

UK Power Networks Environment Report

2015-16



Contents

1	Introduction.....	3
1.1	Executive Summary	3
1.2	Our Business/Who We Are	4
1.3	Purpose of the Report	5
2	Managing Our Environmental Impact	5
2.1	Introduction	5
2.2	Visual Amenity	6
2.3	Oil Leakage	9
2.4	Carbon Impact and Climate Change.....	11
3	Smart Grids, Innovation and Our Role in the Low Carbon Transition.....	29
3.1	Introduction	29
3.2	Progress of the Innovation Strategy.....	31
3.3	Roll Out of Smart Grids and Innovation into Business as Usual	33
3.4	Smart Metering.....	39
4	Annexes and Appendices	41
4.1	EPN	41
4.2	LPN	41
4.3	SPN.....	41
4.4	UK Power Networks.....	41

1 Introduction

1.1 Executive Summary

This report has been prepared in accordance with the requirements of standard condition 47 (Environment Reporting) of the Electricity Distribution Licence and describes the activities UK Power Networks has undertaken in relation to environmental matters during the 2015-16 regulatory year.

Our aim is to reduce the impact that UK Power Networks has on the environment, and we intend to do this by making our operations as sustainable as possible. Our target is to reduce our business carbon footprint by 2 per cent every year over the RIIO-ED1 period. In 2015-16 we achieved a reduction of 14 per cent, taking our business carbon footprint to 66,000 tonnes of CO₂ – down from 77,000 tonnes the previous year. This was made possible by consolidating staff into fewer buildings, implementing energy saving initiatives such as the introduction of LED lighting, and investing £7m to replace older vehicles with safer, more efficient models. The milder winter also had an impact. We aim to reduce our business carbon footprint further by minimising business miles and making further improvements to buildings and vehicle efficiency.

The impact of our overhead lines on the countryside is important to many of our stakeholders. We have committed to underground, by 2023, 80km of overhead line on our South Eastern network and 96km of overhead line on our Eastern network. We believe that landscape experts are the best people to decide which lines to relocate underground. A steering group chaired by Natural England and consisting of representatives from National Parks and Areas of Outstanding Natural Beauty (AONB) decides which overhead lines should be replaced with underground lines. UK Power Networks provides technical advice to the group but is a non-voting member. In 2015-16 we worked with this group to identify the overhead lines to be undergrounded by 2023. Currently, we have two sets of schemes which are at the planning stage: a set of 10 schemes that will remove 29km of overhead line on our Eastern network and a further set of 15 schemes that will remove 52km of overhead line on our South Eastern network. In 2015-16 we removed 5.3km of overhead line on our South Eastern network. No overhead line was replaced on our Eastern Network that year but we expect to see progress once the projects currently in planning move into the delivery phase.

Finding better ways of doing things helps us minimise our impact on the environment. We recognise the key role that innovation plays in preparing us for the low carbon future while helping us ensure that security of supply is delivered cost efficiently and that our service to customers continues to improve. We have committed to spend at least 0.5 per cent of our revenue each year (approximately £7m) on innovation; in 2015-16 we spent £11m. Our portfolio of projects is wide-ranging, including building and operating the largest battery in Great Britain. Further information can be found on our innovation website: <http://innovation.ukpowernetworks.co.uk/innovation/en>

This report includes information on the following topics:

- Our work to underground overhead lines to improve visual amenity
- Our efforts to reduce oil leakage from our assets
- The steps we are taking to reduce our business carbon footprint
- Our management of sulphur hexafluoride (SF₆) gas
- Technical and non-technical losses from our network and our work to understand and reduce them
- Our approach to waste management and prevention
- Our noise pollution and air quality/pollution reduction activities
- How our innovations are helping to minimise the impact of our activities on the environment
- An overview of the benefits we expect to realise from the rollout of smart metering

1.2 Our Business/Who We Are

At UK Power Networks, we manage the distribution of electricity from the National Grid to 8.2 million homes and businesses via our networks in London, the East of England and South East England. Our three licensed subsidiaries Eastern Power Networks plc (EPN), London Power Networks plc (LPN) and South Eastern Power Networks plc (SPN) (see Figure 1) are responsible for operating and maintaining these networks; ensuring we deliver our core function of providing safe, reliable and efficient electricity supplies to existing customers and timely, cost-effective connections to new customers.

Figure 1 – UK Power Networks' operating area



In operating and maintaining our electricity network, we interact with the environment in many ways. We must consider the design and construction of our infrastructure; the use of oil and other insulation products; the energy used to light and heat our offices and depots; and the vehicles used.

Within our operating area are many environmental landscape features of note – AONB, National Parks, Sites of Special Scientific Interest, unique waterways such as The Norfolk Broads, and densely populated Central London which is rich in archaeological significance.

When installing new equipment on the electricity network 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.

UK Power Networks' Environmental Management System is ISO14001 accredited. It is implemented and managed by a team of environmental specialists who deal with both actual and potential environmental issues, acting to reduce the number and severity of environmental impacts.

Environmental governance is provided by the Health, Safety and Environment Committee, which is chaired by our Chief Executive Officer. This is further managed down the organisation via local and business Health, Safety and Environment Committees. Our Environmental Management System is subject to external verification and is audited externally by DNV-GL.

Representatives from our Environment team sit on the Electricity Networks Association (ENA) Environment Committee and help to ensure that best practice is implemented from shared knowledge across the electricity and gas sectors.

1.3 Purpose of the Report

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- Our work to underground overhead lines to improve visual amenity
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UK Power Networks strives to be a Respected Corporate Citizen and protecting the environment is an essential element of achieving this. 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 the business and policies and procedures are put in place to ensure compliance. Relevant activities include environmental permitting, pollution prevention, waste management and preservation of historic and natural habitats.

We have Environment Agency permits to operate three waste transfer stations and seven waste oil storage facilities. Electrical insulating oil which is removed during routine maintenance is reprocessed and reused, thereby reducing demand for new oil to be extracted. We maintain high levels of compliance with our environmental permits through training and compliance monitoring.

If we need to work 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. We engage suitably qualified ecologists to help us with these activities. We consult English Heritage if our work might have an impact on scheduled monuments or other protected historic sites.

We also seek to build good relationships with local authorities and to work collaboratively on initiatives to help reduce the impact of issues such as noise pollution and litter on local communities.

2 Managing Our Environmental Impact

2.1 Introduction

Our aim is to reduce the impact that UK Power Networks has on the environment, and we intend to do this by making our operations as sustainable as possible. Our target is to reduce our business carbon footprint by 2 per cent every year over the RIIO-ED1 period. In 2015-16 we achieved a reduction of 14 per cent, taking our business carbon footprint to 66,000 tonnes of CO₂ – down from 77,000 tonnes the previous year. This was made possible by consolidating staff into fewer buildings, implementing energy saving initiatives such as the introduction of LED lighting, and investing £7m to replace older vehicles with safer, more efficient models. The milder winter also had an impact. We aim to reduce our business carbon footprint further by minimising business miles and making further improvements to buildings and vehicle efficiency.

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group chaired by Natural England and consisting of representatives from National Parks and Areas of Outstanding Natural Beauty (AONB) decides which overhead lines should be replaced with underground lines. UK Power Networks provides technical advice to the group but is a non-voting member. In 2015-16 we worked with this group to identify the overhead lines to be undergrounded by 2023. Currently, we have two sets of schemes which are at the planning stage: a set of 10 schemes that will remove 29km of overhead line on our Eastern network and a further set of 15 schemes that will remove 52km of overhead line on our South Eastern network. In 2015-16 we removed 5.3km of overhead line on our South Eastern network. No overhead line was replaced on our Eastern Network that year but we expect to see progress once the projects currently in planning move into the delivery phase.

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2.2 Visual Amenity

UK Power Networks is a member of a long-established Undergrounding of Overhead Lines Project Steering Group which facilitates the completion of approved network underground projects within its licensed areas, observing the funding criteria specified by Ofgem. Established in 2005, the group consists of landscape experts (members of AONB and National Park organisations) acting as stakeholder representatives, and is chaired and facilitated by Natural England, who has a national remit to advise on the management of designated landscapes. The group meets every three months.

UK Power Networks holds the position of a non-voting member in the Steering Group, providing technical support and guidance for scheme assessments as well as costings for completing the work. This varies from scheme to scheme but will always include the provision of a route for the new cable network and the estimated cost of carrying out the work.

Approval of schemes is organised so that Steering Group members can only vote on schemes in the DNO area in which their protected landscape is located. The landscape experts identify potential new schemes – via newsletters, websites and social media – and formulate proposals, which are then presented to the Steering Group.

A two-stage approval process is in place for new schemes. Stage 1 is an outline of the scheme, which includes indicative routes and budget costs for consultation with stakeholders. The scheme budget is also ring-fenced. Stage 2 is triggered once stakeholders 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. Approved schemes are then handed over to UK Power Networks to acquire the necessary consents to deliver the works. During the consenting and delivery phases UK Power Networks liaises closely with the scheme's proposer on any material issues that arise, such as the re-routing of a proposed cable or substation.

Projects are assessed against a range of scoring criteria which focus on the impact of the line on the landscape character, the impact of the line on visual amenity and the potential impact of undergrounding on features in the landscape (either biodiversity or heritage). A scheme must attain a minimum score of nine points (out of a maximum of 48) in order to be considered for selection. Schemes are nominally capped at £140k per kilometre as it has been determined through experience that this represents the point at which value for money diminishes. However, some schemes, through the technicalities of delivering the work, may represent a value greater than the upper limit and the Steering Group has the discretion to exceed the cap should the scheme warrant it. The scores, subsequent comments and any supporting evidence are then recorded in an Overhead Lines Assessment Form. Throughout the scoring process the Steering Group members debate whether all of the relevant factors have been taken into account and whether any related issues have been resolved. Such issues could include whether the removal of the overhead line is being done in conjunction with other work, such as improvements to facilities to increase visitor numbers to a heritage site.

Table 1 shows the undergrounding schemes which were completed in UK Power Networks' operating area during the 2015-16 regulatory year.

Table 1 – Undergrounding schemes completed in UK Power Networks' operating area

Landscape	Scheme Name	Distance (km)	Current position
Kent Downs	Ightham Mote Phase 2	0.59	Completed
Surrey Hills	Painshill Farm	3.41	Completed
Kent Downs	Ranscombe Farm	1.35	Completed

A further 25 schemes (see Table 2) are in progress, some of which involve lines at different voltages. For such schemes, the benefits increase, as the removal of only one section would further highlight the impact of the remaining lines on the landscape. This encourages the Steering Group to identify schemes which focus on larger areas, where exposure to the benefits can be afforded to as many stakeholders as possible.

