternatives.

Achievements in the 2022/23 regulatory year are shown in the E2 – Environmental Reporting worksheets (please see the Annexes and Appendices).

2.4.3 Technical distribution losses

Distribution losses are either technical or non-technical in nature. Technical distribution losses are a consequence of transferring electricity across the distribution system. Non-technical losses result from the under-recording or non-recording of electricity consumption – for example, the illegal extraction of electricity from the network. As a proportion of energy lost, non-technical losses represent a much smaller value than those associated with technical losses. The remainder of this section examines technical distribution losses. For information on non-technical losses, please see section 2.4.4.

Technical distribution losses have a significant financial and environmental impact on customers due to the need to generate additional electricity (with the associated infrastructure costs and CO_2 emissions), which is subsequently consumed through losses. These technical losses can never be eliminated completely, but through innovation, research and adoption of a robust losses strategy it is possible to manage them and to establish a variety of cost-effective methods to mitigate their impact.

There is a variety of technical losses but the two principal types are fixed and variable. As electricity passes through our network, a small proportion is lost as heat. This is known as a variable loss as it varies with the flow of electricity distributed. Unfortunately, this relationship is not linear and so peaky loads incur proportionately higher losses than those associated with flat load profiles, especially during peak demand periods.

Fixed losses are largely independent of the energy being transferred across the network and mainly relate to energy required to energise transformers. For a typical distribution network around 30% of technical losses will be of the fixed variety and around 70% will be of the variable type, although we observe regional variations in this ratio.

2.4.3.1. Our losses strategy

Our broad strategic objective for managing network technical losses is to control them at a level that is economically justified and to factor appropriate loss mitigation measures into all categories of network investment. We are also working to reduce our technical losses through the introduction of innovative solutions.

Our Losses strategy follows a three-step approach of:

- Understanding losses
- Plan and design
- Build and operate

Our strategy recognises that there are areas that can be tackled with almost immediate effect whilst others require a period of research and learning prior to implementation. Some of the areas/approaches, which rely on new technologies or processes, can only be implemented once a deeper knowledge and understanding has been gained or new technologies are more widely available.

To further our understanding and develop methods for mitigating losses, we commissioned Imperial College London's researchers, Princeton University and other distinguished partners to undertake a variety of studies during the RIIO-ED1 regulatory period, through the Losses Discretionary Reward (LDR) initiative. For the benefit of our stakeholders, we have published reports and other material of interest that our research produced on our losses website[6], which also contains interactive explanations for the various losses types and causes.

Where the cost can be justified by the benefit, we have embedded various solutions into our business-as-usual activities. We accept that understanding losses is an ongoing process and while some areas of losses are well understood, others pose considerable challenges. For example, historically, LV networks contained relatively few measurement points per circuit and where they did exist, the measurement may have consisted of only a single, static maximum demand value for the total substation load.

Notwithstanding data availability challenges, we have developed robust Cost-Benefit Analyses (CBAs) that justified upsizing LV and HV mains cables. To do this, we used a mixture of engineering, statistical and economic analyses to overcome the challenges presented by data sparsity. Our revised approach for HV cables has been widely accepted by our peers in the ENA's Technical Losses Task Group (TLTG).

[6] Managing losses - UKPN DSO (ukpowernetworks.co.uk)

2.4.3.2. Current assessment of distribution losses

Table 13 shows a summary of total losses (technical and non-technical) on our networks from data that has been developed from the E3 – BCF worksheets (see the Annexes and Appendices). From this extract, we are able to provide a position on the percentage of total losses on our three networks.

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Total losses (tCO_2e)									
EPN	1,178,316	1,034,381	1,016,939	838,822	603,788	448,578	607,329	531,037	359,902
LPN	913,887	880,009	779,598	644,058	503,865	495,864	407,761	341,426	290,718
SPN	663,791	559,249	541,021	489,723	379,314	380,844	328,261	313,823	196,685
Total losses (GWh)									
EPN	2,860	2,238	2,468	2,386	2,133	1,755	2,605	2,501	1,861
LPN	2,218	1,904	1,892	1,832	1,780	1,940	1,749	1,608	1,503
SPN	1,611	1,210	1,313	1,393	1,340	1,490	1,408	1,478	1,017
Total units distributed (GWh)									
EPN	32,882	32,721	33,295	33,106	32,994	31,973	30,657	31,567	30,130
LPN	27,632	27,442	27,266	27,012	26,864	25,779	22,309	23,802	23,828
SPN	19,713	19,413	19,468	19,373	19,379	18,763	17,922	18,378	17,500
Total losses (%)									
EPN	8.70%	6.84%	7.41%	7.21%	6.46%	5.49%	8.49%	7.92%	6.18%
LPN	8.03%	6.94%	6.94%	6.78%	6.63%	7.53%	7.83%	6.76%	6.31%
SPN	8.17%	6.23%	6.74%	7.19%	6.91%	7.94%	7.85%	8.04%	5.81%

Table 13: Summary of losses per year and licence area

Table 14 shows the losses reductions reported through the E4 – Losses Snapshot worksheets for the regulatory year 2022/23 (see the Annexes and Appendices). The values in this table should be read in conjunction with the notes below.

Asset	EPN	LPN	SPN
	Saving (MWh)	Saving (MWh)	Saving (MWh)
LV cables	166.8	150.5	203.7
HV cables	230.9	493.3	365.9
Distribution ground-mounted transformers	507.8	803.8	393.3
Distribution pole-mounted transformers	322.1	0.0	113.7
Amorphous steel pole-mounted transformers	6.6	0.0	7.8
Total	**1,234.2**	**1,447.6**	**1,084.4**

Table 14: Summary of losses reduced in last year

Based on the realised benefits reported in the 2022/23 E4 – Losses Snapshot worksheets, a total of 3,766.2 MWh of CBA-justified improvements were made over the 12-month period. This equates to 728.3 tCO_2e in the year[7].

Beyond CBA-justified activities, we undertake a large number of activities that substantially reduce losses but for which losses are not the primary driver. An example would include replacing an aged distribution transformer with a current specification Ecodesign transformer of the same kVA rating. Ecodesign transformers comply with EU Regulations setting compulsory maximum losses levels for distribution transformers that are substantially more efficient than older specification transformers. Replacement in this example therefore reduces losses; but as the EU transformer specification is a mandatory requirement, the losses benefits are not included in the E4 – Losses Snapshot worksheets. Table 15 provides a summary of losses reduced through the adoption of more efficient transformers not supported by CBAs focused on losses.

[7] Greenhouse gas reporting: conversion factors 2022 - GOV.UK (www.gov.uk)

Asset	EPN	LPN	SPN
	Saving (MWh)	Saving (MWh)	Saving (MWh)
Secondary transformers	1,498.0	864.6	1,131.0
Primary and grid transformers	2,864.1	845.5	896.9
Total	**4,362.1**	**1,710.1**	**2,027.9**

Table 15: Losses reduced through the adoption of more efficient transformers not supported by CBAs focused on losses

The totals in Table 15 add up to 8,100.1 MWh, which equates to 1,566.4 tCO_2e.

Adding all figures together, we estimate that losses on our networks were reduced by 11,866 MWh per annum (equivalent to the annual electricity consumption of over 3,180 homes[8]) as a result of the work UK Power Networks has undertaken. Of this 3,766.2 MWh per annum was explicitly driven by losses considerations.

2.4.3.3. Activities undertaken in this regulatory reporting year

Current programmes to manage distribution losses

The following activities are CBA justified and are embedded in our business-as-usual activities to reduce losses:

- **HV cables** – We are installing larger cross-sectional conductors on the main lines of HV underground feeders to reduce resistance and hence variable I^2R losses. We have completed a comprehensive system-wide study which demonstrated that we save 5.94 MWh/annum for every kilometre of HV underground main line that we upsize from 185 to 300 mm^2 aluminium. This study further revealed that the NPV for this change is strongly positive. The methodology developed in this study was presented to our peers in the ENA's TLTG to ensure that our approach is robust.

  Significant volumes have been upgraded following changes to our HV Network Design policy. In total, 1,090 MWh will be saved every year going forward by upsizing main line conductors in the 2022/23 regulatory year. This is reported in the E4 – Losses Snapshot worksheets.

- **LV cables** – We are also installing larger cross-sectional conductors in LV underground feeders to reduce energy losses. Similar to HV cables, we have completed a comprehensive system-wide study which demonstrated that we save 6.35 MWh/annum for every kilometre of underground main line that we upsize from 185 to 300 mm^2 aluminium. This study further revealed that the whole-life benefit for this change is strongly positive.

  Significant volumes have been upgraded following changes to our LV Network Design policy. In total, 521.1 MWh per annum is saved every year going forward through upsized main line LV conductors. This is reported in the E4 – Losses Snapshot worksheets.

- **Use of larger distribution transformers** – We continue to replace existing distribution transformers with larger units where the saving in copper losses (variable) outweighs the increases in iron losses (fixed). Over the last 12 months we have increased the transformer size at 510 sites where the CBA demonstrated a positive NPV, yielding an annual improvement of 2,140.6 MWh. This is reported in the E4 – Losses Snapshot worksheets.

- **Use of amorphous steel transformers** – During LDR tranche 1, we collaborated with a transformer manufacturer to develop a pole-mounted amorphous steel transformer, recognising that fixed losses in distribution transformers account for a significant percentage of overall technical losses. During the 2022/23 regulatory year we installed six of these units on our networks, collectively delivering an energy loss reduction of 14.4 MWh per annum for their entire lifespan.

[8] Average annual electricity consumption per home obtained from: https://www.ovoenergy.com/guides/energy-guides/how-much-electricity-does-a-home-use.html#:~:text=How%20much%20electricity%20does%20a%20UK%20home%20use%3F,very%20large%20amounts%20of%20electricity.

- **Detection of contact voltage losses** – Also during LDR tranche 1, through our work with Princeton University, we discovered a new losses category that does not fit into the standard definition of either technical or non-technical losses – contact voltage losses (CVLs).

  During the RIIO-ED1 price control period, our use of a Mobile Asset Assessment Vehicle (MAAV) has realised a cumulative energy loss reduction of 9,372.6 MWh. We did not include this saving in the tables for this section on the basis that MAAV-related figures are reported in our E6 – Innovative Solutions worksheets (see the Annexes and Appendices).

The following activities were not driven primarily by network losses considerations but were undertaken as part of our business-as-usual activities and have had a positive impact on energy loss reduction.

- **Replacement of distribution and power transformers** – We continue to replace existing transformers with Ecodesign specification units that reduce fixed and variable energy losses. This year we replaced a total of 695 distribution transformers, which reduced losses by 3,493.6 MWh per annum. In addition we replaced 14 primary and grid transformers, further reducing losses by 4,606.5 MWh per annum. These energy loss reductions were not declared in our E4 – Losses Snapshot worksheets because the investments were not driven by energy efficiency considerations.

- **Ongoing review of design standards** – We are continuously developing new business cases to support further losses reductions. Once we have established a positive CBA in favour of an intervention, we amend associated engineering design standards to ensure that our recommendations are implemented swiftly and effectively. In this way, we ensure that losses are minimised for the entire lifespan of our new assets.

2.4.3.4. Forthcoming programmes to manage distribution losses

During the next regulatory year we will implement our updated losses strategy[9] and roll out the proven innovative solutions trialled during RIIO-ED1 as business as usual to reduce our network technical losses.

For EHV cables, we have updated our engineering standards to adopt a pragmatic approach for cable replacement, including standardisation of minimum size and avoiding cable tapering to eliminate or reduce power losses through currents flowing in the metallic sheaths of the cables.

We will continue to broaden our understanding of distribution losses, further develop our tools and processes, and embed these into our business-as-usual activities.

We will also continue to investigate how new approaches and technologies (e.g. flexibility and our Distributed Energy Resources Management System (DERMS) to deliver flexible connections) interact with network losses. Broadly speaking, these technologies are being developed to maximise network utilisation, which delivers financial and societal benefits to our customers by reducing the need to invest in network upgrades – but they will, as a side effect, increase technical losses. We therefore work towards making energy losses a part of every CBA that we develop to assess the economic merits of using new technologies. We will continue our collaboration with manufacturers and disseminate our findings to other DNOs who might benefit from these activities. Looking ahead, we will continue to consider the impact our DSO capabilities are likely to have on network losses.

Finally, we will keep abreast of new technologies coming to the market that may be used to minimise losses. Technological developments may also highlight new areas that we can focus on to target losses.

[9] Managing losses - UKPN DSO (ukpowernetworks.co.uk)

2.4.3.5. Summary of losses activities and benefits during this regulatory reporting year

Table 16 provides a summary of the costs and benefits from our CBA-justified losses activities and has been developed from the E4 – Losses Snapshot worksheets (please see the Annexes and Appendices). From this extract we are able to present the cumulative effect of our CBA-justified losses activities during the whole of the RIIO-ED1 period to date.

Programme/ project title	Regulatory reporting year (2022/23)			RIIO-ED1
	Distributed losses – justified cost	Reduced losses	Reduced emissions associated with losses	Cumulative reduced losses to date
	£m	MWh	tCO_2e	MWh
LV cable	0.38	521.10	100.8	7,465.69
HV cable	0.64	1,090.00	210.8	4,745.71
Distribution transformers	0.94	2,140.60	413.9	11,437.66
Amorphous steel transformers	0.00	14.40	2.8	124.24
Total	**1.96**	**3,766.10**	**728.30**	**23,773.30**

Table 16: Summary of losses reduced, costs and benefits from activities in RIIO-ED1 (technical losses)

Table 17 shows a summary of the volumes of CBA-justified losses activities during this regulatory reporting year and has been developed from the E4 – Losses Snapshot worksheets (please see the Annexes and Appendices).

Programme/project title	Description of unit	Volumes in regulatory reporting year (2022/23)	Forecast volumes for following regulatory year (2023/24)
LV cable	km	82	50.37
HV cable	km	183	64.01
Distribution transformers	each	516	461
33kV cables	km	N/A	16.01
132kV cables	km	N/A	3.93

Table 17: Summary of amount of losses activities in the regulatory reporting year and estimate for the following regulatory year (technical losses)

Furthermore, using the information from Table 15, we are able to present the cumulative effect of losses reduced through the adoption of more efficient transformers that are not supported by loss reduction CBAs. The cumulative losses reduction is approximately 62.8 GWh. These numbers are based on the values reported annually in the RIIO-ED1 RIGs Environment and Innovation Commentary.

2.4.4 Non-technical distribution losses

Non-technical losses occur through failures to correctly record electricity consumption within industry settlement systems. The primary responsibility lies with electricity suppliers, who must ensure that they accurately read meters, set the correct energisation status against each metering point and detect and investigate situations where people tamper with their supplies. Separately, there is that element of electricity theft committed by persons who make unauthorised connections to the distribution system and do not register with a supplier. This is known as theft in conveyance and it falls to the DNO to resolve.

Tackling theft in conveyance is mandated by our licence and industry codes, together with a broader societal obligation. Reducing ongoing theft is one aspect but our operations also identify and remedy the dangerous situations associated with unauthorised connections. Our investigators will frequently encounter overloaded connections, substandard wiring and exposed conductors presenting fire and electrocution risks. UK Power Networks is helping to protect the occupiers of these premises, their neighbours and the wider general public.

As shown in Table 19, our 2022/23 programme of work led to 480 cases of theft in conveyance being resolved across our three licence areas. A further 649 cases investigated during 2022/23 remained 'in progress' and UK Power Networks is either working with property owners to facilitate appropriate connection arrangements or awaiting meter point registration by the customer's chosen supplier. Whilst domestic sites represented the largest component, significant commercial and industrial sites also featured.

The overwhelming majority of cases are resolved through the customer registering their metering point with a supplier in accordance with normal industry processes. Nevertheless, in a small number of cases UK Power Networks may need to consider disconnection of the unauthorised supply. In the absence of serious safety concerns we seek to avoid enforced disconnections but our policy provides for this as a last resort to avoid the indefinite continuation of electricity theft.

In 2022/23 UK Power Networks continued to work with electricity suppliers to promote more effective electricity theft reduction. We remain engaged with the Retail Energy Code Company (RECCo), who oversee industry theft initiatives, and have been granted a seat on their steering panel. As members of the UK Revenue Protection Association (UKRPA), we helped to plan and organise a dedicated Suppliers and Networks Workshop to examine intra-industry barriers to countering the theft of electricity. Under the auspices of the UKRPA, we also continued our cross-industry collaboration to counter online misinformation whereby fraudsters are selling the concept of 'free' electricity.

Table 18 and Table 19 summarise key figures in respect of non-technical losses activities. Table 18 shows projected savings in megawatt-hours as a result of resolved instances of theft in conveyance. It also shows a calculation of the tonnes of CO_2 (equivalent) associated with this volume of electricity losses.

Programme/ project title	Regulatory Reporting Year (2022/23)			RIIO-ED1
	Distribution Losses- Justified Costs	Estimated Reduced Losses	Reduced Emissions associated with Losses	Cumulative Reduced Losses to date
Countering Theft in Conveyance	**£m**	**MWh**	**tCO_2e**	**MWh**
	0.38	14,979	2,897	64,073

Table 18: Summary of losses costs and benefits from resolved theft in conveyance cases in RIIO-ED1

Programme/project title	Description of unit	Volumes in 2022/23 Reporting Year[10]
Countering Theft in Conveyance	Resolved theft in conveyance cases	480
	'In Progress' cases	649

Table 19: Summary of theft in conveyance losses activities in the 2022/23 Regulatory Reporting Year

[10] Given that activities are driven by theft in conveyance being reported to, or identified by UK Power Networks, volumes for the 2023/24 regulatory year cannot be accurately forecast. In essence, the volume of work undertaken during the year will be driven principally by the quantity and quality of leads received from numerous industry parties and supplemented by self-generated leads. We estimate total leads to be broadly in line with the previous year's figures.

2.5 Other environment-related activities

2.5.1 Flood preparedness

In 2022/23 we continued to invest in our flood protection programme to ensure that customer supplies are protected from flood risk and exceeded our commitment of protecting 78 substations from the impact of flooding during the RIIO-ED1 price control period. This commitment typically takes the form of investing in physical asset protection at substations to ensure that customer supplies are not interrupted during an extreme flooding event.

In 2022/23 we successfully flood-protected nine substations serving in excess of 98,800 customers, bringing the total number of substations mitigated in RIIO-ED1 to 80. Protection will usually be achieved by protecting or raising critical equipment above the 1:1,000 year flood level, allowing for a climate change factor and 300mm freeboard to ensure that mitigations remain effective for the lifetime of our substations.

Investment has also taken the form of research, monitoring and ongoing analysis of flood risk across our operating areas. We are continuously investing to assess flood risk and to develop further capability in dynamic flood risk analysis and response across all three of our licence areas. Improvements in geospatial data and a programme of advanced flood risk assessments supported our RIIO-ED2 strategy. We are targeting to accelerate flood mitigation investment in RIIO-ED2 to protect an additional 85 substations over the five-year period.

Alongside the typical approach of protection from fluvial and tidal flooding, we ensure that supplies and critical assets are fully flood-protected from all sources. Assessments and projects also consider localised surface water flooding and groundwater flooding. In densely populated areas, such as central London, infrastructure failure of water mains can cause devastation to critical subterranean substation assets and must also be considered. We work closely with water infrastructure owners and implement flood-protection measures where required.

We have sought to provide flood-protection measures that are cost-efficient over the lifetime of the asset and deliver the maximum risk reduction to improve the number of customers protected in a worst-case scenario. Overall resilience in the network means that customers can often be very quickly reconnected at minimal inconvenience following flooding of critical equipment through automated switching. River levels and Environment Agency guidance are monitored during extreme weather events to inform the potential deployment of 1,000 metres of demountable flood barriers.

Aside from our targeted flood mitigation programme, we have implemented improvements in business-as-usual processes to ensure that flood resilience is at the forefront of all project planning and major investment in the network. Increasingly, plant and equipment is specified or modified to ensure a greater clearance from ground level and building designs have been adapted to ensure additional resilience from flooding. We are actively working with equipment suppliers to help design and improve innovative products that boost overall flood resilience throughout the network.

Our flood protection programme complies with two key documents: UK Power Networks' policy and design guidance document EDS 07-0106 – Substation Flood Protection and the industry best practice document ETR 138 – Resilience to Flooding of Grid and Primary Substations. UK Power Networks is an active participant in ENA flooding and climate change groups to ensure consistency, industry best practice and compliance to the most up-to-date regulation and standards.

We recognise that in addition to protecting customer supplies and our own assets we have a responsibility to both stakeholders and neighbouring communities to be an active participant in local flooding forums and proposed third-party projects to protect both property and business. Often, a reliable electricity supply is vital to operate third-party pumps or automated flood-protection systems. UK Power Networks was an active and willing participant in a number of public meetings, forums and consultations in 2022/23, including ongoing participation in the government's 'Climate services for a Net Zero resilient world (CS-N0W)' research programme[11], collaboration in the Climate Resilience Demonstrator (CreDo) digital twin project[12] and participating in the ENA's Climate Change Resilience Working Group.

UK Power Networks records and reports its flood related costs, volumes, protected sites and customer numbers to Ofgem each year. For more information, please refer to the Annexes and Appendices which contain a link to the worksheets CV16 and M1 (Flood Mitigation) for our three licensees.

2.5.2 Other environment-related activities

At the start of RIIO-ED1, UK Power Networks committed to the key targets presented in Table 20. We also launched a series of initiatives to exceed these targets where feasible and prepare the groundwork for target setting in RIIO-ED2. Over the course of RIIO-ED1 we achieved two DNO firsts: attaining the Carbon Trust Standard for carbon reduction; and verifying our carbon targets with the Science Based Target Initiative (SBTi), electing to include our scope 3 supply chain emissions in the validated target[13].

RIIO-ED1 KPI	Target	2022/23 position
Carbon reduction	16%	35.9%
Avoidance to landfill office and depots	70% avoidance	88.5%
Avoidance to landfill – street works waste	98% avoidance	99.9%
Sulphur hexafluoride leaks from bank in service	Leak rate less than 0.2%	0.05%
Fluid filled cable leaks (see section 2.3)	Reduce by 2% per annum from a starting point of 207,000 litres	188,355 litres against a 2022/23 target of 176,107 litres* *Note: a 34% reduction in oil leakage since 2014/15 has been achieved (see section 2.3)
Noise complaints	Investigate all noise complaints	All investigated. In addition, noise contours mapped for grid and primary sites. All local authorities engaged to ensure agent of change (developer) has appropriate planning conditions assigned to them.
Underground overhead high voltage lines in areas of outstanding natural beauty (see section 2.2)	80 km in SPN 96 km in EPN	11.23 km in SPN (16% of allowance used) 33.27 km in EPN (59% of allowance used)

Table 20: Our key environmental targets for RIIO-ED1

[11] Climate services for a Net Zero resilient world (CS-N0W): overview - GOV.UK (www.gov.uk)
[12] What is CReDo? - DT Hub Community (digitaltwinhub.co.uk)
[13] Standard Bearers | The Carbon Trust Companies taking action - Science Based Targets

In RIIO-ED2 we have built our environmental commitments around four key pillars. The key targets for 2028 are summarised in Table 21.