Table 2 – Undergrounding schemes in progress

Licensee	Landscape	Scheme name
EPN	Norfolk Coast AONB	Bayfield
EPN	Suffolk Coast & Heaths AONB	Felixstowe Ferry
EPN	Suffolk Coast & Heaths AONB	Shingle Street
EPN	Dedham Vale AONB	Flatford
EPN	Broads Authority	Cantley
EPN	Broads Authority	Ludham Marshes
EPN	Suffolk Coast & Heaths AONB	Southwold
EPN	Suffolk Coast & Heaths AONB	Orford North
EPN	Suffolk Coast & Heaths AONB	Orford South
EPN	Broads Authority	Share Marshes
SPN	Kent Downs AONB	Olantigh
SPN	Kent Downs AONB	Bodsham
SPN	Surrey Hills AONB	Abinger Hammer Phase 2
SPN	Surrey Hills AONB	Raikes Farm
SPN	Surrey Hills AONB	Dowdes Farm
SPN	South Downs National Park	Telescombe Tye
SPN	South Downs National Park	Swanborough Levels
SPN	Kent Downs AONB	Birling
SPN	South Downs National Park	Piddinghoe
SPN	South Downs National Park	Saddlescombe Farm
SPN	South Downs National Park	Adur Valley Phase 2
SPN	Kent Downs AONB	Lees Court
SPN	Kent Downs AONB	Elham Valley
SPN	South Downs National Park	Littlington Phase 2
SPN	Kent Downs AONB	Birling Phase 2

The Steering Group members are aware of the 10 per cent allowance for Visual Amenity outside of Designated Areas. We are working with them to develop two schemes (Sheffield Park and Royal Military Canal) to use this element of the allowance in 2016-17.

The stakeholder group has been tasked with developing schemes that utilise the full extent of the allowance by the end of 2017, with UK Power Networks working to ensure that the required consents are obtained by the end of 2018.

Achievements in the 2015-16 regulatory year are shown in the RIGs worksheet *E1 – Visual Amenity* (please see Annexes and Appendices). This shows that no works were physically completed in the EPN area for the year, due to the relevant stakeholder consultations and consents not being in place in time for work to begin. In the SPN area, a total of 5.35km of overhead line were removed at Dunsfold in the Surrey Hills AONB and at Ightham and Cuxton in the Kent Downs AONB.

The following ‘before’ and ‘after’ photographs demonstrate the immediate visual impact that the removal of overhead lines can provide.

Figure 2 – Ranscombe Farm, Cuxton, Kent (SPN licence area) before the removal of overhead lines



Figure 3 – Ranscombe Farm after the removal of overhead lines



Figure 4 – Ightham Mote (Phase 2), Kent (SPN licence area) before the removal of overhead lines



Figure 5 – Ightham Mote (Phase 2) after the removal of overhead lines



2.3 Oil Leakage

Fluid Filled Cables are an essential part of the electricity distribution network in the UK. The technology was developed in the 1920s, when the first cable networks were installed at 33kV, 66kV and 132kV. Within UK Power Networks’ three licence areas, 38 per cent of all cables running at these voltages are fluid filled.

In the [Executive Summary of our RIIO-ED1 Business Plan](#) (March 2014) we gave a broad commitment to reduce cable fluid loss by 2 per cent per annum for the duration of the RIIO-ED1 price control period. Our targets in RIIO-ED1 were recognised within the RIIO-ED1 Final Determination commentary by Ofgem as stretching and building on good practice already in place.

Cable fluid loss is measured by the total amount of fluid used to top up cables minus any fluid recovered. This represents the total amount of fluid added to cables but not recovered. UK Power Networks’ strategy is to reduce cable fluid loss by investing in the network to refurbish and replace poor condition circuits. Where circuits develop new leaks, our strategy is to ensure we are at the forefront of new technology and best practice to identify and repair damage as quickly as possible. Our strategy is explained further in this section.

Key reasons for reducing oil losses include:

- Compliance with environmental legislation and the Fluid Filled Cable agreement between the Environment Agency and the ENA
- Ensuring a consistent supply to customers, by reducing instances of power loss caused by leaking cables
- Ensuring we operate the network as efficiently as possible, by reducing the cost to customers of ‘cleaning up’ oil leakages

2.3.1 2015-16 Performance

In 2015-16 a total of 208,248 litres of oil were lost in UK Power Networks’ three licence areas – a significant reduction compared to average performance in the DPCR5 period (April 2010 to March 2015). This was in line with expectations, as schemes to reduce oil loss by cable replacement can take a number of years to yield benefits. A summary of 2015-16 oil loss is provided in Table 3 below. This has been extracted from the RIGs worksheet *E2 – Environmental Reporting* (see Appendix 2) for each of UK Power Networks’ licensees.

Table 3 – Comparison of oil lost in 2015-16 to historical performance in DPCR5

Licensee	Average annual cable fluid losses – DPCR5 ¹	Cable fluid losses – 2015-16 ²	Difference (volume)	Difference (%)
EPN	48,435 litres	33,036 litres	15,399 reduction	32% reduction
LPN	122,384 litres	124,082 litres	1,698 increase	1% increase
SPN	52,729 litres	51,130 litres	1,599 reduction	3% reduction
Combined	223,548 litres	208,248 litres	15,300 reduction	7% reduction

The data in Table 3 shows that a firm commitment is already in place to reduce cable fluid losses. Following the establishment of a number of activities in RIIO-ED1, it is anticipated that losses will further reduce in line with the commitment made in our RIIO-ED1 Business Plan. These activities, which started in 2015-16, are summarised below:

- Capital replacement and refurbishment of Fluid Filled Cables

¹ The data in this column represents the average amount of cable fluid lost and not captured in each year of DPCR5, the price control period from April 2010 to March 2015.

² Cable fluid losses are measured by the total fluid used to top up cables minus the total fluid recovered for all three of UK Power Networks’ regions.

The projects described in our RIIO-ED1 Business Plan were reviewed in order to prioritise where circuit performance was known to be poorest. The highest priority projects were authorised internally at a senior leadership level and are currently at the design stage, with construction planned for 2016-17 and 2017-18.

- Review of available leak location technology providers

A review of leak location technology providers was carried out to determine whether leak location technology had progressed beyond UK Power Networks' existing in-house capabilities. As part of this review, a poor condition circuit was surveyed by UK Power Networks' staff and by an alternative service provider, with a view to comparing results and interpretation by operators. The trial found that the in-house leak detection (supported by experienced staff) was more effective in determining the location of the leak when compared to the alternative service provider's results.

- Initiation of Network Innovation Allowance projects

A number of innovation projects have started which if successful will directly contribute to a reduction in oil loss. The learning from these projects will be shared with other DNOs so that areas of best practice can be identified to support others in meeting similar commitments. These projects include:

- Self-Healing Cables

This is a collaborative project 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. If successful, this project is anticipated to provide benefits from reduced cable fluid loss from 2020 onwards. The current phase of this project is registered under the NIA project NIA-NPG-009 and started in March 2016³.

- Pressurised Cable Active Control & Monitoring

This project reviews the operating systems for Fluid Filled Cables so as to allow cables to be operated at lower pressures without the risk of customer interruptions. If successful, this project is anticipated to provide benefits from reduced cable fluid loss from 2017-18 onwards. This project is registered under the NIA project NIA-UKPN-0012 and started in September 2015.

In addition, UK Power Networks has continued to work with key stakeholders to share best practice and work to target the poorest performing circuits. This work included:

- Engaging with the Environment Agency at six-monthly meetings of the ENA Fluid Filled Cable Liaison Group to review performance. (At these meetings best practice is shared with the other DNOs.)
- Meeting with the other DNOs to discuss and share best practice, on a six-monthly basis or as required. These meetings were arranged where specific projects had been delivered and the learning could be shared with interested parties. For example, a presentation of the Small Bore Cable Replacement Technology project was arranged at which UK Power Networks demonstrated the use of new innovative technology in Greenwich to reduce the time taken to carry out excavations as part of cable replacements
- Discussing individual poor performing circuits with local stakeholders including the Canal and River Trust and local authorities (as required), enabling UK Power Networks to hear and take account of stakeholders' views

³ The NIA, or Networks Innovation Allowance, is a funding scheme under RIIO-ED1 where the licensee undertakes smaller scale innovative projects which have the potential to deliver benefits to network customers. More information is available on all NIA projects on the [ENA Portal](#).

As the above projects are funded through workstreams which require project specific reporting in the RIGs (e.g. the Network Innovation Allowance), they are not recorded under costs or volumes within the RIGs worksheet E2 – *Environmental Reporting* (please see Annexes and Appendices). It is therefore not possible to compare or analyse the costs and volumes included with this worksheet.

In summary, UK Power Networks has successfully reduced cable fluid losses by 7 per cent in the first year of RIIO-ED1 when compared to average loss during DPCR5. It is anticipated that by the third year of the current regulatory period (2017-18), the plans outlined above will reduce oil leakage in line with the 2 per cent year on year commitment made in our RIIO-ED1 Business Plan.

Achievements in the 2015-16 regulatory year are shown in the RIGs worksheet E2 – Environment Reporting (please see Annexes and Appendices).

2.4 Carbon Impact and Climate Change

2.4.1 Business Carbon Footprint

The Greenhouse Gas (GHG) Protocol categorises direct and indirect emissions into three broad 'scopes'. These apply to UK Power Networks as follows:

- Scope 1: Direct GHG emissions from sources owned or controlled by UK Power Networks
- Scope 2: Indirect GHG emissions from the consumption of purchased electricity, heat or steam
- Scope 3: Other indirect emissions such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by UK Power Networks and electricity-related activities (e.g. transmission and distribution losses) not covered in Scope 2 (e.g. outsourced activities)

Our annual Business Carbon Footprint (BCF) Report, covering carbon emissions from our three licensees, is published on our [website](#). The current version covers the regulatory year 2015-2016. The latest government issued conversion factors (released on 1 June 2016) have been used in all calculations.

We have an overall target to reduce our BCF by 2 per cent each year of the RIIO-ED1 reporting period, as specified in our RIIO-ED1 Business Plan (March 2014). To check progress against this target, we create a monthly BCF value from the data provided by the internal and external sources referred to below. Any anomalies in the data are highlighted in this monthly report and are carefully examined to establish the underlying reasons. Corrective actions are then implemented if necessary.

Monthly reports are submitted by various parts of our business covering each of the topics below:

- Electricity and gas meter readings
- Fleet fuel usage
- Business mileage and transport expense claims
- Generator fuel usage
- Sulphur hexafluoride (SF₆) top-ups
- Headcount

We also gather information from external sources. Booking reports are submitted by our external travel provider, Clarity, on a monthly basis and our contractors are required to report on any work that is subcontracted or accumulated as a direct result of works undertaken on our behalf.

For elements such as the purchase of fuel for temporary generation, SF₆ top-ups, substation energy use and some of our building energy, the reported data is apportioned directly to each of our three licensees. Data that is only available centrally is apportioned between the licensees on a headcount basis. This approach was favoured over geographical

apportionment, as LPN only accounts for around 2 per cent of the total land area, which would result in an unrealistically small value.

Our entire BCF reporting process has been subjected to internal audits over the last two years. Elements have also been examined on an annual basis by the external auditors DNV-GL, as part of UK Power Networks' ISO 14001 accreditation.

Energy Saving Opportunity Scheme legislation introduced last year required all UK companies with more than 250 employees to commission an external audit of their current energy usage by 5 December 2015, in order to identify opportunities for energy saving. Where an aspect of energy usage amounted to less than 3 per cent of a company's total energy usage, it could be discounted.

As the Environment Agency deemed that network losses were the responsibility of the DNOs, we had the option of simply auditing our network losses and discounting all other aspects of our energy usage. Instead, we chose to report our network losses as an appendix and to have all other aspects of our business energy usage externally audited. Business cases are being examined for the energy saving opportunities identified and the impacts of these should manifest themselves in future reductions of our BCF.