Pillar	Objectives	Targets
Carbon	Science Based Target Initiative – exceed our verified Well Below 2 Degree target for scope 1, 2 and 3 emissions	Exceed minimum reduction of 25%
	Exceed an equivalent SBTi target of 1.5 for our Business Carbon Footprint (directly controlled emissions scopes 1 and 2 excluding network losses)	Exceed minimum reduction of 42%
Resource use	Circular economy approach to high impact materials in early RIIO-ED2	Develop circular economy tool and set targets for high impact materials
	Recycle office, depot and network waste	80% recycling target by 2028 No recoverable waste to landfill by 2025
	Re-use street works spoil	99.5% recovered and reused by 2028
Biodiversity	Biodiversity Net Gain (BNG) at all new grid and primary sites	Achieve 10-20% BNG increase
	BNG improvement at 100 existing sites	Achieve aggregate BNG increase of 30%
Pollution	Reduce nitrogen oxide (Nox) emissions from our fleet and generators	33% reduction by 2028
	Fluid filled cable leak reduction	15% decrease by 2028 compared to beginning of the period

Table 21: Our key environmental targets for RIIO-ED2

Progress, preparatory work and actions to date to support these targets are outlined in the following sections and in our commentary on the BCF (please see section 2.4.1).

The focus on sustainability is increasing, and the need to proactively address both environmental risks and opportunities has not waned. We are committed to reviewing our targets annually, to ensure they are still aligned to evolving needs and are fit for purpose. As demonstrated in RIIO-ED1, as it became apparent that many of the targets would be exceeded, we launched a Green Action Plan creating more stretching targets and areas of new focus. This enabled us to build an ambitious environmental action plan for RIIO-ED2. In addition, as an early adopter among DNOs of the SBTi, we made a commitment to review and upgrade our carbon targets earlier than required in the SBTi cycle.

2.5.2.1. Energy management

We have continued to invest and install energy efficiency measures within our estate. Our long-term strategy has been to replace ageing assets such as air conditioning systems and boilers with new technology to use less energy and reduce our BCF.

Some examples of improvements we made this year are:

- Replacing ageing air conditioning systems in many of our offices
- Installing timers for air conditioning systems, and drying rooms across all three of our regions
- Replacing heating systems at key locations
- Refurbishing facilities by installing LEDs and fabric insulation at key locations

During 2022/23 the kWh associated with electricity use in our key occupied buildings has reduced by 9.4%. Over the entire eight-year period of RIIO-ED1 we have seen a total reduction of 64.7% in electricity carbon emissions associated with these buildings, while our gas emissions are also down by 22.6%. The 64.7% reduction in electricity carbon emissions has been assisted by improvements in the carbon intensity of electricity generation in the UK, as coal is replaced by renewables in the generation mix. There is no such reduction in the carbon intensity of gas so the 22.6% reduction is down to heating system improvements.

2.5.2.2. Biodiversity

Ilketshall Grid is one of 100 UK Power Networks substations which were selected for biodiversity enhancement in RIIO-ED1.

In July 2020, when Suffolk Wildlife Trust ecologists visited the substation to assess biodiversity, they found that reeds had filled the pond completely so there was no open water, significantly reducing its value to wildlife. In February 2021, based on their recommendations, the pond was enrolled in Natural England's district level licensing scheme to create and restore breeding ponds for great crested newts.

During the first stage of the restoration (see Figure 5), employee volunteers removed some trees from the south side of the pond to allow more sunlight to reach the water. The cut wood was used to build a hibernaculum beside the pond, offering a safe refuge for newts, invertebrates, or small mammals.

Figure 5: First stage of the restoration

A digger dredged out all the reeds, before reprofiling the base of the pond and creating a few slightly deeper sump areas (see Figure 6). Some of the extracted material was used to create raised banks on either side of the pond. These will provide good terrestrial habitat for newts.

Figure 6: Second stage of the restoration

The pond had naturally refilled with water by April 2022 when Suffolk Wildlife Trust ecologists visited again. They assessed the pond using the 10-point Habitat Suitability Index[14], rating the pond as 'Excellent' for great crested newts. Great diving beetle and dragonfly nymphs were among the invertebrates seen in the pond, evidence of excellent water quality, and several smooth newts were observed.

[14] Great Crested Newt Habitat Suitability Index (HSI) - Amphibian and Reptile Groups of the UK (arguk.org)

The ecologists also collected water samples for eDNA testing which, when analysed in the laboratory, provided evidence that great crested newts had been using the pond. When more vegetation has developed the pond will almost certainly be used for breeding.

'Before' and 'after' images of the pond are shown in Figure 7. The pond will continue to be regularly monitored as part of the Natural England scheme.

Before

After

Figure 7: The pond at Ilketshall Grid before and after restoration

We have committed to identifying a further 100 of our sites for biodiversity enhancement between 2023 and 2028.

2.5.2.3. Noise and local authority engagement

During 2022/23 we continued to build on our engagement around low frequency noise from substations with local authorities and the acoustic community. We have now delivered webinars to 211 environmental health officers and local authority planners in our operating area. 52% of the local authorities represented at these training events subsequently registered for our Open Data Portal and can now use our noise contours triage tool to assess future development.

Since attending the webinars, environmental health officers from several local authorities have contacted UK Power Networks to seek guidance about proposals for new developments in their area. This will have helped to ensure that our business is protected from future noise nuisance claims and the associated costs.

Our low frequency noise presentation has been delivered at branch meetings of the Institute of Acoustics (IOA), the professional body for acoustic consultants. These were attended by 127 members of the IOA who were also given the opportunity to register for the Open Data Portal noise contours. As a result of our engagement with IOA members, UK Power Networks was approached by Defra and will contribute to a project aimed at producing specific guidance about new development near existing substations.

During 2022/23 we received 40 enquiries about substation noise, which is only slightly higher than the annual average (excluding 2020/21 when there was a spike during the COVID-19 pandemic). Our environment team addresses noise enquiries by conducting an initial desktop assessment to determine the likelihood that our equipment is causing a noise nuisance. When appropriate, a noise survey is conducted by a member of the team or a specialist acoustic consultant to investigate further and make recommendations. Findings are assessed against the procedure for assessment of low frequency noise complaints which was developed by Salford University (NANR 45) on behalf of Defra to determine whether a low frequency noise would be considered a statutory nuisance under the Environmental Protection Act.

It is important to note that most enquiries prove to be not justified because the noise is either below the level of nuisance or is not attributable to a UK Power Networks asset.

2.5.2.4. Water management

Water management, while not a material environmental impact for our operations, is, nevertheless, material to the UK, as recent extreme weather events and droughts have demonstrated. Climate forecasts suggest that water scarcity, particularly in the South East, could become an area of greater concern. As part of our Environmental Action Plan, we have set ourselves a voluntary target to reduce our water consumption by 10% over the RIIO-ED2 period.

Our offices, depots and operations are not significant users of water but experience has shown that low level leaks can sometimes go undetected, so our initial focus has been on improving monitoring, smart metering, and consumption reporting. This has enabled us to target those sites that are high volume users with problematic access for gaining meter reads (e.g. meters in inaccessible, difficult to reach pits). Our efforts have already identified anomalous consumption patterns that have either identified leaks or inaccurate reporting.

This year we have continued our facilities refurbishment programme by upgrading our office welfare facilities with water saving devices when refurbishments are undertaken. We have recently refurbished our Maidstone and Bury St Edmunds offices, which involved installing sensor-flow urinals rather than time flow urinals, saving up to 80% on water consumption, sensor taps that can save up to 65% usage, and toilet sensor controls that can save up to 30% usage.

On some of our major projects we have been able to use eco-cabins which are fitted with water efficiency equipment, eliminating the need for automatic weekly services. Rainwater harvesting is used with extra-large water tanks for WC facilities. Waterless urinals, on-demand hot water and sensor technology are all features we have installed to avoid wasting water.

Our Alliance Contractors (see section 2.5.2.10) have taken similar steps with their on-site welfare and water use with eco-cabins where possible. Adopting additional bespoke controls at some development sites that include grey water (rainwater) harvesting to use for small batches of concrete mixing and dust suppression for handheld cutting, as well as restricting water flow on taps and urinals so that excessive flushing and flow rates are minimised but still meet welfare requirements.

2.5.2.5. Environmental awareness and training

Our in-house environmental awareness course ‘Working with the Environment in UK Power Networks’ continues to be maintained and delivered by our environment advisers. All new apprentices joining the business are required to pass this course. To date 410 employees have successfully completed the training.

Environment advisers also worked with digital learning specialists from our technical training team to develop two eLearning courses for operational staff: ‘Consignment of Hazardous Waste Asbestos’ and ‘Environmental Spill Awareness’. Both courses were launched in 2022.

The Consignment of Hazardous Waste Asbestos course (see Figure 8) was developed for employees who are trained to remove certain types of asbestos waste. It shows them how to correctly complete a waste consignment note and ensures they understand their duty to comply with the hazardous waste regulations when transporting this type of waste. During the 2022/23 regulatory year, 492 people successfully completed the course.

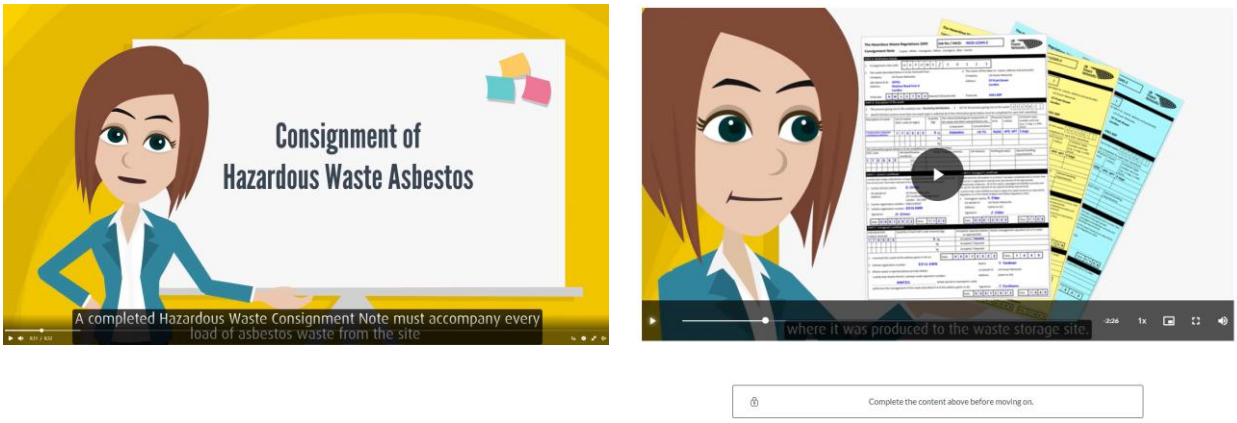

Figure 8: Consignment of Hazardous Waste Asbestos eLearning course for operational staff

The Environmental Spill Awareness course (see Figure 9) ensures that operational employees know how to prevent and manage spills. It explores the contents of a spill kit, how and when to use it, and when to call in specialist contractors. This helps to ensure that pollution is prevented, or that its impact is minimised. Following its launch 343 people have successfully completed this course, ensuring that they know how to prevent and manage spills.

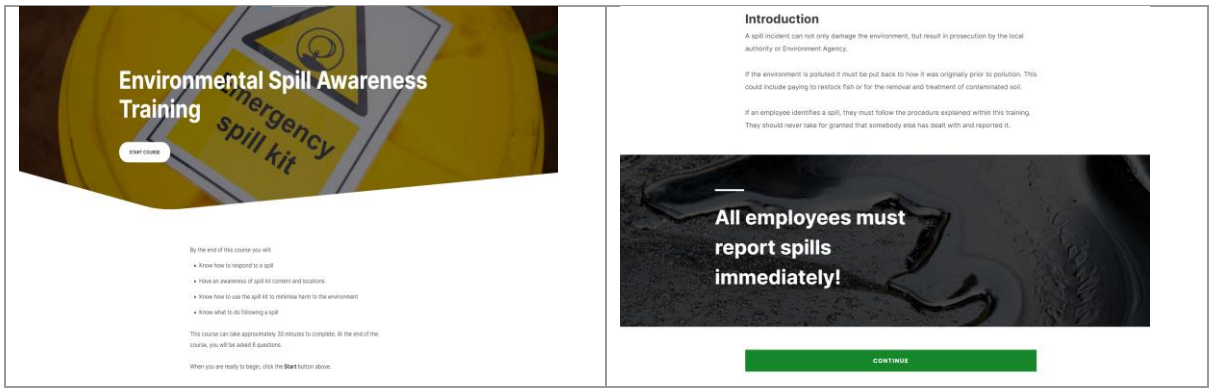

Figure 9: Environmental Spill Awareness course for operational staff

2.5.2.6. Alliance Contractor Forum

UK Power Networks introduced its ED1SON Alliance in 2015, a partnership of key contractors implementing major infrastructure projects. The Alliance Contractor Forum was established to assist in achieving the environmental commitments that are highlighted in UK Power Networks' Business Plan and Environmental Action Plan for the RIIO-ED2 period. Attended by key contractors and UK Power Networks sustainability leads, it acts as a platform for our key supply chain partners to regularly interact and share innovative ideas to help reduce our impact on the environment. The targets for this forum have been reviewed and aligned to our new RIIO-ED2 Business Plan commitments for the 2023-2028 period (see Figure 10).

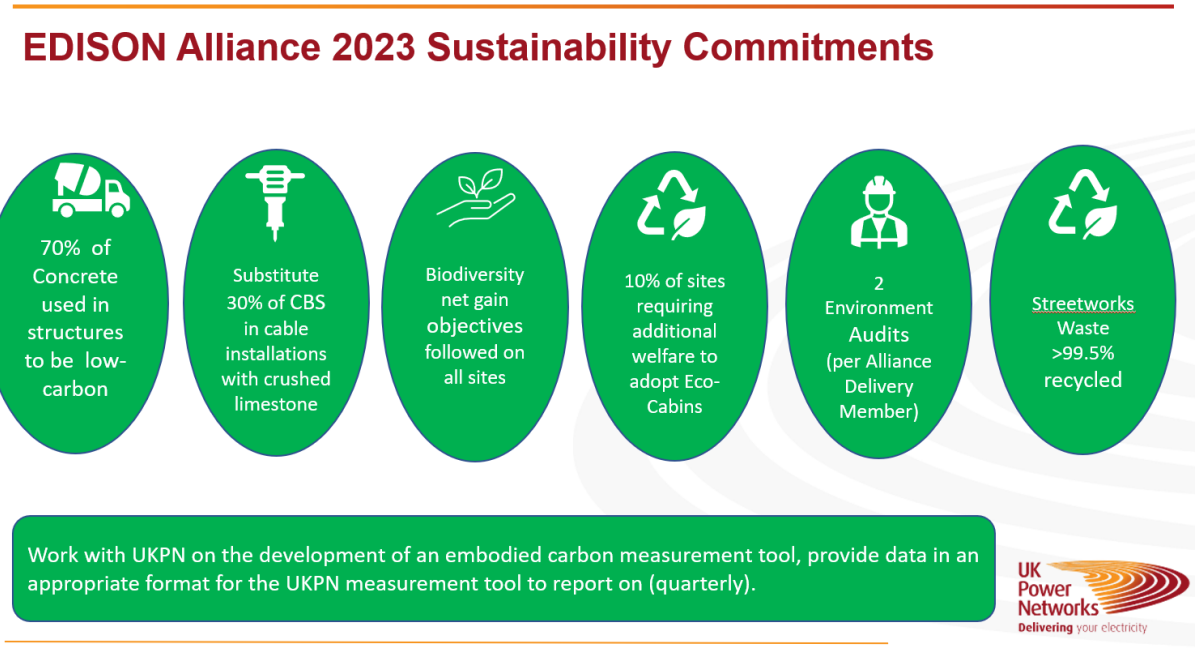

Figure 10: ED1SON Alliance 2023 sustainability commitments

Regular meetings are held to track performance against targets and share best practice and innovations.

Recent actions and discussions from Alliance forums include:

- Progression of the hybrid generator trials and sourcing opportunities for fully certified lower carbon hydrotreated vegetable oils (HVOs)
- Maximising the use of low carbon concrete
- Impact and preparation of regulatory change associated with street works waste management
- Establishing site signage to inform customers and staff of our biodiversity improvement areas

2.5.2.7. Civil sanctions

We report on any cautions, notices, warnings, penalties, prosecutions, and reportable environmental incidents. Our 2022/23 results are reported in our E2 – Environmental Reporting worksheets (please see the Annexes and Appendices).

During 2022/23 we reported 14 events to the Environment Agency, all relating to leaks from fluid filled cables which had the potential to cause pollution; one of these was due to cable damage by a third party. Five notices, warnings or letters were received. Three of these related to fly tipping on UK Power Networks' land, and two were regarding vermin.

2.5.2.8. Global environmental benchmarking

Through our shareholders' participation in global sustainability indices, we continue to report our sustainability performance in the Dow Jones Sustainability Index and the Hang Seng Sustainability Index. Our participation in completing these indices and providing supportive evidence associated to environmental, social and governance (ESG) criteria, demonstrates that UK Power Networks operates in an environmentally sustainable and corporately responsible manner.

We support our shareholders to maintain a strong position in both the Dow Jones and Hang Seng Sustainability indices. Our reporting includes quantitative and qualitative information on the following:

- Governance strategy and policy
- Environmental, legislative and regulatory risk management
- Supply chain management
- Innovation management
- Operational eco-efficiency
- Biodiversity
- Climate strategy
- Corporate citizenship and philanthropy
- Stakeholder engagement

2.5.2.9. Circular economy and waste management

During 2022/23 UK Power Networks moved forward in understanding and implementing circular economy (CE) principles into the business. We began exploring CE in both our product and waste streams. We also collated our data using the Ellen MacArthur Circulytics toolkit as part of the process in assessing our material use and successfully made our first submission to the Ellen MacArthur Foundation[15].

Through engaging with various parts of our business and our supply chain, we have improved our data collection methodology and have been able to identify and measure CE for specific waste and material streams, such as packaging around personal protective equipment (PPE) and power tools and specifying low carbon concrete. We continue to refine and enhance our waste data capture and analysis, ensuring we collect and measure waste data across the business. This has enabled us to deliver monthly waste statistics to measure and display our progress as a company. In RIIO-ED2 we will focus on developing a detailed understanding of our waste and material streams so that we can continue driving waste minimisation efforts.

During 2022/23 we generated 4,083 tonnes of office and depot waste. Of this, 471 tonnes of non-recoverable waste (11.5%) ended up in landfill. The remaining 3,612 tonnes (88.5%) were diverted from landfill and were either recycled or used for energy recovery. This is significantly ahead of our existing target for the RIIO-ED1 price control period of 70% diversion from landfill.

2.5.2.10. Streetworks waste classification

UK Power Networks continues to engage with Streetworks UK and has actively taken part in trials, submitting over 100 samples to aid the design and development of the new sampling protocol. We have developed tools to assist internal teams in undertaking desk top assessments which will inform and feed into both the site-based and overall waste assessments.

This project has been developed to prepare for the removal of the Environment Agency's Regulatory Position Statement (RPS) 211, which has allowed utility companies to classify small volumes of excavated waste as non-hazardous, without the need for extensive classification. This RPS remains under review by the Environment Agency whilst Streetworks UK and its members develop an enhanced sampling protocol. The new protocol's purpose is to preclude the requirement for extensive classification by developing a sampling plan to capture site specific data. Once the sampling protocol has been agreed by the Environment Agency, the RPS will be withdrawn.

[15] https://ellenmacarthurfoundation.org/a-toolkit-for-policymakers

3 Smart Grids, Innovation and Our Role in the Low Carbon Transition

3.1 Introduction

As we look back on 2022 as the UK's hottest year on record[16], it is clear that the push towards net zero is more important than ever. We are committed to playing a leading role in supporting this transition.

We are in the midst of a period of unprecedented change for the UK's electricity system and its customers. Volumes of electric vehicles (EVs) and low carbon technologies (LCTs) such as heat pumps continue to rise. At the same time, we are acutely aware of the cost pressures our customers face in the current economic climate and that they expect more of the electricity industry. Customers' attitudes and behaviours are changing as they respond to the rise in energy costs, while the number of people eligible for priority support in the event of a power cut continues to grow. We firmly believe that we can best support the transition to net zero through smart network operation, innovation, and collaboration with our customers.

Changes to the way energy is produced and used will impact customers in ways that are not yet fully understood, so it is vital that our strategy remains agile and adaptable to shifting trends and new capabilities. We now have a team that is solely focused on developing innovative ways of ensuring no customer is left behind in the journey to net zero. Over the course of the RIIO-ED1 price control period we have worked hard to embed innovation in our business. We will refine our approach still further as we move into RIIO-ED2.

This section highlights the changing policy context, low carbon technology uptake, our innovation portfolio, innovation benefits delivered into business as usual, and our strategy for maximising the benefits of smart metering.

3.1.1 Key challenges and how we will address them

The UK's legally binding target to reach net zero by 2050 will require extensive collaboration across organisations, industries, and sectors to achieve. That is why we collaborate with many organisations to identify opportunities and maximise outcomes for our stakeholders and customers. Collaboration ensures that we have a diverse portfolio of projects and source the best ideas. We have evolved our Innovation Strategy so that our role going forward is less focused on driving benefits solely within the network, for the benefit of consumers, and more focused on delivering a social return on investment.

Given the pressures on our customers' finances, increasing energy bills, the climate change challenge and the opportunity to innovate to support our customers in vulnerable circumstances, there has never been a greater need for innovators to tackle these macro challenges. As we move into RIIO-ED2, our focus will widen to deliver greater impact through innovation, by evolving the pillars of our Innovation Strategy:

- Innovating to reduce consumer vulnerability
- Facilitating net zero and the energy system transition
- Proactively optimising assets and practices
- Expanding flexibility and commercial evolution
- Opening data and maximising digitalisation
- Expanding to whole energy systems

[16] Climate change drives UK's first year over 10°C - Met Office

For more detail on our Innovation Strategy, please see section 3.2.