Distribution losses and UK Power Networks' Losses Strategy are covered in detail in section 2.4.3 of this report. For the purposes of this section we have provided our overall BCF without distribution losses for the 2014-15 and 2015-16 regulatory years, broken down by licensee – please see Table 4 below.

Table 4 – BCF without distribution losses

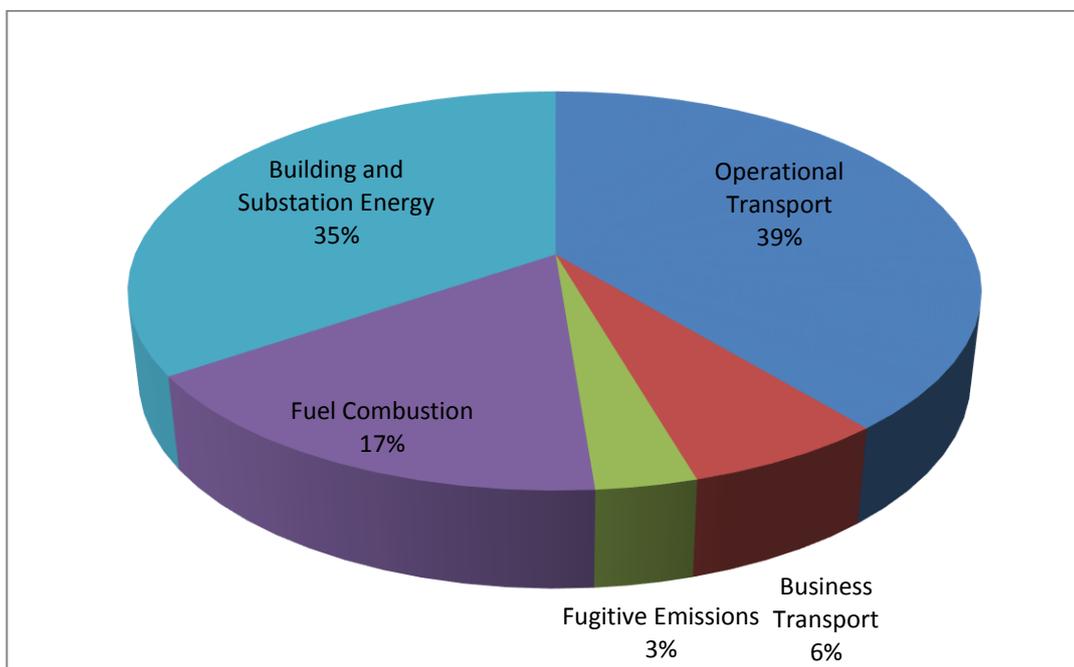
Licensee	2014-15 (tCO ₂ e)	2015-16 (tCO ₂ e)	% change
EPN	32,539	27,608	-15%
LPN	19,777	17,401	-12%
SPN	25,025	21,212	-15%
Combined	77,341	66,221	-14%

During the year we achieved a 14 per cent reduction in tCO₂e, the components of which are discussed below.

For 2015-16 and subsequent regulatory years, DNOs are required to report company and contractor emissions separately in their BCF submissions to Ofgem. However, for ease of comparison, we have provided combined figures for 2014-15 and 2015-16 in each of the tables in this section.

Figure 6 illustrates the relative proportions of the different elements of our BCF. Further detail is provided below.

Figure 6 – BCF breakdown excluding losses



2.4.1.1 Operational Transport

Fuel purchased for UK Power Networks’ fleet vehicles is captured using fuel cards. Contactor transport data is obtained from contractor fuel cards, submitted via a manual reporting process. In 2015-16, 99.2 per cent of the fuel purchased in this way was diesel.

A £7m major replacement of our fleet has taken place in recent years, replacing many older vehicles with safer, more reliable fuel efficient models. Our contractor emissions have reduced as functions such as tree trimming have been brought in-house. As can be seen from Table 5 below, overall Operational Transport emissions have reduced as a result of the fleet upgrade, with only a minimal increase in UK Power Networks’ own emissions.

Table 5 – Overall transport emissions

Licensee	Direct operational staff	% of staff	2014-15 – total (tCO ₂ e)	2015-16 – our fleet (units)	2015-16 – contractors (units)	2015-16 – combined (units)	% change
EPN	980	39%	11,451	5,455	4,687	10,142	-11%
LPN	758	30%	9,284	4,217	3,623	7,841	-16%
SPN	762	31%	10,213	4,240	3,643	7,883	-23%
Combined	2,500	100%	30,948			25,865	-16%

2.4.1.2 Building and Substation Energy

Data is collated from the electricity and gas bills received for each site. The data is predominantly for electricity usage. (Gas represents less than 7 per cent of our building energy usage.)

Data is measured in kWh then converted into tCO₂e. In shared buildings overall UK Power Networks headcount is used as a factor to determine the amount of energy consumed by each licensee.

Savings were achieved through consolidating staff into fewer buildings – for example, by relocating staff from our offices in Braintree and Sundridge as well as some smaller sites. Many of the remaining offices have had energy saving initiatives implemented, such as the introduction of LED lighting. The removal of staff catering facilities from our Energy House and Newington House sites has also reduced energy consumption.

The figures in Table 6 include energy used in our metered and unmetered substations. To determine the estimated consumption for our unmetered substations, typical energy usage in relation to heating, lighting and security was analysed for grid, primary and secondary substations and applied across the business, based on the numbers of unmetered substations of that type in operation.

The accuracy of data from our metered substations has improved following a business drive to obtain actual meter readings at these sites, and in particular from properties more than 90 days in arrears on a meter reading. This has had the biggest impact in the LPN area, where the majority of substations are metered.

Factors such as the national change to the fuel mix of UK electricity, an increase in renewables and the closure of coal fire power stations, led to a reduction in the carbon factor per kWh of electricity in the UK by 6.8 per cent between 2014 and 2015 and by a further 10.8 per cent between 2015 and 2016. This has had a significant impact on all electricity usage aspects of our BCF, as shown in Table 6.

Table 6 – Electricity usage

Licensee	2014-15 – total (tCO ₂ e)	2015-16 – total (tCO ₂ e)	% change
EPN	13,575	10,641	-22%
LPN	6,943	6,835	-2%
SPN	6,649	5,414	-19%
Combined	27,166	22,890	-16%

2.4.1.3 Fuel Combustion

This section covers emissions from plant and equipment (e.g. temporary generators used during fault repairs) and planned work on the network. Data on such emissions is obtained from three different sources:

- From external contractors providing standby diesel generators and reporting monthly fuel usage. Invoices for diesel fuel are used to collate the monthly fuel usage by licence area. Though provided as required by external contractors, these are classed as Scope 1 emissions, as they are in direct use on our network
- From fuel cards capturing the fuel used by company-owned plant and equipment
- From invoices submitted by the tanker company which fills the tanks at several of our sites used for our own generators

The source data is separated by licensee and therefore no headcount conversion needs to be applied. The reduction in emissions due to temporary generation, as shown in Table 7, reflects fewer faults on our network.

Table 7 – Emissions due to temporary generation

Licensee	2014-15 – total (tCO ₂ e)	2015-16 – total (UK Power Networks)	2015-16 – contractors (units)	2015-16 – combined (units)	% change
EPN	4,322	3,279	259	3,537	-18%
LPN	1,718	1,130	200	1,330	-23%
SPN	6,329	5,959	200	6,160	-3%
Combined	12,368			11,027	-11%

2.4.1.4 Business Transport

This section refers primarily to employees’ mileage and public transport (for attendance at meetings etc), which constitute our indirect operational emissions. For some public transport journeys where only cost data is available, this has been converted into miles using industry standard methodologies. The carbon conversion factors have then been applied.

Business travel data is captured from four different sources:

- SAP (our financial management system) – mileage and travel claimed as expenses
- Clarity Travel (our approved travel provider)
- Corporate credit card – travel purchased with company credit cards
- Fuel cards – fuel purchased with company fuel cards

In all cases the mode of transport (air, rail or road) is recorded.

Business travel data is not recorded by licensee and therefore the total business mileage has been apportioned based on the number of indirect staff employed in each licence area.

Vehicles which are owned by UK Power Networks or purchased through our business needs self-purchase scheme account for 74 per cent of our total business mileage. This enables us to use each vehicle’s actual CO₂ rating when calculating its contribution to our carbon footprint. Where employees claim business mileage for privately owned vehicles (the remaining 26 per cent of journeys), the make and model of the vehicle is not known and therefore the government’s unknown vehicle average conversion factor is used.

The provision and encouraged use of teleconferencing facilities and a business-wide attempt to reduce travel generally, means that although there are some regional variations, overall our business mileage continues on a downward trend – as Table 8 demonstrates.

Table 8 – Business mileage summary

Licensee	Indirect staff	% of staff	2014/15 – total (tCO ₂ e)	2015/16 – UK Power Networks (units)	2015/16 – contractors (units)	2015/16 – combined (units)	% change
EPN	1,248	43%	1,652	1,566	197	1,763	+7%
LPN	807	28%	1,339	1,026	152	1,178	-12%
SPN	829	29%	1,473	1,201	153	1,354	-8%
Combined	2,884	100%	4,464			4,295	-4%

2.4.1.5 Fugitive Emissions

Sulphur hexafluoride (SF₆) is an electrical insulating gas which is commonly found in modern electrical switchgear. This gas can leak following faults or from old equipment.

We have a number of procedures in place to minimise the escape of SF₆ to the environment; these are covered in detail in the next section. From a BCF perspective, we have included the levels of SF₆ emissions (fugitive emissions) reported by our three licensees in 2014-15 and 2015-16. As can be seen from Table 9 below, overall these reduced by more than 10 per cent this year.

Table 9 – SF₆ emissions

Licensee	Total – April 2014-March 2015 (tCO ₂ e)	Total – April 2015-March 2016 (tCO ₂ e)	% change
EPN SF ₆ losses	1,541	1,525	-1%
LPN SF ₆ losses	493	218	-56%
SPN SF ₆ losses	362	401	+11%
Combined	2,395	2,144	-10%

Emissions from air conditioning have not been included; this is consistent with the approach used for our 2014-15 BCF submission.

2.4.1.6 Distribution Losses

These calculations measure units exiting our distribution network compared to units entering from Grid Supply Points and any other sources.

Achievements in the 2015-16 regulatory year are shown in the RIGs worksheet *E4 – Losses Snapshot* (please see Annexes and Appendices).

Overall losses performance is presented in Table 10. The final data for 2015-16 is expected to change as future reconciliations are received and therefore the current position should not be taken as a forecast of future performance.

Table 10 – Distribution losses

Licensee	2014-15	2015-16 (tCO ₂ e)	% change
EPN	1,178,316	922,168	-22%
LPN	913,867	784,543	-14%
SPN	663,791	498,581	-25%
Combined	2,755,974	2,205,292	-20%

Our overall business carbon footprint with losses is presented in Table 11.

Table 11 – Distribution losses including BCF

Licensee	2014-15 (tCO ₂ e)	2015-16 (tCO ₂ e)	% change
EPN	1,210,855	949,776	-22%
LPN	933,663	801,944	-14%
SPN	688,816	519,793	-25%
Combined	2,833,335	2,271,513	-20%

Distribution losses are covered in detail in section 2.4.3 of this report.