3.1.2 Our role in the low carbon transition

We recognise that our role in delivering a zero-carbon electricity system and enabling the UK to reach the net zero target brings the following key challenges:

- Significant volumes of decentralised generation
- Bidirectional power and information flows
- Significant volumes of renewables with managed intermittency
- Customer sites that both produce and consume electricity
- Growing volumes of EV charge points connecting at LV
- Uncertain volumes of EV charge points and heat pumps
- Managing significant growth in customer interaction rates

We have therefore adopted an approach and plan that include the following measures:

- Building market intelligence systems that provide early visibility of emerging customer and system needs, so that we have the maximum time possible to respond to unexpected changes in demand
- Empowering our DSO to make decisions in the best interests of customers, having considered all potential solutions on a level playing field basis so that we can use every possible solution to solve unanticipated problems
- Investing strategically, ahead of demand, in areas where there is high certainty of need – a commitment we made as part of our RIIO-ED2 business plan. This includes delivering an additional 7-8 MW of capacity in areas located near 14 motorway and trunk road service stations and helping 242,000 off-gas grid homes in our operating area to transition away from fossil fuels
- Ensuring we have the resources to respond flexibly to needs. We will do this by deploying automation and innovation, building our digital skills through the creation of a Digital Skills Academy which has now been launched. This service is now open to employees in relevant roles looking to develop their skills. We are also further promoting competition in the connections market, so that parties who want to connect to our network have genuine choices about who can provide them with the services they need
- Working with local authorities, community stakeholders and other utilities to help them realise their net zero ambitions, by unlocking network investment consistently and in a timely way
- Working with Ofgem to establish flexible and responsive regulatory mechanisms that match our funding to the volume of investment that we need to make
- Critically, continuously monitoring the implementation of our strategy so that we can adjust what we do ('course-correct') to stay on track

3.1.3 Low carbon technology (LCT) and distributed generation (DG) uptake

Since 2015 we have monitored yearly uptakes of DG, EV charge points and heat pumps and reported these values to Ofgem. Increasing DG and LCT volumes can drive increasing requirements for network capacity. To deliver the efficient and strategic network improvements needed to support LCTs on our network, we have developed our expertise in forecasting and monitoring the load on our network and improved our engagement with local authorities to gain local insight on developments. However, genuine uncertainty remains in the detail of where and when LCT uptake will occur.

Rather than commit upfront to large, expensive network upgrades for LCT predictions that may not materialise when and where expected we will use 'uncertainty mechanisms' agreed with our regulator, Ofgem, to fund this work. This means that when it becomes clear that the demand is materialising, we will use these uncertainty mechanisms to gain the funding needed. These uncertainty mechanisms will allow us to support higher volumes of LCTs being connected on our network should there be sharper than expected uptakes in demand for new connections, while keeping costs down if investment is not required in a specific area.

We are closely monitoring the installation of LCTs and continuously assessing their impact on our network. Our focus in RIIO-ED2 will be on increasing visibility of the LV network in particular, where LCTs such as EVs primarily connect. Our LV visibility strategy is comprised of adopting a data-first approach; we are now modelling loading across our whole LV network and enhancing this insight by deploying physical monitoring economically and efficiently for specific locations.[17]

The values presented in Table 22 and Table 23 are for the 2022/23 regulatory year and are reported in the E7 – LCTs worksheets for our three licence areas (please see the Annexes and Appendices). They show the combined values for the primary and secondary networks. It should be noted that the values for 'EV slow charge' and 'EV fast charge' have been updated to reflect the latest information available at the time of submitting this report.

	EPN	LPN	SPN	Total
Heat pumps	3,489	321	1,513	**5,323**
EV slow charge	99	2,351	152	**2,602**
EV fast charge	10,850	2,662	7,483	**20,995**
PVs (G83)	22,030	3,118	12,694	**37,842**
Other DG (G83)	-	-	-	-
DG (non-G83)	797	222	500	**1,519**
Total	**37,265**	**8,674**	**22,342**	**68,281**

Table 22: Number of LCTs connected in the last regulatory year (not including storage)

	EPN	LPN	SPN	Total
Heat pumps	30.4	3.2	14.5	**48.1**
EV slow charge	0.4	8.7	0.6	**9.6**
EV fast charge	122.5	31.8	77.7	**232.0**
PVs (G83)	95.2	11.0	56.2	**162.4**
Other DG (G83)	-	-	-	-
DG (non-G83)	46.7	6.5	15.7	**68.9**
Total	**295.1**	**61.1**	**164.7**	**520.9**

Table 23: Additional megawatts of LCTs connected in the last regulatory year (not including storage)

Heat pumps

In our RIIO-ED1 Business Plan we predicted that over 60,000 heat pumps would connect to our network in 2022/23, whereas 5,323 actually connected. As we highlighted in previous years, the Business Plan Data Template (BPDT) assumption was that in 2016 the Zero Carbon Homes policy would be implemented, kick starting heat pump deployment. The Heat and Building Strategy released in late 2021 has outlined the government's approach to decarbonising this sector. It is a market-based approach, focused on stimulating early demand through regulation, levies, and capital funding. The strategy targets at least 600,000 heat pump installations annually by 2028, approximately one-third of which is expected to be installed in UK Power Networks' operating area. In July 2023, the Climate Change Committee's head of net zero noted that under current policies it was difficult to see how the government's target of 600,000 heat pumps would be achieved[18].

[17] Source: UK Power Networks – EV Strategy 2023 UK Power Networks Electric Vehicle Strategy 2023

[18] https://utilityweek.co.uk/ccc-boss-casts-doubt-on-600000-heat-pump-target/

Policies such as the Boiler Upgrade Scheme are expected to encourage significant growth in heat pump installations. Additionally, the Future Homes Standard will come into effect from 2025, requiring new homes to be fitted with a zero-carbon heating source, such as a heat pump. While we expect that this will lead to a further increase in heat pump deployment, we cannot be sure of the trajectory of heat pump installations for 2023/24 due to the decrease in heat pump installations from 2021/22 to 2022/23 and the uncertain economic climate.

EV charge points

In our RIIO-ED1 Business Plan we predicted over 61,000 charge points connecting in 2022/23, whereas our records show that 23,597 actually connected. This is significantly fewer than in 2021/22 due to the closure of the EV Homecharge scheme (EVHS) in April 2022. This led to 2021/22 being a bumper year for domestic charge point installations, as people wanted to take advantage of the EVHS discount before it ended. The follow-on EV chargepoint scheme is only for those living in flats or rented accommodation, not homeowners.

The EV Infrastructure Strategy indicates that charge point installations will continue to increase, especially the rapid en-route and public on-street market segments as the UK targets a minimum of 300,000 public chargers by 2030. The Rapid Charging Fund will support rapid en-route charging points along motorways and A roads. Meanwhile, the Local EV Infrastructure fund will support local authorities in improving on-street public charging infrastructure. Consequently, we expect the number of EV charge points to increase in the next regulatory year. However, as previously stated, we cannot be sure of the trajectory of charge point installations for 2023/24 due to the decrease in charge point installations from 2021/22 to 2022/23 and the uncertain economic climate.

Distributed generation

In our RIIO-ED1 Business Plan we predicted that over 21,000 photovoltaic (PV) units would connect to the secondary network in 2022/23, whereas approximately 37,842 units actually connected. This is the first year in the RIIO-ED1 regulatory period where actual PV installations exceeded our forecast, with the 2022/23 regulatory year seeing more PV installations than the three preceding years combined. Industry analysis suggests that this increase could be due to the rise in energy prices leading to an improvement in the business case for domestic and industrial/commercial PV for self-consumption.

The outlook for distributed generation installations is positive for the next regulatory year as there are now various policies and systems to facilitate the development of local flexibility services, along with a national call for post-pandemic green recovery in meeting the 2050 net zero target. In addition, we currently have almost 500 MW of grid scale storage connected to our network. We believe that this capacity should be reflected in the E7 tables when they are developed into the M20 return for RIIO-ED2, to provide visibility of storage assets.

3.2 Progress of the Innovation Strategy

One of the key findings from discussing the future with our innovation stakeholders is that everyone recognises that the challenges we face span the entire industry – and beyond – and require greater collaboration between parties to tackle them. We have therefore evolved our Innovation Strategy so that our role going forward is less focused on driving benefits solely within the network, for the benefit of consumers, and more focused on enabling innovation across the industry and delivering a social return on investment.

The path to decarbonise transport and heat is not fully clear, and the impact that this transition will have on customers' finances is a great concern for all. Our Innovation Strategy must provide agility to face future uncertainties, leverage other sources of funding and remain open to disruptors. It must maximise the opportunities of seizing benefits across the energy value chain and provide a venue to collectively determine solutions that will unlock and deliver benefits to society. These shifts will have significant implications for customers; therefore we recognise the importance of focusing our innovation efforts on ensuring no one is left behind in the energy transition.

2022/23 was a year of change, as we closed out RIIO-ED1 and prepared for RIIO-ED2. Our RIIO-ED1 innovation portfolio focused on three pillars: Efficient and Effective, Net Zero Ready, and Future Ready, illustrated in Figure 11.

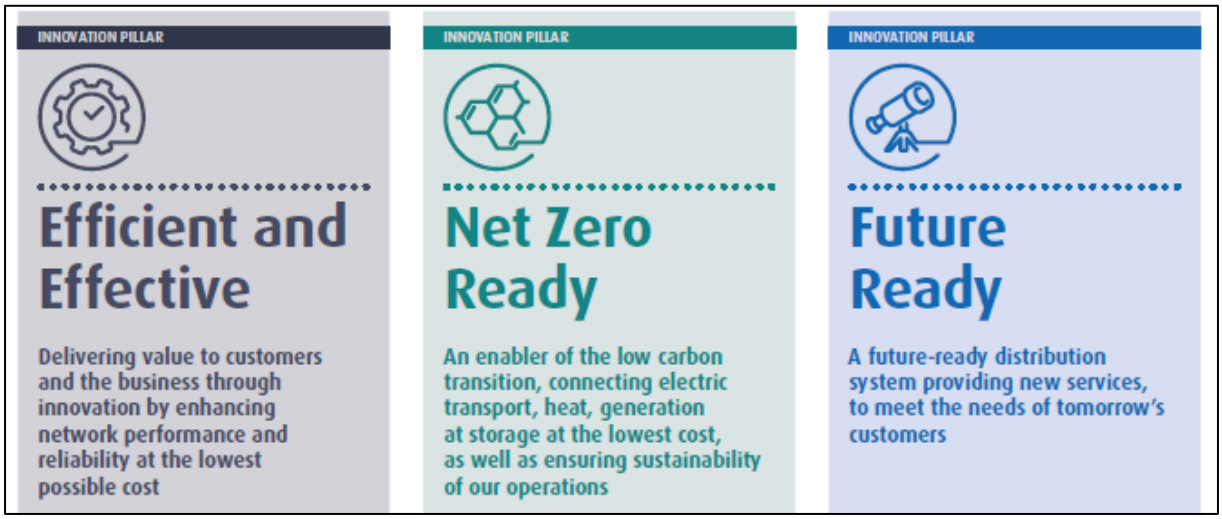

Figure 11: Areas of focus in our Innovation Strategy in RIIO-ED1

As the year progressed, we started to consider how project ideas would fit into the new RIIO-ED2 governance and where projects must have the potential to facilitate the energy system transition and/or benefit consumers in vulnerable situations.

Based on the changing needs of our customers, the industry and the regulatory framework, we have adopted the industry-wide themes illustrated in Figure 12.

Figure 12: Our RIIO-ED2 innovation themes

Our Innovation Strategy will maintain the highest level of investment – including through our own funding – whilst leveraging our innovation culture, processes, frameworks, and experience of deploying innovation into business as usual to deliver benefits to our network and customers.

3.2.1 Summary of the trials undertaken in the 2022/23 regulatory year

A culture of innovation that has developed over the eight years of RIIO-ED1 reaches to the very heart of UK Power Networks. Innovation is not confined to a single department or to a handful of passionate individuals, but to our teams across the business. From tree cutting to customer service, field engineers to telecommunications specialists – an innovative approach is delivering benefits for our customers, today and for the future.

Within our overall innovation portfolio we worked extensively on three key themes in RIIO-ED1: Net Zero Ready, Future Ready, and Efficient and Effective. Our whole systems strategy was a key element of our RIIO-ED2 Business Plan. It outlines our approach to facilitating net zero at the lowest cost, with an in-depth description of our proactive approach to enable the transition in bought transport and heat. The themes from our NIA Annual Summary are shown below.

3.2.1.1. Net Zero Ready

Under this theme, we aim to support the transition away from fossil fuels. The market share of EVs in the UK has remained consistent with a 12 month rolling average of approximately 22% in both March 2022 and March 2023[19]. Although the market share of EVs has remained relatively unchanged, sales of battery EVs (BEVs) increased by 18.6% between March 2022 and March 2023, with sales of plug-in hybrid EVs (PHEVs) increasing by 11.8% over the same period. Heat pumps, heat networks and hydrogen are now widely considered as the collective solution needed to decarbonise homes. The following summary provides more information on how we are addressing the key themes in our Innovation Strategy.

- **Optimise Prime** is the world's largest trial of commercial EVs, aiming to understand and minimise the impact that electrification of commercial vehicles will have on distribution networks. Working with Hitachi, British Gas, Royal Mail and Uber, we studied charging behaviour and investigated flexibility opportunities for return to home, depot based and mixed charging fleets. We tested alternative network connection options to reduce the time and cost it takes to connect, as well as providing tools and data to support fleet managers in the EV transition.

- **Emerge** aims to reduce the time taken for domestic customers to switch to LCTs and reduce the disruption of multiple home visits. Recognising that a fuse upgrade could be a blocker to the replacement of a gas boiler with a heat pump in an emergency breakdown event, we worked with Octopus Energy to explore what is required to enable appropriate third-party meter operator organisations to undertake fuse upgrades for customers.

- **CommuniHeat** is developing a roadmap to enable rural communities to switch to low carbon heating in a way that ensures comfort, affordability and a smooth transition. With the village of Barcombe as a case study, CommuniHeat is writing the book on how communities can achieve this transition over the next 10 years so we can share our learning with other off-gas communities throughout the UK. We are working in partnership with Barcombe residents, the local community energy group Ovesco and the engineering practice Buro Happold.

- **NeatHeat** is investigating the potential of Zero Emission Boilers (ZEB) as an alternative to carbon-intensive gas boilers in homes where a heat pump is unsuitable due to limited space. The ZEB manufacturer tepeo is installing storage-based heating technology in customers' homes whilst OVO Energy is testing whether a first-of-its-kind time-of-use tariff will incentivise storage heating outside peak hours. The goal is to understand the impact on the network and customers in terms of disruption, time and cost.

- **Shift 2.0** was established to explore the potential for dynamic and locational pricing to address secondary peaks, herding behaviour and congestion in certain parts of the network caused by the rapid uptake of LCTs, new electricity tariffs and wider energy market price signals. By understanding the scale and timing of these issues, the appropriate mechanisms and systems can be designed to further stimulate the evolution of market-led customer propositions and business models.

3.2.1.2. Future Ready

Being Future Ready means meeting the needs of tomorrow's customers, as our customers are changing and their requirements from DNOs are evolving. Future Ready also seeks to ensure that the benefits of the energy transition towards net zero are accessible to all and covers the provision of new services involving Distributed Energy Resources (DERs). Our projects in this area include facilitating the reliable connection of increased DERs to power distribution networks as well as increasing the resilience of the LV network with greater visibility, monitoring and control. Below we highlight a Network Innovation Competition (NIC) project and four Network Innovation Allowance (NIA) projects in our Future Ready portfolio.

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[19] March new car market continues recovery with eighth month of growth - SMMT

- **Constellation** is an NIC-funded project led by UK Power Networks and delivered in partnership with ABB, GE, the University of Strathclyde's Power Network Demonstration Centre (PNDC), Siemens and Vodafone. The project aims to demonstrate how protection and control solutions located locally within DNO substations can be used to facilitate the connection of more DERs on to distribution networks. It also includes a smart service that de-risks the likelihood of sudden and widespread DER curtailment and/or disconnection. This world-first innovation initiative is essential to facilitating net zero through enhancing the core of the distribution network: substations. It will introduce first-of-its-kind local intelligence at the substation level that complements existing functionality, in a sustainably cost-efficient manner for our customers.

- The NIA-funded project **Collaborative Local Energy Optimisation (CLEO)** will provide core planning data sets via an online, self-service energy planning tool to support the planning process for our local authorities, helping them to make the best choices for their communities. This local area energy planning self-service tool will allow local authorities to layer local input such as decarbonisation strategies and action plans, local market trends, social inclusion policies and transport plans upon our network infrastructure data, to develop options for their communities.

- The NIA-funded project **High Voltage (HV) Autoquote** will provide a self-service connection that offers customers between 300 kVA and 1 MVA. Furthermore, it aims to provide budget estimates for connections from 1 MVA to 2.5 MVA and will codify the tacit logic used in HV quotations to enable this automation. It will also include the development of logic to assess the cost of traffic management. This innovation project will perform the necessary analysis and change to put connection offer requests in the hands of the consumer, allowing them to see the cost of different options interactively, reducing time to deliver connection offers and improving service delivery.

- The NIA-funded project **Our View** is investigating the benefits of using video-aided technologies to enhance customer service delivery and the safety of field staff. This will allow customers to initiate video calls with our agents when reporting problems, allowing the potential for faster resolution and improving customer satisfaction. It will also allow our task force to benefit from technologies such as Artificial Intelligence (AI) when completing risk assessments. Once successful, the solution can be integrated into existing workflows to optimise processes and maximise the benefits to both our customers and task force.

- **Social Connect** is helping to accelerate the identification of customers in or at risk of entering fuel poverty. The project is currently developing an innovative AI tool, modelled using the best available data including Smart Meter System data to enhance our understanding of fuel poverty across our licence areas. This work will enable UK Power Networks to support more customers in vulnerable circumstances and provide further opportunities to promote energy efficiency as a way to reduce energy bills.

3.2.1.3. Efficient and Effective

Electricity distribution networks are evolving at an unprecedented rate. The national net zero target and a profound transformation of the energy landscape have led electricity customers to change the way they use electricity. A renewed focus on digitisation and decarbonisation of heat and transport provides our customers with the opportunity to make a positive impact on our operating environment and address the climate change issue. However, this considerable opportunity comes with key technical and commercial challenges to resolve. UK Power Networks believes that DNOs should be at the centre of the energy revolution and among the key protagonists – alongside their customers – of the country's decarbonisation journey.

The Efficient and Effective strategic focus area represents UK Power Networks' response to the decarbonisation challenge. Its key objective is to deliver smart solutions and distribution network improvements to guarantee a smooth low carbon transition at the lowest possible cost. Numerous innovation projects are delivered by UK Power Networks' specialists and external partners to explore new, enhanced ways of designing, operating and managing the network.

UK Power Networks strives to improve network performance by placing innovation at the heart of everyday activities. Delivering a successful, first-of-its-kind project means delivering smart savings for customers. Some of our key project highlights are reported below.

- **Stratus** – trialling first-of-a-kind smart transformers in the distribution network to increase visibility of the LV networks (improved data quality to network engineers), optimise voltage quality and the running arrangement of the distribution network of the future.

- **Power Protect** – aims to support our most vulnerable customers by providing a portable power supply in planned and unplanned outage scenarios where these customers are off supply for an extended period of time. The project will develop and trial a solution to proactively identify vulnerable customers and dispatch batteries. This forecasting solution will enable us to increase our customer safety, reduce operational costs during power outage restoration and ultimately deliver benefits to customers.

- **HV feeder monitoring to pre-empt faults** – trialling a data-driven and machine learning based predictive monitoring solution to monitor feeders and pre-empt faults. Typical network issues include, for example, vegetation contact with overhead lines, cable pole termination issues and damage to insulators. The solution aims to detect and locate these network issues before they develop into faults.

- **Phase Switch System (PSS)** – developing and testing an innovative power electronic phase switch system to optimise load balance between substations.

3.3 Roll-out of smart grids and innovation into business as usual

3.3.1 Rolling out innovative solutions into business as usual

UK Power Networks has a process for monitoring the progress of innovative solutions to ensure that when they are ready they are deployed by the business to achieve benefits and these benefits are quantified. This is detailed on pages 21-22 of our Innovation Strategy.

We now have 58 business-as-usual smart solutions deployed. These are categorised into seven distinct areas:

1. **Improve network capacity** – These solutions are focused on increasing capacity within the existing infrastructure. They include our London network interconnection, any demand side response procurement, load sharing across assets, and deployment of load blinding relays.

2. **Improve asset lifecycle** – Derived from our Efficient and Effective innovation portfolio, these solutions are designed to extend the lifecycle of our existing assets. They include devices such as the joint shell; techniques for managing oil, such as oil regeneration or the Perfluorocarbon Tracer (PFT) fluid filled cable to help locate leaks; tools to assess our overhead lines; and improving maintenance of our poles, such as the use of woodpecker filler.

3. **Improve network performance** – These solutions are focused on improving the quality of supply of our networks. They include devices such as LV re-closers, the automated power restoration system, and our contingency analysis tools that help us plan outages.

4. **Improve vegetation** – These solutions are focused on improving the way we manage the vegetation around our assets, for example any technique that will help us target our tree cutting practices more efficiently.

5. **Improve safety** – These solutions are focused on improving safety for our employees and anyone who comes into contact with our assets. They include 3D laser surveying, a new condensed aerosol fire suppression system and the Mobile Asset Assessment Vehicle (MAAV) that helps us assess the voltage of the network on the move.

6. **Improve environmental impact** – These solutions are focused on reducing the impact our assets have on the surrounding environment. They include the use of polymer-based bunding equipment, which replaces the traditional concrete/brickwork for transformers.

7. **Improve connections performance** – These solutions target benefits for our connections customers. They allow customers to connect to our network quicker and more cheaply and include flexible distributed generation (FDG) and timed connections.

Table 24 lists all 58 innovation projects that have transitioned into business as usual, the applicable voltage level and the associated RIIO output area. The first column indicates the Environment Report where further information describing the project can be found, with colour coding to distinguish between regulatory years. No new projects were deployed as business as usual during 2022/23.

The financial benefits assessment approach followed by UK Power Networks in preparing the E6 – Innovative Solutions worksheets on the impact of innovative solutions is to identify:

+ Avoided costs due to the solution
- Costs of deploying the solution
+ CI and CML saving (interruption incentive)
+ Losses saving
+ Estimated Impact on Fatality (£ million)
+ Estimated Impact on Serious Injury (£ million)

These benefits are calculated consistent with the RIIO-ED1 CBA guidance and the total of these items demonstrates the financial benefits. The tables also indicate MVA capacity released, but this is not given a financial equivalent.

In total, our 58 business-as-usual solutions have delivered £508 million of savings since 2015. This year we saved £94.7 million by deploying the smart solutions reported in the E6 – Innovative Solutions worksheets. The values are calculated based on the detailed E6 submission, but this financial summary is not included in the E6 worksheets.