2.4.2 Sulphur Hexafluoride Emissions (SF₆ Emitted)

We are committed to reducing leakage of SF₆ from our network assets, both as an internal measure and also as required by law. (The EU F-gas Regulations require all SF₆ leaks to be resolved without undue delay.) In addition, we have made a commitment in the [Executive Summary of our RIIO-ED1 Business Plan](#) (March 2014) to “maintain sulphur hexafluoride (SF₆) leakage at less than 0.2 per cent as a proportion of SF₆ in service”. Our commitment covers the RIIO-ED1 period and is applicable to all three of our licence areas.

SF₆ is used in our switchgear as an insulation medium, an arc extinction method or for both functions, from 11kV up to 132kV. SF₆ leakage is measured in kilogrammes as the amount of SF₆ that is used to top up our gas filled switchgear. The total capacity of SF₆ utilised in assets on our network is slightly less than 97,000kg across our three licence areas – please see the corresponding breakdown in Table 12 below.

Table 12 – Installed SF₆ capacity per licensee

Licensee	Install capacity (kg)
SPN	19,318
LPN	41,825
EPN	35,825
Combined	96,968

Gas circuit breakers are becoming more prevalent on our network as more oil switchgear is removed, and there will be a subsequent increase in SF₆ filled switchgear on the network to replace them. This is especially true at the 132kV voltage level, where SF₆ is the industry standard arc extinction for circuit breakers. It is also the most viable insulation medium for switchgear of all voltages in the LPN area, offering advantages at installation due to the compact nature of this type of switchgear.

Due to the replacement of oil breakers, the expected trajectory of the SF₆ capacity on our network is forecast to increase in RIIO-ED1 by approximately 5,000kg⁴. Over the last two years, UK Power Networks as a whole has comfortably met the SF₆ leakage targets set out in our 77 output commitments as part of our [RIIO-ED1 Business Plan](#) (March 2014). With the slight increase in SF₆ capacity, combined with the level of investment in SF₆ leak rectification, we would expect our quantity of SF₆ topped up, as a percentage of installed capacity, to reduce further.

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. System development is considered later in the project life-cycle and hence system development decisions do not directly impact the trajectory of UK Power Networks’ SF₆ bank.

⁴ This is an estimate based on the average kilogrammes of SF₆ in a new GIS bay (F35), the average capacity of an AIS SF₆ circuit breaker (DB145) and a prediction of the scope of works that will be completed for switchgear projects currently in our RIIO-ED1 plan.

2.4.2.1 Our current strategy

We are taking action to minimise SF₆ emissions in order to:

- Comply with the EU F-gas Regulations
- Minimise our impact on the environment and achieve our objective of being a Respected Corporate Citizen. SF₆ is 22,800 times more harmful to global warming than Carbon Dioxide (CO₂)
- Minimise the outages required to top up leaking circuit breakers – reducing costs associated with the top-up and the period of time the network is at risk
- Reduce the probability of maloperation or failure and hence minimise the risk to our operational staff working on the network, as well as improve network performance

Our strategy is to take remedial action against all known leaks in strict accordance with the EU F-gas Regulations. We gauge the amount of SF₆ leakage by the number of SF₆ top-ups completed. For all known SF₆ leaks, our approach is to instruct the manufacturer to carry out leak detection works on the affected unit, scope up the works and complete all refurbishment works required to mitigate the leak. This often constitutes an on-site refurbishment or factory refurbishment. In these scenarios, refurbishment 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 of the circuit breaker, a replacement will be sought.

We plan to invest £450k in 2016-17 to rectify leaks from 33kV and 132kV switchgear. This sum represents the estimated cost of rectifying all known SF₆ leaks from UK Power Networks' assets.

Our current process for recording top-ups is as follows:

- Raise a defect for low gas pressure on SF₆ filled circuit breakers
- Raise a work order to top up the low pressure circuit breaker
- Arrange for an authorised engineer to top up the circuit breaker to the manufacturer's recommended pressure. The magnitude of the top-up is a mandatory input field to close the work order

SF₆ is a hazardous material and must be treated with care, in a manner compliant with the EU F-gas Regulations. We have produced three documents specifying the operating constraints that apply to the handling of SF₆ or the operation of any switchgear containing this substance. One of these documents is *Engineering Design Standard EDS 03-0036 – Management of Switchgear Containing SF₆*, which offers guidance on the management of switchgear containing SF₆ from voltages of 6.6kV up to 132kV. More specifically, it details the processes followed in identifying and managing SF₆ filled switchgear that may be leaking. This is a policy that applies to plant and staff universally across the company.

2.4.2.2 Stakeholder engagement

The key stakeholders in this area are the parties who are directly affected by an SF₆ leak – among them, operational staff and manufacturers. Correspondence is required with operational staff (e.g. field engineers and craftsmen) when ascertaining the feasibility of remedial works. For example, information about the precise source of an SF₆ leak will enable the manufacturer to decide whether the proposed remedial action is cost effective – and will prevent costly and potentially unnecessary leak detection visits from the manufacturer. Communication is open between other manufacturers when seeking to innovate UK Power Networks' SF₆ handling policy.

2.4.2.3 Our current programme to reduce emissions

Our current programme adheres to the requirements of the EU F-gas Regulations – to resolve all gas leaks without undue delay. Generally, for 11kV primary switchgear and above, a refurbishment will be sought. For secondary 11kV

switchgear and below, it is generally more prudent to action a replacement than to undertake remedial refurbishment works, due to the associated costs.

The quantity of SF₆ topped up is recorded automatically during the completion of top-up work orders. These work orders are created automatically when a low SF₆ gas alarm is detected.

SF₆ leakage figures are stored in the UK Power Networks asset register and are reported to the senior management team in our Asset Management directorate on a monthly basis. They are also submitted to Ofgem annually, as part of the commentary accompanying the RIGs worksheet *E2 – Environment Reporting*.

Over the last five years our performance in the LPN and SPN areas has been well within our 0.2 per cent target. The EPN area has shown a downward trend over the same period of time, with more recent figures close to or at our target levels. Accordingly, the EPN area is receiving the largest investment in SF₆ leak rectification works.

Following the significant investment in SF₆ leak intervention scheduled for 2016 and 2017, we expect to maintain our performance well within the 0.2 per cent leakage target set out in our RIIO-ED1 Business Plan.

2.4.2.4 Our future strategy

Our future strategy is focused on minimising the costs and downtime associated with SF₆ top-ups and involves a new approach of allocating gas carts in certain regions to increase the transparency/accuracy of top-up figures. It is proposed that these gas carts will have the capacity to check the quality of SF₆ gas, remove moisture and top up breakers whilst recording the exact quantity of SF₆ topped up, using a mass flowmeter. Utilising gas carts has significant benefits from a recording perspective. They are much more accurate than our current method which involves weighing the gas cylinder with scales before and after the top-up. Furthermore, the ability to check gas quality will enable us to re-use a greater quantity of SF₆; previously we have only used new SF₆ for any top-ups.

There are several wide-ranging benefits to a proposed all-purpose gas cart per licensee, as listed below:

- More accurate leakage reporting – data would also be stored on all gas carts, providing a secondary historical record of the SF₆ top-up
- Saved maintenance time/costs – there are many different types of pipe connection and often the correct ones are not available – or even known
- Saving on the costs of paying manufacturers to de-gas and top up for remedial works (approximately £12k per year)
- Reclamation of used SF₆ rather than disposal – with the new portable SF₆ gas cart, gas can be quality tested and subsequently re-used in place of new bottles at all sites, saving approximately £6.3k per year (one 63kg bottle per licensee)
- Savings on the purchase of a gas cart for new 132kV GIS board (one in RIIO-ED1) of approximately £50k per year
- A total estimated saving of £68k in the first year

The above figures provide an initial estimate of the benefits of a new gas cart per licensee, using SPN as an example. The total estimated benefit in the first year would cover the costs of the new gas cart.

This project is currently at the feasibility stage. Pending a successful delivery business case, the project is planned for mobilisation in 2017.

Our RIIO-ED1 Business Plan showed that four new GIS boards and 94 132kV AIS breakers with SF₆ arc extinction were expected to be installed during the RIIO-ED1 period. This constitutes approximately 5,000kg of additional SF₆ capacity in assets on our network.

UK Power Networks is keeping abreast of all innovations related to SF₆ as an insulation medium, including the exploration of SF₆ alternatives. Alstom and National Grid have worked collectively to develop G3 as a viable alternative to SF₆. We have made enquiries with both parties and will monitor the development of this new technology as a possible future alternative to SF₆ for use as an insulation medium/arc protection method in new switchgear.

Achievements in the 2015-16 regulatory year are shown in the RIGs worksheet *E2 – Environment Reporting* (please see Annexes and Appendices).

2.4.3 Distribution Losses

2.4.3.1 Technical Distribution Losses

Distribution network losses – the difference between the electrical energy entering the network and the energy delivered to the end customer – are a consequence of transferring electricity across the distribution system and can have a significant financial and environmental impact on customers.

There are a variety of technical losses but the two principal types are fixed and variable. As energy passes through our network, a small proportion of energy is lost as heat during transportation. This is known as a variable loss, as it varies with the amount of energy distributed. Unfortunately, this relationship is not linear and so peaky loads incur higher losses than those associated with a flatter load profile. Fixed losses are independent of the energy being transferred across the network and generally relate to losses associated with the energy required to energise transformers. The level of technical losses within a system will depend on a number of factors, but for a typical distribution network around 30 per cent of technical losses will be due to fixed losses and around 70 per cent will be due to variable losses (although there will be regional variations in this ratio).

Distribution networks also suffer loss of energy through non-technical losses. These result from the under-recording or non-recording of electricity consumption – for example, when a customer extracts energy from the network illegally. As a proportion of energy lost, non-technical losses represent a much smaller value than those associated with technical losses – approximately 1/27th of the overall losses⁵. Non-technical losses are covered in detail later in this section.

The focus of UK Power Networks' Losses Strategy remains the same as our original strategy, published as an annex to our RIIO-ED1 submission in March 2014. Within our strategy are 14 areas of focus on technical losses and three areas of focus on non-technical losses. Many of the related activities can be undertaken immediately and work is already under way to implement them. Others will be undertaken once more is known about how technical losses are incurred and where they predominantly occur on the network. The remainder are dependent on new technologies or methods of operating the network and will be implemented once it is feasible to do so. Activities which are already under way are detailed in our RIGs worksheet *E4 – Losses Snapshot* (please see Annexes and Appendices), but at a high level, the overall split is as follows:

Current activities:

- Replacement of existing transformers with ECO2015 specification⁶ equivalents which will reduce the fixed iron losses that are constantly present on the network, irrespective of the current passing through it

⁵ Ofgem's Energy Efficiency Paper suggested that 2012-13 values across GB were 27TWh. Of these 19.6TWh related to distribution network technical losses, 6.4TWh to transmission technical losses and 1TWh to non-technical losses. (<https://www.ofgem.gov.uk/publications-and-updates/energy-efficiency-directive-assessment-energy-efficiency-potential-great-britain-s-gas-and-electricity-infrastructure>)

⁶ The EU Ecodesign Directive for transformers took effect from July 2015 and requires all transformers placed in the market (or being installed for the first time) to comply with strict new design specifications that specifically address transformer losses. The directive has been devised to eliminate the worst performing transformer models from being installed across the EU and is expected to save in the region of 16TWh per year from 2020 onwards. A second tier of design specifications will come into force from July 2021.

- Replacement of existing transformers with larger units where the saving in copper losses (variable) outweighs the increases in iron losses (fixed)
- Installation of larger cross-section conductors to reduce resistance and hence variable I²R losses
- Amendments to Engineering Design Standards to ensure that the above practices are implemented proactively in future designs where the long term benefit outweighs the upfront capital cost. This will ensure that losses are minimised and this benefit remains with the asset throughout its life.

Areas of near term focus:

- Understanding the impact that inefficient use of the network has on losses. Factors that are considered inefficient include poor power factor, poor power quality and large levels of phase imbalance. These factors lead to increased currents relative to the useful energy that is delivered to the customer. The larger currents in turn increase variable I²R losses. Tackling these areas can mean that existing assets are utilised more efficiently, without the need to undertake costly network reinforcement.
- Reconfiguration of existing networks to ensure that circuit lengths are minimised. Reducing circuit length reduces the circuit resistance, which again has an impact on the variable network losses associated with the circuit. The reconfiguration of the network needs careful consideration to ensure that it complements other network drivers, such as Quality of Supply
- Consideration of alternative solutions to traditional asset replacement and network reinforcement schemes where the cost benefit of the losses impact changes the solution that is delivered. This may include installing larger assets than would otherwise have been justified if the value of the avoided losses outweighs the increased capital cost of the asset.

Longer term areas of focus:

- Considering the impact that the transition from DNO to Distribution System Operator (DSO) has on network losses and identifying how these new mechanisms can be used to manage network losses in the context of ever-increasing network utilisation. These mechanisms include Active Network Management (ANM), Demand Side Management (DSM), Distributed Generation (DG), Battery Storage and a range of Low Carbon Technologies (LCTs). Generally, these technologies are being developed to maximise network utilisation – almost without exception, this will worsen network losses. However, they may be used infrequently for this purpose, and we therefore intend to explore whether they can be used to minimise network losses for the remainder of the time.
- Development of new technologies coming to market which may be used to minimise losses. While the exact nature of these technologies is not yet fully understood, it is likely that they will enable DNOs to undertake their current focus more efficiently. It may also highlight new areas that DNOs can focus on to target losses.

The total losses shown in Table 13 have been developed from the RIGs worksheet *E3-BCF* (please see Annexes and Appendices). From these two extracts we are able to provide a position on the percentage of total losses on our three networks.

Table 13 – Summary of losses

	2011	2012	2013	2014	2015	2016
Total Losses (tCO ₂ e) ⁷						
EPN	1,267,925	1,049,245	1,152,525	1,112,211	1,178,316	922,168
LPN	853,709	794,489	843,139	839,961	913,887	784,543
SPN	736,912	659,789	675,935	611,716	663,791	498,581
Total Losses (GWh)						
EPN	3,077	2,546	2,797	2,699	2,860	2,238
LPN	2,072	1,928	2,046	2,038	2,218	1,904
SPN	1,788	1,601	1,640	1,485	1,611	1,210
Total units distributed (GWh)						
EPN	34,525	34,093	35,108	33,794	32,882	32,721
LPN	29,355	28,492	28,722	28,006	27,632	27,442
SPN	21,694	20,813	20,994	20,508	19,713	19,413
Total losses (%)						
EPN	8.91	7.47	7.97	7.99	8.70	6.84
LPN	7.06	6.77	7.12	7.28	8.03	6.94
SPN	8.24	7.69	7.81	7.24	8.17	6.23

Table 14 shows the losses improvements reported through our RIGs worksheet *E4 – Losses Snapshot* (please see Annexes and Appendices) for the regulatory year 2015-16. These should be read in conjunction with the notes below.

Table 14 – Summary of losses improvements

Asset	EPN	LPN	SPN
	Saving (MWh)	Saving (MWh)	Saving (MWh)
LV Cable	572	143	229
HV Cable	463	0	0
Distribution Ground Mounted Transformer	912	753	491
Distribution Pole Mounted Transformer	93	0	41
Primary Transformer	352	78	78
Grid Transformer	2,144	2,144	1,072
Total	4,536	3,118	1,912

- LV cable – amendments to UK Power Networks' LV design standards have resulted in larger LV cables being installed than in previous years. The reduced resistance of these will have a long term losses benefit
- HV cable – reinforcement/asset replacement schemes to replace significant lengths of HV cable have resulted in larger cable sizes being installed relative to the existing assets that they replace to drive a longer term reduction in losses
- Distribution transformer replacement – through using ECO2015 specification transformers and installing larger units, where justified by cost benefit analysis, fixed (and variable) losses associated with distribution transformers have reduced as a result of the activities undertaken

⁷ We have used the following conversion factor in producing this table: 1kWh = 0.41205 kgCO₂

- Primary/grid transformers – a number of schemes in the EPN, LPN and SPN areas have resulted in modern low loss primary and grid transformers being installed, which save significant losses in relation to the units they replace

UK Power Networks' Losses Strategy is based on an 'opportunistic' approach where losses benefits are delivered at close to zero cost through existing programmes of work. Therefore, the forecast volumes that are reported will relate to our RIIO-ED1 volumes and to work that delivers an improvement in the overall losses position.

Based on the realised benefits reported in the 2015-16 RIGs worksheet *E4 – Losses Snapshot* (please see Annexes and Appendices), a total of 9,565.8MWh of improvements were made over the 12-month period. This equates to 23,214.6 tCO₂e in the year.

2.4.3.2 Assessment of progress in developing tools and methodology for distribution losses

UK Power Networks' Losses Discretionary Reward (LDR) [tranche 1 submission](#) (29 January 2016) proposed a wide range of activities that focus on understanding losses, and in particular on implementing processes to help manage them.

The LDR focus is split across four categories that Ofgem wished DNOs to concentrate on, and within these categories are 17 distinct areas of focus. Though in their infancy, a number of these areas of focus will provide tools to understand and manage losses, a framework methodology to help standardise the assessment of losses, and enhanced modelling tools that will enable activities associated with the reduction of losses to be targeted within UK Power Networks' three licence areas.

Of note, in relation to this work, are the following activities:

- Development of a holistic network modelling tool with Imperial College London – this will allow the prompt assessment of a wide range of approaches across our three licence areas and will also help us to focus particular activities in specific areas where they are proven to deliver maximum benefits efficiently
- Development of a standard assessment framework against which losses can be measured – this will help to ensure a consistent approach, enabling benchmarking of activities across our three licence areas and in relation to other DNOs
- Development of an innovative approach to identifying losses through the use of a Mobile Asset Assessment Vehicle
- Employing the Power Network Demonstration Centre (PNDC) to develop an innovative method of trialling interventions related to losses prior to implementing them on the wider network – this will develop concepts that have been proved at the modelling stage and enable measurements to be taken to validate the modelled values

Table 15 and Table 16 summarise key figures in respect of technical losses activities.

Table 15 – Summary of losses costs and benefits from activities in RIIO-ED1 (technical losses)

Programme/project title	Regulatory reporting year (2015-16)			RIIO-ED1
	Distributed losses – justified cost	Reduced losses	Reduced emissions associated with losses	Cumulative reduced losses to date
	£m	MWh	tCO2e	MWh
LV Cable	0.192	944	2,292	944
HV Cable	0	463	1,124	463
Distribution Transformers	0.911	2,290	5,557	2,290
Primary Transformers	0	508	1,234	508
Grid Transformers	0	5,360	13,008	5,360

Table 16 – Summary of amount of losses activities in regulatory reporting year and estimate for the following regulatory year (technical losses)

Programme/project title	Description of unit	Volumes in regulatory reporting year (2015-16)	Forecast volumes for following regulatory year (2016-17) ⁸
LV Cable	km	30.4	N/A
HV Cable	km	64.5	N/A
Distribution Transformers	ea	1,124	N/A
Primary Transformers	ea	13	N/A
Grid Transformers	ea	5	N/A

2.4.3.3 Non-technical Distribution Losses

As previously mentioned, distribution networks suffer loss of energy through non-technical losses resulting from the under-recording or non-recording of electricity consumption. Responsibility for the management of non-technical losses lies primarily with electricity suppliers, who read meters, record consumption and pursue customers who commit theft through tampering with or ‘bypassing’ their electricity meter. Nevertheless, up to 10 per cent of reported electricity theft is committed by persons who make unauthorised connections to the distribution system and do not register with a supplier. In the electricity industry this is known as theft in conveyance.

Investigating and resolving instances of theft in conveyance is the responsibility of distributors such as UK Power Networks. In accordance with our obligation under standard condition 49 of the Electricity Distribution Licence to tackle theft in a reasonable, cost-effective manner, in 2014-15 we undertook a Cost Benefit Analysis (CBA) prior to undertaking this work. This showed that UK Power Networks derived no material financial benefit in the short term from undertaking work to investigate and resolve theft. However, the CBA did importantly show that there would be a material benefit to customers from the resolution of theft cases – a reduction in losses, which all customers ultimately pay for.

⁸ The volumes are based on activities that deliver a losses improvement and are therefore calculated retrospectively rather than forecast. At a high level, we would expect an increase in LV cable length reported, due to the effect of the change in LV design standard – whereas distribution transformers are expected to be on a par with 2015-16 figures. For the other three items, these are subject to programmes of work, but we anticipate volumes being broadly similar.

Notwithstanding the CBA process, UK Power Networks has always had an active programme of detecting and investigating suspected instances of theft in conveyance. This forms part of our wider legal and social obligations and contributes towards our corporate objectives.

During 2015-16 our programme of work led to around 300 cases of theft being resolved in our three licence areas. The vast majority of cases were resolved through the customer making an application to an electricity supplier and the subsequent registration of the metering point in settlement. In a small number of cases it was necessary for UK Power Networks to disconnect the customer's supply.

Table 17 and Table 18 summarise key figures in respect of non-technical losses activities.