Solution described in Environment Report	Solution	Voltage level of issue	RIIO output	Benefits (£m)	
				2022/23	RIIO-ED1 total
Increase Network Capacity/Optimise Utilisation					
2017/18	Dynamic Transformer Rating (RTTR)	33kV	Load Indices	0.00	1.64
2017/18	Flexible DG Connections	LV, 11kV, 33kV	Connections Service	48.36	198.49
2017/18	LPN Interconnection	11kV	Totex	0.18	12.10
2017/18	Energy Storage	33kV	Load Indices	0.00	6.18
2017/18	Demand Side Storage	33kV	Load Indices	-9.44	-0.75
2017/18	FUN-LV	LV	Totex	0.00	0.34
2017/18	Load Blinding Relays	33kV	Connections Service	9.90	23.18
2018/19	Kent Active System Management	33kV, 132kV	Load Indices	0.00	0.00
2019/20	Recharge the Future	11kV	Availability	0.00	0.00
2019/20	Load Blinding Relays for Busbar Protection	11kV, 33kV	Totex	0.64	1.24
2019/20	Haysys PIU	LV	Totex	0.05	0.27
2020/21	N-3 with NGESO ICCP	132kV	Connections Service	-0.05	1.75
2020/21	LV Flexibility	LV	CI, CML	2.14	4.83
2021/22	Charge Collective	EHV	Connections	0.20	0.20

Solution described in Environment Report	Solution	Voltage level of issue	RIIO output	Benefits (£m)	
				2022/23	RIIO-ED1 total
Improve Asset Life Cycle Management					
2017/18	Joint Shell	LV	Health Indices	0.07	1.15
2017/18	Oil Regeneration	33kV, 132kV	Health Indices	0.00	-0.34
2017/18	PFT (Fluid-filled cable leak location)	33kV/66kV/ 132kV	Environment	0.78	9.42
2017/18	CNAIM Modelling	All	Health Indices	12.79	98.07
2017/18	Woodpecker Filler	All	Health Indices	0.05	0.47
2018/19	OHL Assessment Tool	HV, EHV	Health Indices	5.83	21.85
2018/19	Pressurised Cable Active Management	132-33kV	Environment	0.11	0.52
2019/20	Load Share	132kV	Totex	0.00	14.55
2020/21	Advanced Analytics Cable Length Estimation	EHV	CI, CML	0.00	0.16
2020/21	Engineered Poles	All	Environment	0.00	0.00
2021/22	GIS Temperature Monitoring	33kV	Reliability and Availability	0.03	0.03
Improve Network Performance					
2017/18	LV Re-energising Devices	LV	CI, CML	0.80	6.26
2017/18	Automated Power Restoration System	11kV	CI, CML	11.51	73.04
2017/18	Mobile Asset Assessment Vehicle	LV	CI, CML, Losses, Safety	0.00	-7.28
2018/19	OHL Assessment using Panoramic Images	11kV	Health Indices	0.00	0.00
2018/19	Primary Outage Restoration Tool (PORT)	11kV	CI, CML	1.90	5.80
2018/19	Directional Earth Fault Passage Indicator	11kV	CI, CML	-0.01	-0.02
2019/20	Infrared Imaging Camera	LV	CI, CML	0.14	0.47
2019/20	OHL FPIs	11kV	CI, CML	0.60	-0.15
2019/20	Remote Portable Switch	HV	CI, CML	1.38	6.39
2019/20	Fusesaver	HV	CI, CML	0.64	0.45
2020/21	Detection of Broken or Low Hanging OHL	11kV	Safety	0.00	0.00
2020/21	Jumper Cutter	11kV	CI, CML	0.99	2.91
2020/21	Network Vision	11kV	Customer Satisfaction	-0.11	-0.24
2020/21	Storm Joint	11kV	CI, CML	0.00	0.00
2020/21	VisNet Fault Location	0.4kV	CI, CML	0.11	-0.19
2021/22	Unified Protection	11kV	CI, CML	0.00	0.00
2021/22	Mobile Field Control	11kV	CI, CML	0.00	0.00
2021/22	Storm Resilience	11kV	CI, CML	-0.05	-0.05
Improve Vegetation Management					
2017/18	LIDAR Vegetation Management	11kV, 33kV, 132kV	Totex	0.00	16.29

Solution described in Environment Report	Solution	Voltage level of issue	RIIO output	Benefits (£m)	
				2022/23	RIIO-ED1 total
Improve Safety					
2017/18	Public Safety	All	Safety	-0.23	-1.86
2017/18	3D Laser Surveying	EHV	Safety	0.06	0.28
2018/19	Fire Pro Fire Suppression System	HV, EHV	Guaranteed Standards (ATTC/Q)	0.01	0.21
2020/21	Smart Traffic Lights Kent	11kV	Safety	0.11	0.19
2021/22	Line Search	LV, HV	Safety	0.00	0.00
2021/22	Cable Plough	33kV	Safety	0.42	0.17
Improve Environmental Impact					
2017/18	Innovative Bunding	HV, EHV	Environment	0.00	0.06
Improve Connection Performance					
2017/18	Distribution Network Visibility (DNV) Application	HV, EHV	Guaranteed Standards (ATTC/Q)	0.20	0.43
2017/18	Point of Connection (POC) Mast	33kV	Connections Service	0.00	0.63
2017/18	Timed Connection	HV, EHV	Connections Service	1.48	5.91
2019/20	Global Earthing System	11kV	Connections	0.00	0.00
2019/20	Timed Connection Assessment Tool	HV, EHV	Connections Service	-0.01	-0.02
2020/21	Smart Connect (Transpower)	LV	Connections	3.17	3.51
2021/22	Underground Fault Prediction and Earthing Assessments	LV	Safety	0.00	-0.03

Table 24: Our 58 business-as-usual innovative solutions by type, voltage level, related RIIO output table, and benefits delivered in £ million, in 2022/23 and in RIIO-ED1 in total

3.3.1.1. Solutions that changed from last year

In 2022/23 our 58 E6 solutions delivered £94.7 million of financial savings, as itemised in the E6 tables, alongside additional safety, customer service and efficiency benefits.

While there were some projects with lower than expected benefits, the significant E6 benefits in 2022/23 are due to several factors:

- Increased value from Flexible DG Connections
- Increased value from Common Network Asset Indices Methodology (CNAIM) modelling
- Continued benefits from Automated Power Restoration
- Increased value from Smart Connect
- Stopped operation of the MAAV, which had been delivering negative benefits

3.3.1.2. New solutions rolled out

Our innovative solutions are at various stages of roll-out. Throughout their life cycle they undergo a process of assessment, development and monitoring through to a completed roll-out to business as usual. The process is described in our 2017/18 Environment Report (see section 3.3 of that document) and our Innovation Strategy.

During the 2022/23 regulatory year we focused on supporting the development and scale-up of existing solutions to maximise their potential. Consequently, no new solutions were added to the 58 already deployed to business as usual.

3.3.1.3. Innovative solutions for connections

There are 12 solutions which support our connections customers; please see Table 25.

Solution
Flexible DG Connections
Load Blinding Relays
Distribution Network Visibility (DNV) Application
Point of Connection (POC) Mast
Timed Connections
Global Earthing System
Smart Traffic Lights Kent
Timed Connection Assessment Tool

Solution
N-3 with NGESO ICCP
Smart Connect
Underground Fault Prediction and Earthing Assessments
Charge Collective

Table 25: Solutions which support our connections customers

Table 26 presents the savings delivered by these solutions in RIIO-ED1 to the nearest £10,000. The majority of savings come from our Flexible DG Connections project as our flexible connections approach (reducing cost and time to connect) is rolled into our new Active Network Management solution, which is being deployed across all three of our licence areas.

Innovative solutions for connections	Total RIIO-ED1 savings to date
Flexible DG Connections	£198,490,000
Load Blinding Relays	£23,180,000
Distribution Network Visibility (DNV) Application	£430,000
Point of Connection (POC) Mast	£630,000
Timed Connection	£5,910,000
Smart Traffic Lights Kent	£190,000
Timed Connection Assessment Tool	-£20,000
N-3 with NGESO ICCP	1,750,000
Smart Connect	£3,510,000

Table 26: Total RIIO-ED1 savings from innovative solutions for connections

3.3.1.4. New solutions being considered for business-as-usual deployment

The 13 NIA projects shown in Table 27 are expected to close down in the 2023/24 regulatory year.

Solution
Neighbourhood Green
Emerge
Stratus
High Voltage (HV) Auto Quote
Automated Tunnel and Shaft Inspections
Our View
Powercast
Radio Teleprotection

Solution
LV Interconnected Pairs
LV Fault Passage Indicator
EPRI Research Collaboration on Overhead Transmission (P35) and Substations (P37)
Miles Better Fault Location
Socially Green

Table 27: NIA projects due to complete in the 2023/24 regulatory year

Via our innovation gate process (described in our Innovation Strategy), at the closedown of each project we assess its potential and plans to successfully transition into business as usual, to become part of our solutions going forward. The regulatory year 2023/24 will be the first year of reporting innovation benefits using the Innovation Measurement Framework. This was introduced in RIIO-ED2 to replace E6 – Innovative Solutions for the reporting of innovation benefits.

3.3.1.5. Number of times solutions were deployed in this regulatory year

Table 28 indicates the number of times our current innovation solutions were deployed in this regulatory year, as indicated in the E6 – Innovative Solutions worksheets.

Solution	Additional Deployments 2022/23
Increase Network Capacity/ Optimise Utilisation	
Dynamic Transformer Rating (RTTR)	0
Flexible DG Connections	3
LPN Interconnection	19
Energy Storage	0
Demand Side Response	0
FUN-LV	0
Load Blinding Relays	0
Kent Active System Management	0
Recharge the Future	0
Load Blinding Relays for Busbar Protection	1
Haysys PIU	4
N-3 with NGESO ICCP	0
LV Flexibility	0
Charge Collective	1
Improve Asset Life Cycle Management	
Joint Shell	83
Oil Regeneration	0
PFT	19
CNAIM Modelling	104
Woodpecker Filler	22
OHL Assessment Tool	131
Pressurised Cable Active Management	3
Load Share	0
Advanced Analytics Cable Length Estimation	0
Engineered Poles	0
GIS Temperature Monitoring	0
Improve Network Performance	
LV Re-energising Devices	2,011
Automated Power Restoration System	9,769
Mobile Asset Assessment Vehicle	0
OHL Assessment using Panoramic Images	0
Primary Outage Restoration Tool (PORT)	658
Directional Earth Fault Passage Indicator	8
Infrared Imaging Camera	0
OHL FPIs	-766
Remote Portable Switch	82
Fusesaver	20
Detection of Broken or Low Hanging OHL	0
Jumper Cutter	0
Network Vision	5,911
Storm Joint	0
VisNet Fault Location	0
Unified Protection	0
Mobile Field Control	0
Storm Resilience	0
Improve Vegetation Management	
LIDAR Vegetation Management	0
Improve Safety	
Public Safety	0
3D Laser Surveying	13
Fire Pro Fire Suppression System	6
Smart Traffic Lights Kent	0
Line Search	0
Cable Plough	0
Improve Environmental Impact	
Innovative Bunding	0
Improve Connection Performance	
Distribution Network Visibility (DNV) Application	0
Point of Connection (POC) Mast	0
Timed Connection	1
Global Earthing System	0
Timed Connection Assessment Tool	8
Smart Connect (TransPower)	0
Underground Fault Prediction and Earthing Assessments	0

Table 28: Additional solution deployments in this regulatory year

Looking ahead to 2023/24, across our portfolio of deployed innovative solutions we would expect that:

- Our innovative solutions for improving network performance (including LV re-energising devices and remote portable switches) will continue to be deployed
- Our innovative solutions for improving the asset life cycle (including our CNAIM solution) will continue to provide benefits
- Our innovative solutions for improving network capacity and utilisation (Flexible DG Connections) will also continue
- Overall, benefits delivered to customers through reduced connection times and costs will continue if further developers connect their projects to FDG zones

We will assess our 58 existing solutions and assess how they can match the Innovation Measurement Framework in RIIO-ED2.

3.3.1.6. Additional information, methodology and CBAs

The complete methodology and CBAs can be found in our Annexes and Appendices.