Table 17 – Summary of losses costs and benefits from activities in RIIO-ED1 (non-technical losses)

Programme/project title	Regulatory reporting year (2015-16)			RIIO-ED1
	Estimated distribution losses – justified costs	Estimated reduced losses	Reduced emissions associated with losses	Cumulative reduced losses to date
Countering Theft in Conveyance	£m	MWh	tCO ₂ e	MWh
	0.21	1,200	603	1,200

Table 18 – Summary of amount of losses activities in regulatory reporting year and estimate for the following regulatory year

Programme/project title	Description of unit	Volumes in regulatory reporting year (2015-16)	Forecast volumes for following regulatory year (2016-17) ⁹
Countering Theft in Conveyance	Theft in Conveyance Investigation/Case	300	300

2.4.4 Other Environment-related Activities

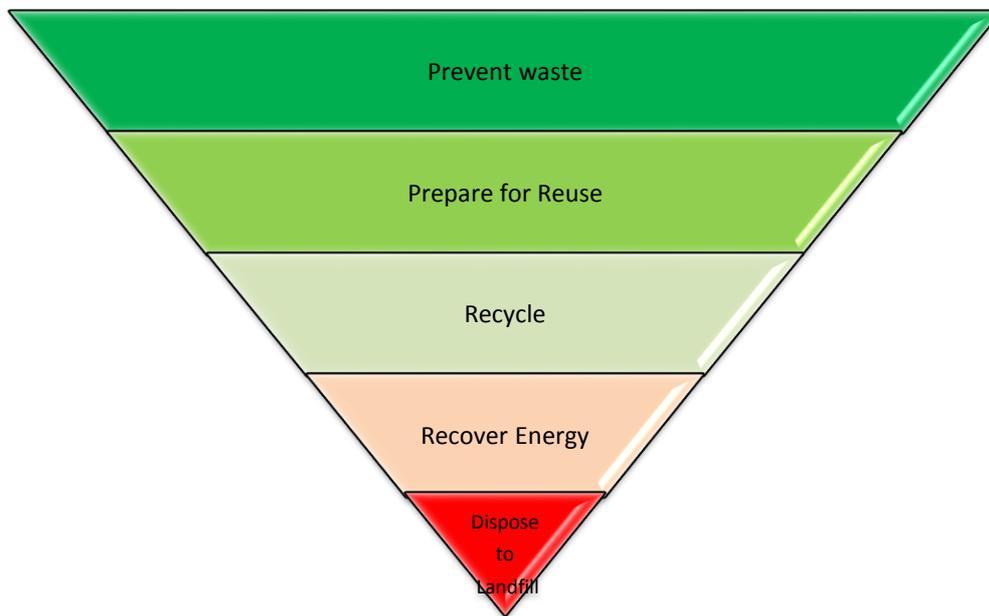
2.4.4.1 Waste/landfill/recycling

We aim to divert as much waste as possible from landfill, including at least 70 per cent of office and depot waste and 98 per cent of street works spoil (the waste left over from street works). In 2015-16 we diverted 95 per cent of our office and depot waste and 97.3 per cent of our street works waste from landfill. We are investigating what proportion of waste sent to waste transfer stations might subsequently be diverted to landfill to improve upon these results.

We manage our waste streams using the 'waste hierarchy' shown in Figure 7 below.

⁹ Given that activities are driven by theft in conveyance being reported to, or identified by UK Power Networks, these volumes cannot be accurately forecast. In essence, the volume of work undertaken during the year will be principally driven 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.

Figure 7 – Waste hierarchy



We are acutely aware of the environmental and economic importance of preventing waste and strive for continuous improvement. Some of the initiatives we have in place are:

- 'Follow-me' printing at all of our main office sites to reduce paper waste
- A 'no under-desk bins' policy to encourage staff to sort their rubbish into general waste, paper, newspaper, cardboard, plastic bottles and cans
- The use of a specialist firm to recycle mobile phones, laptops, desktops and monitors for refurbishment and use in the developing world
- The recycling, refurbishment and reuse wherever possible of waste metal from items such as electricity transformers and switchgear
- Ensuring that anything removed from the ground during our street works operations is sorted at a street works recycling plant into graded materials for reuse, in compliance with the Department of Transport Code of Practice for the Reinstatement of Openings in Highways
- A process for ensuring that trees trimmed or felled as part of our maintenance programme around power lines are chipped, mulched, left in habitat piles or used for biomass fuel or timber, depending on customers' requirements

All of our major projects have a Project Waste Management Plan in place. This identifies the person responsible for its implementation and describes the expected waste streams, how the streams will be managed, the contractors to be used and how the quantities will be recorded.

2.4.4.2 Noise Pollution and air quality/pollution reduction activities and strategy

When operating our network, we have a responsibility to ensure that any noise from our equipment is mitigated to an acceptable level, especially if it is sited in a residential area. Most of the enquiries or complaints we receive about noise are related to low frequency noise (up to 160 hertz) associated with our transformers and substations. In 2015-16 we received 45 complaints as reported in RIGs worksheet *E2 – Environmental Reporting* (please see Annexes and Appendices).

Low frequency noise is transmitted through the air or ground and can be challenging to mitigate due to its long wavelength. If the noise is emitted by a substation that is integral to a building, it is usually ground-borne and can be mitigated through the installation of anti-vibration pads. Integrated substations are quite common in the LPN area, where properties are often sited directly above our equipment. Airborne noises must be blocked by a physical barrier – typically a metal screen with insulation.

To determine if our equipment is causing the disturbance and gauge the noise level emitted, we carry out noise surveys using a rating method developed by Salford University. This rating method was commissioned by the Department for Environment, Food and Rural Affairs (Defra) and can be used to determine whether a low frequency noise would be considered a Statutory Nuisance under the Environmental Protection Act.

Where the acoustic landscape is more complex, we engage an acoustic consultant to assist with the rating method and provide guidance on specialist mitigation measures.

Noise complaints can be challenging to resolve and mitigations to deliver noise reduction frequently include safety considerations – for example, maintaining safety clearances at our sites and ensuring our equipment continues to operate at the correct temperature. Wherever possible we liaise with local authorities on noise complaints to identify an appropriate course of action. We also aim to build good relationships with Environmental Health Officers by sharing information and knowledge, particularly in relation to low frequency noise.

We ensure we keep abreast of innovations in this area and are committed to reviewing new noise control techniques as they become available. We are currently assessing a new, innovative noise screen for possible installation at one of our sites. The technology works to reduce low frequency noise from transformers by disrupting, rather than insulating against the noise field.

We frequently have to use generators to maintain supply, and this can prompt complaints from local residents about both noise and fumes. Our Innovation team has developed a new hybrid generator which uses a diesel engine to charge batteries during daytime hours and can then be used to power properties at night, thus reducing the likelihood of a noise complaint. This equipment is capable of supplying 8kVA (enough for one property) and the team is working on a larger version that is capable of supplying multiple properties.

2.4.4.3 Environmental employee awareness schemes/incentives/practices.

In 2015 we launched an externally accredited environmental training course. Candidates learn how our business interacts with the environment; the steps we take to prevent harm and how they can protect the environment whilst working.

2.4.4.4 Adaptation/flood preparedness.

UK Power Networks is committed to understanding and protecting its grid and primary substations from flood risk, starting with the purchase of 1,000m of “Geodesign” temporary flood barrier and continuing with a programme of major works to assess, prioritise and deliver flood protection measures throughout the DPCR5 and RIIO-ED1 price control periods. This programme is supported by two documents: the policy and design guidance document *EDS 07-0106 – Substation Flood Protection*, which is available for use by internal and external parties; and the DNO group document *ETR138 – Resilience to Flooding of Grid and Primary substations*.

UK Power Networks records its costs, volumes, protected sites and customer numbers in the RIGs tables which are submitted to Ofgem each year.

Over the last few years, a large amount of research has been undertaken into pluvial/surface water risk. Events such as the flooding incidents in Tooley Street (April 2008 and May 2009) have highlighted the risk substations are at from surface water flooding. As a result, the LPN flood protection programme has been focused primarily on surface water flood protection of sites with plant below street level. Following site specific assessments, over 20 sites were identified as being at risk; flood protection measures in the form of bunding, flood gates and sealing duct and cable entries have been implemented during the last few years.

UK Power Networks has sought to deliver flood protection measures which are cost efficient and deliver the most risk reduction, to improve the numbers of customers protected. Where sites are being developed and new buildings and plant are being installed and it has been previously identified that the site is at risk from flooding, measures will be designed and built in to ensure the new plant is protected. This will normally be achieved by raising the critical equipment above the Environment Agency 1:100 or 1:1000 flood level, allowing for climate change, and incorporating a 300mm freeboard. Examples are our Tottenham Grid and Bushey Mill Grid sites, of which the latter has already shown its worth during the February 2014 floods where, despite the site flooding, the power supply was maintained. Another example is our Forest Row primary substation, which has been protected to a 1:100 flood level through designing and installing the new transformer to be above the flood level, while installing a flood wall around the existing transformer.

The focus for 2016 has been on reviewing the flood risk data as it has been developed and undertaking surveys and flood risk assessments in order to understand and prioritise the risk and works for the remainder of R10-ED1. Flood protection delivery this year has been completed in Forest Row in SPN as part of a major project and feasibility surveys are being carried out at a number of sites (22 in EPN, two in LPN and 22 in SPN), with surveys completed at all EPN and LPN sites and 13 SPN sites.

A scheme is being developed at a secondary substation on Eastern Esplanade, Southend-on-Sea, which provides the supply to the adjacent Anglian Water pumping station, which in turn protects the local area from pluvial flooding.

We are committed to working with the Environment Agency and other stakeholders on any reviews they undertake, and to learning from previous events to ensure that UK Power Networks and the rest of the industry address flooding-related issues for the benefit of customers.

2.4.4.5 Habitat enhancement/ecological best practice/protected species management.

Some of our substations have undeveloped areas which provide a home for wildlife and we have worked with the Wildlife Trust to develop habitat management plans for these. Key features of these sites include a pond which has been improved to enable great crested newts to thrive, a nationally scarce plant species, and grassland with three different species of orchids. A substation building which was found to contain a bat maternity roost was modified, under the direction of licensed ecologists, to make it safer for future generations.

In addition to measures to protect habitats and species at the planning stage, we provide guidance so that staff can recognise protected species. If one is observed in proximity to our equipment, it can be flagged on our mapping system.

2.4.4.6 Joint partnership agreements.

Since 2011 we have supported the nine Wildlife Trusts in our three licence areas, both financially and through providing a volunteer workforce. Annual support provides a relatively secure income for the Trusts and we provide volunteer work parties for each Trust every year. We believe that the scale of our partnership is unique, both for the Trusts and for the energy sector. In addition, we are utilising the expertise of the Wildlife Trust's ecologists to create habitat management plans for selected major substations, many of which contain land largely undisturbed by people for years.

This initiative helps the Wildlife Trusts deliver their overall aim of providing sustainable care of vital, fragmented habitats

and protecting rare and threatened species. At the same time, the Trusts seek to inspire and engage local communities with the wildlife on their doorstep. As a result, the Trusts further the long-term protection of biodiversity in the UK and in doing so, encourage people to value nature's contribution to society and the economy, whilst at the same time providing access to outdoor spaces that support recreation, health and wellbeing, learning and opportunities for social interaction.

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

3.1 Introduction

At UK Power Networks, we recognise the key role that innovation plays in preparing us for the low carbon future while helping us both to ensure that security of supply is delivered cost efficiently and that our service to customers continues to improve.

The 2050 Climate Change targets require the UK to reduce carbon emissions by 80 per cent compared to 1990. The underpinning principle is that the UK should target near zero emissions from power generation, transport and building energy use by 2050. The government has recently accepted the fifth Carbon Budget proposals from the Committee on Climate Change. The fifth Carbon Budget set out the following targets for the period to 2030:

- The reduction of the carbon intensity of power generation to between 200-250g/kWh by 2020 and less than 110g/kWh in 2030. This implies that by 2030, 75 per cent of generation should be low carbon. It should be noted that technologies such as nuclear and carbon capture and storage would be included within this target
- The reduction in the carbon intensity of the transport sector from 125gCO₂/km to 102gCO₂/km by 2020 and 86gCO₂/km by 2030. This implies that 9 per cent of new car and van sales in 2020 and up to 60 per cent of new car and van sales in 2030 must be electric vehicles
- Heat pumps and heat networks from low carbon sources to provide heat for around 13 per cent of homes and over half of business heat demand

DNOs will play a significant role in facilitating the achievement of these targets. This will include ensuring that there is sufficient capacity to meet the future demand requirements from technologies such as electric vehicles or to connect renewable generation.

3.1.1 The generation challenge

The most significant challenge in recent years has been the growth in renewable generation, particularly solar. Over the weekend of 9-10 April 2016, solar generators provided more electricity than coal for the first time in the UK – a symbolic milestone which highlights the major changes occurring in our electricity system. National Grid estimates that the system now has 10-11GW of solar generation and 10-14GW of wind capacity – sufficient to exceed consumer demand at certain times in summer. DNOs such as UK Power Networks are at the forefront of enabling these changes – 90 per cent of solar energy alone connects directly to the distribution system. However, changes in the Feed in Tariff (FIT) and the Renewables Obligation have reduced the financial attractiveness of solar generation in particular, and consequently we expect growth in future years to be slower than has historically been the case.

During the period 2010-11 to 2014-15, we connected almost 3GW of generation in our three licence areas, with solar generation being the largest contributor. As a consequence, the cost of connection on particular areas of our network increased substantially. This could have been a barrier to generation connecting, however, the focus of one of our Low Carbon Networks Fund (LCNF) Tier 2 projects, Flexible Plug & Play (FPP), was to address this issue. Under FPP we developed the flexible distributed generation service, a cutting-edge service which connects power sources such as wind or solar to constrained areas of network. This service delivers cheaper and faster connections and enables schemes that would have been financially unviable under the traditional connections approach to go ahead. In the first year of ED1 alone this approach has saved our connection customers over £66m.

3.1.2 The electric vehicle challenge

We are starting to see electric vehicle (EV) sales pick up: approximately 57,000 EVs had been sold in the UK as at the end of March 2016. In the global market, China expects to set a target of approximately 5 million EVs by 2020, up from 400,000 in 2015. We expect the forecast drop in the cost of storage technology, driven by scale on a global level, to reduce the cost of EVs and hence increase the take-up of this technology. We also expect growth in EVs to increase compared to 2015-16.

While EV take-up is currently at a low level, we have been experiencing significant interest from a range of stakeholders involved in this developing market. During 2015-16 we were involved in a range of activities to help facilitate EV take-up. These included:

- Working with the Office of Low Emission Vehicles (OLEV) on the Plugged in Car grant notification process
- Active participation in a range of Transport for London (TfL) activities, e.g. the Ultra-Low Emission Vehicle working group and LoCity
- Hosting connection working sessions with London bus operators and the TfL rapid charge point team
- Holding connection-related “Ask the expert” surgeries with major fleet operators, e.g. Hertz and the London Taxi Company (LTC)

3.1.3 The heat pump challenge

The take-up of heat pumps has been significantly smaller than expected. In 2015-16 we were notified of 600 heat pumps connecting to our network – 2 per cent of the volume we expected to connect. As National Grid notes in its 2016 Future Energy Scenarios, decarbonisation of heat is the area where the biggest change needs to occur in order to achieve the carbon target. To facilitate the connection of heat pumps in 2015-16, UK Power Networks led an ENA stakeholder event for manufacturers and installers of heat pumps to help them with the connection notification process.

3.1.4 Key emerging challenges

3.1.4.1 Electricity storage

In the last six months, grid-scale storage has emerged as a topic of major commercial interest to developers, manufacturers, construction partners, regulators and government. At the time of writing, UK Power Networks alone had received over 500 applications to connect battery storage for a total capacity of 11GW.

To understand the capabilities of this new technology, UK Power Networks has built and is now testing the first energy storage centre in Great Britain. Our Smarter Network Storage (SNS) project features a 6MW/10MWh storage solution comprising approximately 50,000 lithium-ion batteries, located in Leighton Buzzard, Bedfordshire. This technology has enabled us to manage electricity demand at peak times without building excess network capacity. In addition, we are now exploring how the battery can support National Grid in the provision of frequency services.

3.1.4.2 Transition to a Distribution System Operator

The increase in intermittent generation, coupled with the forecast growth in EVs, electricity storage and heat pumps, will make the distribution system more complex to operate. The traditional model of energy flowing from large-scale generators via the transmission and distribution networks to end customers is being superseded by one where there is a two-way flow of both electricity and information. The distribution network must be more flexible and accommodate two-way power flows where consumers are not only drawing power from the grid, but also supplying power back to it. In the future, there will also be an increase of data from smart meters and smart appliances that can help us to understand and better manage peak demand in order to keep costs down.

To deal with this new level of complexity, DNOs will need to evolve into Distribution System Operators (DSOs). This means they will be responsible for procuring services which allow them to balance the power flows on their networks and

also provide services to Transmission System Operators (TSOs) to facilitate the efficient operation of the national transmission network. We are already working to better understand and prepare ourselves. Several major activities related to this include: our Flexible DG programme, our demand side response programmes and our proposed Network Innovation Competition project TDI v2.0 – to be delivered in collaboration with the TSOs.

3.1.5 Volumes of Low Carbon Technologies deployed in 2015-16

Table 19 details, by licensee, the volumes of each low carbon technology deployed in 2015-16. Further information is provided in RIGs worksheet E7 – LCTs (please see Annexes and Appendices).

Table 19 – Volumes of Low Carbon Technologies deployed in 2015-16

Technology Type	EPN	LPN	SPN	Combined
Heat Pumps	374	12	214	600
EV slow charge	391	190	203	784
EV fast charge	1,130	440	566	2,136
PVs (G83)	19,755	1,631	7,054	28,440
Other DG (G83)	0	0	0	0
DG (non G83)	670	85	369	1124
Total	22,320	2,358	8,406	33,084

3.2 Progress of the Innovation Strategy

There were no material changes to our Innovation Strategy in 2015-16. However, we were keen to engage with stakeholders on our approach and undertook a consultation process in late 2015 to gauge their views. We will use their feedback to further shape our strategy and will publish an update in 2016-17.

Our Innovation Strategy sets out seven key ‘themes’ or challenges around which we have organised our innovation activities for RIIO-ED1. These are shown in Figure 8 and described below.

Figure 8 – Innovation Strategy themes



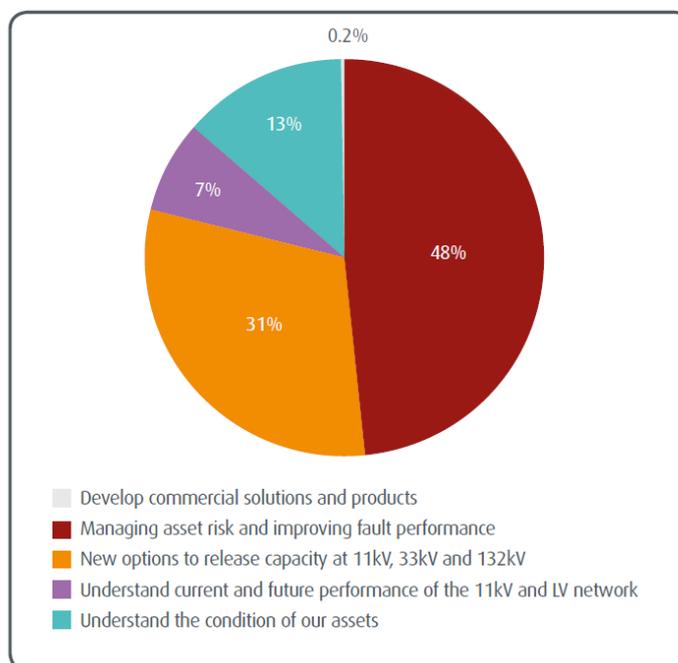
The themes cover the activities to provide our day-to-day service to customers and also consider our relationship with them. They are:

- 1) Managing the risk of our assets and improving fault performance. This corresponds to our core function of keeping the lights on, restoring outages and managing any risks associated with our electrical equipment to the public
- 2) Understanding current and future performance of the 11kV and LV networks, which are currently least visible to us in real time
- 3) Identifying new options to release capacity at 11kV, 33kV and 132kV, where commercial buildings and renewables connect and where we interface to the transmission network
- 4) Developing commercial solutions and products that will enable the uptake of new technologies
- 5) Understanding the condition of our assets to inform how long we can use them for and how to effectively refurbish them
- 6) Leveraging industrial and commercial Demand Side Response (DSR) and dispatchable generation to enable assets connected to our networks to support us avoid building unnecessary new assets
- 7) Managing residential and small and medium size enterprise consumer demand and addressing the biggest changes in demand on our network

We are making good progress: of the 31 ongoing innovation projects, 25 have been funded under the Network Innovation Allowance (NIA), four have been funded as Tier Two projects under the LCNF, and two have received external funding.

[Our 2015-16 NIA Annual Summary](#) lists all of the ongoing NIA funded projects, detailing how they map to our innovation themes and hence our overall strategy. Figure 9 shows the percentage of 2015-16 NIA expenditure against the five innovation themes we are currently working on.

Figure 9 – Percentage of 2015/16 NIA expenditure by innovation theme



Our LCNF Tier Two projects are larger, covering multiple innovation themes. Table 20 details each of these projects, the licence area where trials are being conducted, the innovation themes being addressed, the planned year of completion and 2015-16 expenditure. More detailed information on our expenditure under the NIA can be found on our [website](#).

Table 20 – A summary of our LCNF Tier 2 projects

Project	Licence area where trialled	Start date	Planned end date	Total budget	2015-16 expenditure
SNS	EPN	January 2013	December 2016	£17,525,395	£415,370
FUN-LV	LPN and SPN	January 2014	December 2016	£8,349,197	£4,703,352
energywise	LPN	January 2014	December 2017	£4,246,417	£1,379,958
KASM	SPN	January 2015	December 2017	£3,852,501	£1,684,652

3.3 Roll Out of Smart Grids and Innovation into Business as Usual

3.3.1 Process of transitioning and monitoring successful innovative solutions

As part of our commitment to innovation and to delivering value for money for our customers, we successfully deployed 11 Innovative Solutions during the 2015-16 regulatory year. These solutions were reported to Ofgem in our 2015-16 RIGs submission and are also presented here. It should be noted that these activities do not yet include any solutions facilitated through the Innovation Rollout Mechanism (IRM), with the first notification window yet to take place. Further

information is provided in RIGs worksheets *E6 – Innovative Solutions* and *E8 – IRM* (please see Annexes and Appendices).

The Innovative Solutions are at various stages of rollout and are the results of our process of assessing, developing and monitoring Innovative Solutions throughout their life-cycle, through to a completed rollout as business as usual. This process comprises the following activities:

- Innovative ideas are captured, assessed and developed through innovation projects
 - This includes the capture of internal and external innovation activities (including innovation projects delivered by other UK DNOs) or experiences that are in line with UK Power Networks' Innovation Strategy, and the development and testing of the solution through a range of central and business-led projects.
 - We actively monitor and engage with innovation projects developed across the industry under NIA and LCNF funding to ensure we are up to speed on ideas that will help benefit our customers

- Readiness and benefits performance assessment
 - This includes the development of a detailed cost benefit analysis (CBA) for potentially ready-to-deploy solutions for systematic assessment against a comprehensive evaluation framework.
 - This evaluation framework is linked to our Innovation Strategy, our business priorities, and the Ofgem CBA and E6 RIGs table requirements.
 - The Ofgem CBA is used throughout, without any changes being made to the template.
 - Our innovation benefits tracking framework has been endorsed by Navigant Consulting as compliant with the EPRI Smart Grids Assessment Guide.