3.3.2 Smart metering

Our strategy for maximising the net benefits of smart metering

We have established two teams who are working on our smart metering programme to deliver a system that will enable us to realise benefits from smart metering assets. They are:

- The Smart Meter Programme Delivery team – responsible for designing and developing the technical solution that will deliver smart meter benefits for customers and our business from the utilisation of energisation checks, power outage and restore alerts, voltage threshold violation alerts, energy consumption data, and voltage measurements
- The Smart Meter Operations team – the business owner of the Data Communications Company (DCC) adaptor that allows us to connect to smart meters through the DCC's infrastructure

To realise the benefits from smart metering we recognise that we must continually learn from the data provided from smart meters, whilst being mindful of the requirements of our Smart Meter Data Privacy Plan (DPP)[20] . Combining data expertise, technological capability and business knowledge, these teams have the following responsibilities:

- To act as UK Power Networks' key point of contact with the DCC and other relevant industry partners
- To deliver UK Power Networks' benefits realisation plan
- To develop understanding and insight into smart meter data within the business, to support other functions on how best to embed smart meter data into their day-to-day activities to deliver business benefits

[20] https://www.ofgem.gov.uk/publications-and-updates/approval-letter-ukpns-data-privacy-plan-access-household-electricity-smart-metering-data

Our strategy for maximising the net benefits of smart metering for customers sets out three key areas from which benefits from smart meter data will be realised. These are shown in Table 29 below.

Benefit	Description
Improved real-time data Customer service enhancements Fault management	Smart meters providing real-time data for fault management via the 'last gasp' facility and the capability to remotely test the meter to ascertain the energisation status of the supply to a customer's premises, can significantly improve fault management performance and customer service. It will be possible to identify and target faults more quickly and to provide the customer with significantly enhanced information and a faster response.
Improved asset and performance data Network condition and planning	Having accurate information regarding the loading of assets (i.e. visibility of real load profiles at each substation and the LV network) will allow utilisation of these assets to be maximised whilst ensuring they are not overloaded. In turn, this may lead to a reduction in the number of faults on the network, helping to reduce overall operational expenditure and keep charges low for customers. The availability of detailed consumption data across the network offers the opportunity to significantly improve network planning. For example, consumption data will support the identification of specific areas of the LV network that may need reinforcement and allow informed decisions to be made to defer network reinforcement.
Improved real-time control Supporting the future network	The combination of smart meter data and asset data with greater real-time control will pave the way for the network of the future. It will provide the information and capability to support expansion of LCTs and time of use tariffs. There will be the ability to undertake active network management on the LV network and to defer the need for further network reinforcement and new investment, paving the way for a full smart grid using smart meter data.

Table 29: Key areas in which benefits from smart meter data will be realised

Smart meters enable a capability for the active management of electricity distribution networks where the data provides a granular view of performance of the LV network and of the quality of supply delivered to customers. Smart meters can record energisation status, voltage measurements and energy consumption and send outbound messages to UK Power Networks if there is a network parameter threshold breach, when the meter experiences a power cut or when power is restored.

We developed our strategy to initially focus on delivering benefits directly to customers ahead of delivering capabilities with benefits specifically for UK Power Networks. Our focus is now directed towards better understanding the data from smart meters so that we can begin to deliver improvements in our network diagrams and network control systems, to provide further benefits to our customers. Using data from smart meters will support our capabilities to quickly identify and respond to power outages, better balance supply with demand and support suppliers in utilising sources of local and renewable energy.

Increasing numbers of solar panels, EVs, battery storage and other LCTs place further demands on the distribution system and on the LV network in particular. It is therefore essential that we manage our networks to cope with the increasing energy demand in an efficient, coordinated and economical way. The data obtained from smart meters will be used to provide a much clearer view of loads on the LV network that is not available from traditional meters. Greater visibility of energy usage on the network will in turn support cost-efficient investment decision making, and with better visibility in this area we will enhance our practices to deliver the benefits to support delivery of the government's net zero commitment.

Smart meter installation volumes

Table 30 shows the volumes of cumulative smart meter installations reported by our three licensees for the 2022/23 regulatory year in the Cost and Volumes Reporting Pack worksheets CV34 – Smart Meters.

During the year installation volumes increased such that 55% of UK Power Networks' customers now have a smart meter installed. This compares to 48% in the previous regulatory year.

Licensee	Total MPANs	2021/22 smart meter volumes	2022/23 smart meter volumes	2022/23 percentage penetration of smart meters
EPN	3,703,367	1,894,204	2,190,243	59%
LPN	2,413,292	938,456	1,078,700	45%
SPN	2,348,340	1,223,531	1,401,981	60%
Total	**8,464,999**	**4,056,191**	**4,670,924**	**55%**

Table 30: Smart meter installations

At the end of the 2022/23 regulatory year a total of 4.67 million smart meters had been installed in customers' premises in our three licence areas. The proportions of SMETS1 and SMETS2 meters installed were 46% and 54%, respectively.

Current status of IT and communications investments

Our DCC gateway infrastructure is fully operational and is receiving data from SMETS1 meters adopted into the DCC system and from SMETS2 meters. We have maintained our gateway adaptor with regular upgrades to ensure UK Power Networks' platform is aligned to the DCC version of their system and that it remains compliant with SEC security standards as verified through the annual SEC Security audit.

The UK Power Networks DCC gateway infrastructure was designed at the beginning of RIIO-ED1 and commissioned towards the end of 2017, based on system requirements for the anticipated meter volumes during the early years of the Smart Metering Implementation Programme. As the volume of smart meters installed in customers' premises has continued to increase each year, we have carried out a review of our DCC Gateway system requirements to ensure the continued efficient operation of our smart meter infrastructure, especially as we approached the 50% saturation level of smart meters across our customer base.

UK Power Networks has designed a cloud-based DCC Gateway that will replace the on-premises system to provide a resilient system with easily scalable resources to meet the requirements of the increasing volume of smart meters and the associated data, which includes half-hourly voltage and energy consumption data. We will collect and process this data in accordance with the requirements of our Ofgem approved DPP[21] so that we are able to deliver benefits to our customers and business.

Through the ENA, we work collaboratively with other DNO member companies to coordinate queries with the DCC to leverage challenges related to data quality issues and to collectively achieve a resolution to these issues.

We have maintained our commitment to realise benefits from smart meter data through additional developments and enhancements to our IT systems; however, data quality issues have caused delays to our smart meter programme, resulting in additional costs and changes to our IT systems. Additional work was required to fully understand the data issues before we could design, develop and implement solutions to manage and mitigate them – delaying the delivery of benefits to our customers.

[21] https://www.ofgem.gov.uk/publications-and-updates/approval-letter-ukpns-data-privacy-plan-access-household-electricity-smart-metering-data

Actions taken in 2022/23 to maximise the value of smart meter data

During the previous years of the smart metering programme our focus was to deliver direct benefits to customers who needed to contact UK Power Networks to report a power cut at their premises. We have achieved this through integration of our DCC adaptor into our business systems and applications, providing customers with a self-serve capability to carry out smart meter energisation status checks, in addition to being able to speak directly with our call agents.

Our customers with smart meters now benefit from the energisation check capability, with a swift and accurate response to determine whether their power cut is due to power loss from our network, a meter-related issue or a problem on their internal wiring/fuseboard. The energisation check also provides the customer with relevant information where the power cut has been caused by our network. If the check identifies that the problem is related to the customer's meter, internal wiring or fuseboard, it provides information on what the customer should do.

Summary of estimated smart meter benefits realised to date

We have developed our capabilities and delivered benefits to customers during their power-cut journey when communicating with UK Power Networks; these are now embedded within our normal business processes. Customers benefit from their interaction through a self-service facility to check the energisation status of the electricity supply to their premises, in addition to speaking directly with a call agent.

Our plans for realising smart meter benefits in 2023/24 and in future years

In previous Environment Reports we have highlighted industry-wide data quality issues and challenges, including the timely delivery and accuracy of power outage and restore alerts received from smart meters. The quality of smart meter data continues to be discussed at an industry level between network operators, the DCC and DESNZ to identify solutions to address all smart meter data issues. Our Smart Meter Operations team is working closely with the other parties to support the delivery of improvements within the DCC infrastructure and data communications systems, to leverage improvements.

In the interim, we have projects under way to maximise our capability to deliver benefits from our smart metering, such as being able to utilise power outage alerts through the introduction of a check to verify if the alert received is genuine. This verification check is currently under development and is planned for implementation in 2023/24. Another project, related to quality of supply to customers and network performance, is focused on voltage levels and management.

We continue to support the supplier-led roll-out of smart meters, addressing any required interventions identified within our network on supply termination equipment which could prevent a smart meter from being installed. Our approach to this work complies with all industry defined Smart Meter Intervention Performance Service Level Agreements, with our Interventions teams performing a coordinating role to help our engineers support energy suppliers' installations.

As reported in our 2021/22 Environment Report, we have developed a web-page portal for meter operators to directly report to us any service termination equipment defect delaying installation of a smart meter or any equipment that requires our attention after installation of a smart meter. Our innovative work has continued, where we are now considering how to support suppliers and other Distribution Connection and Use of System Agreement (DCUSA) parties when they notify us of plans to de-energise metering equipment as part of any planned work, thereby providing advance notification of the proposed supply interruption at a customer's premises.

We have reviewed our smart metering system and its requirements for managing the increasing volumes of smart meters and associated data that will be retrieved from them. We have designed a new cloud-based platform for our smart metering system that will provide a resilient and scalable solution to address any system resource constraints. We are planning to build and deliver the new system during the regulatory year 2023/24.

Our new cloud-based smart metering system will become an enabler for the high volume data that will be used within our Network Modelling toolsets and the Network Control Outage Management System used within our licence areas to leverage benefits from the use of smart meter data for network analysis and network control.

The above highlights our goals, with key investments that will enable benefits to be realised from data received from the significant volumes of smart meters now installed in our regions.

Our realisation of smart meter benefits is dependent on the wider roll-out of SMETS2 compliant meters and establishing access to smart meter data. We continue to support the industry roll-out of smart meters and further develop our systems to receive their data. Table 31 presents our expenditure (including IT expenditure) in this regard for the 2022/23 regulatory year. For more information, please see the worksheets E5 – Smart Metering and CV34 – Smart Meter Interventions in the Annexes and Appendices.

Source	Category	EPN	LPN	SPN	Total
E5	Smart Meter Communication Licensee Costs	3.59	2.46	2.45	8.50
E5	Smart Meter Information Technology Costs	1.12	0.95	0.48	2.55
CV34	Smart Meter Interventions – On-site/Physical Activities (including prior year restatement)	3.97	2.04	1.77	7.78
CV34	Smart Meter Interventions – Extra Scheduling & Call Centre	0.61	0.35	0.32	1.28
CV34	Smart Meter Interventions – Smart Meter Registration	0.00	0.00	0.00	0.00

Table 31: Summary of 2022/23 – smart metering-related expenditure in £ million

4 Annexes and Appendices

4.1 EPN

Environment and Innovation Pack – Tabs E1-E8 – 2022/23

4.2 LPN

Environment and Innovation Pack – Tabs E1-E8 – 2022/23

4.3 SPN

Environment and Innovation Pack – Tabs E1-E8 – 2022/23

4.4 UK Power Networks

CV16 and M1 Flood Mitigation – 2022/23

Environment and Innovation Commentary – 2022/23

RIGs E6 CBA – 2022/23

Generic CBA RIIO-ED1 – GMTs – 2022/23

Generic CBA RIIO-ED1 – PMTs – 2022/23

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