- Smart solution implementation and performance tracking
 - This stage includes the continued monitoring of solution performance, using the evaluation framework established previously and with a responsible solution owner managing data, reporting, accuracy, auditability and overall solution performance.

3.3.2 Our 2015-16 Innovative Solutions

The following pages provide an overview of each of the 11 Innovative Solutions deployed within one or more of UK Power Networks' licensed areas during the 2015-16 regulatory year. This overview includes: the nature of the solution; how it delivers value to customers; links to any relevant innovation projects that supported the development of the solution; and links to the detailed CBA assessing the solution performance.

In addition, summary details from each solution's CBA, including the benefits performance achieved by the solutions in 2015-16, are presented in Table 21.

3.3.2.1 Power Transformer Real Time Thermal Rating

Dynamic Transformer Rating (DTR) allows additional capacity to be made available from existing assets. It also defers reinforcement by retrofitting a Transformer Management System (TMS) onto existing assets to provide real-time monitoring of the transformer's health and continuously calculate the transformer thermal capacity, thereby safely loading the transformer closer to the maximum top oil temperature.

Greater understanding and improved visibility of asset performance will lead to a reduction in asset replacement and the more cost-effective release of capacity onto the network, facilitating the connection of additional loads and low carbon technologies.

This solution is an innovative new way of increasing network capacity at a lower cost than reinforcing/upgrading assets and has been developed through the NIA funding mechanism in the UK Power Networks Power Transformer Real Time

Thermal Ratings project. The innovation project that developed this solution has equipped UK Power Networks' transformers with a range of monitoring systems as well as innovative cooling arrangements, and has completed detailed heat rise testing on the network to determine the opportunity presented by real-time thermal ratings.

Further detail on this innovation project is provided [here](#). A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.2.2 LPN Interconnection

This solution relates to the advanced design philosophy of the interconnected 11kV feeder groups in the LPN network. By including a relatively high number of feeders with the capability to interconnect as a feeder group, UK Power Networks supports higher network utilisation while still maintaining N-1 resilience. This means that in the event of loss of one 11kV feeder from the group due to a fault, all the substations supplied by that feeder can be energised through multiple 11kV interconnection points (normally open). By designing the network with larger numbers of 11kV feeders connected in this way as a feeder group, resilience can be maintained with significant benefits in the percentage utilisation of each individual feeder.

This smart network arrangement allows for higher circuit utilisation levels and thus higher levels of network cost efficiency. Each 11kV circuit (for a four-feeder group) can be loaded to 75 per cent of its thermal capacity (or 80 per cent for a five-feeder group) as opposed to 50 per cent for a conventional radial network with single points of interconnection between two feeders.

This solution is considered across the industry as an Innovative Solution and has been confirmed as part of the RIIO-ED1 smart solutions assessment. Further details of this smart grid design philosophy are provided in our [RIIO-ED1 smart grid strategy annex](#). A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.2.3 Energy Storage

This solution involves the deployment of utility-scale batteries in order to provide ancillary services (i.e. load following) in parallel with a peak loping function that reduces critical peaks on the distribution network, and thus defer or avoid the need for reinforcement. This solution has been deployed in our EPN area as a UK Power Networks-owned device connected directly to the distribution system, although enrolment of a third party storage device in the DSR program could similarly provide these benefits.

This solution is regarded as an Innovative Solution for providing network capacity, while also creating value through supporting the national transmission system, and has been developed through our LCNF Tier 2 funded project Smarter Network Storage. Further details of this innovation project are provided [here](#).

3.3.2.4 Demand Side Response

Demand Side Response (DSR) involves contracting with our network customers for a peak load reduction service that defers or avoids the need for traditional reinforcement. This can be delivered either from a reduction in demand from demand customers or by generators generating for a contracted period. It can address occasional shortfalls in capacity on the network and provides us with option-value to focus our reinforcement programme where it is most needed.

This solution is an innovative approach to network capacity management, providing greater flexibility and cost effectiveness compared to traditional reinforcement, and was developed through our LCNF Tier 2 funded project Low Carbon London. Further details of the Low Carbon London project are provided [here](#).

3.3.2.5 Asset Risk and Prioritisation Modelling

UK Power Networks' Asset Risk and Prioritisation (ARP) model provides a step forward in respect of the existing condition-based risk management functionality. It provides the capability to assess the financial and technical consequences of future decisions to replace assets, incorporating detailed condition data sets, and uses this analysis to guide UK Power Networks to the optimum asset replacement, refurbishment and maintenance programmes. This results in lower asset risk, longer asset lifetimes and lower overall replacement cost requirements.

Condition-based risk management is considered across the industry as an Innovative Solution for managing asset risk and health-driven investment and has been confirmed as part of the RIIO-ED1 smart solutions assessment. A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.2.6 Oil Regeneration

Oil Regeneration extends the life of transformers by regenerating oil in transformers where the oil has high moisture and acidity. Regenerating the oil in situ not only improves the moisture and acidity condition but also removes sludge from transformer oil, resulting in an 'as new' oil condition that will prolong the working life of the transformer.

Oil regeneration involves circulating the oil through bauxite pillars in order to remove acidity and sludge from the transformer oil, as well as remove the moisture from the winding papers. It also helps to remove sludge deposits in the transformer and cooler. By restoring transformer oil to its original new condition, oil regeneration can extend the serviceable life of a transformer by at least 16 years.

This solution is considered across the industry as an innovative way of cost effectively extending the serviceable life of critical transformer assets and has been confirmed as part of the RIIO-ED1 smart solutions assessment. A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.2.7 Bidoyngs

The installation of Bidoyngs on the LV distribution system deploys a 'reclosing' device with two fuses (primary and secondary) in parallel that can autonomously re-energise the network after a transient fault. The primary fuse operates first in the event of an intermittent fault; then, after a programmed delay (less than three minutes) the secondary fuse is switched in, causing the network to re-energise.

For sustained faults, the secondary fuse will also operate and the Bidoyng's fault location service will provide distance-to-fault information to UK Power Networks' field operatives, who can then more quickly locate and fix the fault. The solution reduces the frequency and length of power outages experienced by our customers.

This is an innovative improvement in the functionality of a basic LV fuse and has been trialled by Electricity North West Limited as part of a First Tier LCNF project. Further details of this innovation project are provided [here](#) and are held on the shared industry Smarter Networks Portal. A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.2.8 Automated Power Restoration System

The Automated Power Restoration System (APRS) virtual model of the electricity network – a module built into the PowerOn Advanced Distribution Management System (ADMS) – allows the control system to remotely operate switches to restore electricity supplies in a range of outage scenarios, by autonomously calculating the restoration actions required. The APRS system is activated when a circuit breaker operates on that system. The software system assesses the running arrangements at the time and communicates to the sites where remote control and monitoring devices are fitted,

using fault indicators to isolate the section of the network where the fault lies. It can then instruct other parts of the network to switch themselves back on and thus restore the power supply.

The solution is qualified as an Innovative Solution for the deployment of APRS as this PowerOn module delivers a truly advanced smart grid functionality not previously available to UK Power Networks. A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.2.9 LIDAR Vegetation Management

LiDAR technology refers to a system of aerial laser imaging and surveying, via either helicopters or light aircraft equipped with LiDAR equipment. This Innovative Solution uses commissioned LiDAR surveys to identify critical clearances, danger and hazard vegetation, and abnormal line states along the right-of-way (ROW) of the distribution system. In turn this provides improved visibility of the relative risks posed by vegetation growth on overhead line routes and thus enables more targeted, cost-efficient vegetation cutting.

This solution was originally trialled by SP Networks as part of an NIA innovation project. Further details of this innovation project are provided [here](#) and are held on the shared industry Smarter Networks Portal. A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.2.10 Flexible DG Connections

Flexible DG (FDG) Connections are a technical and commercial arrangement under which a customer seeking a connection to the network agrees that their DG device's power export can temporarily be curtailed in times of network constraint, in order to ensure that network voltages and currents remain within operational limits.

This solution is a key enabler for connecting new DG – particularly renewable generation – when the network is experiencing reverse power issues. FDG schemes are operated by a UK Power Networks Active Network Management (ANM) solution and access is managed on a 'Last In First Out' (LIFO) principle, with each generator being assigned a position within a global priority stack. When new generators apply for a connection, they are given a position at the bottom of the priority stack and are curtailed first during a constraint event.

This solution was developed through our LCNF Tier 2 funded project Flexible Plug & Play. Further details of this innovation project are provided [here](#). A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.2.11 Load Blinding Relays

This solution uses protection relays with 'load blinding' functionality to manage constraints and maximise network utilisation by connecting more DG. Load blinding relays allow these increases in the DG capacity of the network and associated reverse power flows, because these relays can discriminate between acceptable reverse power flows and an upstream fault. Traditional protection would have needed to operate to clear fault infeed.

Load blinding is useful for heavily loaded lines where if the current increases and its electrical characteristics (phase angle) are determined to represent normal power flows, the relay will be kept from operating. This scheme will have the benefit of removing the protection-related constraints on reverse power flow whilst maintaining relatively simple tried and tested philosophy for the protection settings.

This solution is qualified as an Innovative Solution as it was developed through our LCNF Tier 2 funded project Flexible Plug & Play. Further details of this innovation project are provided [here](#). A link to the detailed CBA for 2015-16 solution performance can be found in the Annexes and Appendices.

3.3.3 Our customer connections focused solutions

Table 21 summarises the quantified performance of these solutions in 2015-16. In particular, the connection cost reductions of approximately £67m that we have delivered to our customers can be seen in the table through our innovative Flexible DG Connections and Load Blinding Relay solution performances. These are also described in more detail in the preceding sections. This outcome is a result of our Innovation Strategy recognising the importance of connections focused innovation for our customers.

Table 21 – Summary of 2015-16 Innovative Solutions

		Financial impact (net £m, 2015-16)	Ofgem output category	Additional benefits	2015-16 volumes deployed	Indicative 2016-17 forecast volume range
Increase Network Capacity/ Optimise Utilisation						
1	Power Transformer Real Time Thermal Rating	0.0	Reliability & Availability	Expected 2016/17	6 MVA released	4-10 transformers
2	LPN Interconnection	0.8	Reliability & Availability		23 projects	15-30 projects
3	Energy Storage	2.1	Reliability & Availability	7.5	7.5 MVA released	0 substations
4	Demand Side Response	0.2	Reliability & Availability	0.6	0.6 MVA released	0-2 substations
Improve Asset Life Cycle Management						
5	ARP Modelling	2.0	Reliability & Availability		43 assets modelled	43 assets modelled
6	Oil Regeneration	-0.3	Reliability & Availability	Improved long term asset condition	11 transformers	4-10 transformers
Improve Network Performance						
7	Bidoyngs	-1.5	Reliability & Availability	-0.8 CI -1.3 CML	601 devices	600 devices
8	Automated Power Restoration System	-0.8	Reliability & Availability	-3.5 CI -0.1 CML	1145 schemes	schemes
Improve Vegetation Management						
9	LIDAR Vegetation Management	8.3	Reliability & Availability		143 surveys	100-200 surveys
Improve Connection Performance						
10	Flexible DG Connections	66.2	Connections		6 customers connected	2-8 customers connected
11	Load Blinding Relays	0.8	Connections		1 customer connected	0-2 customers connected
	Total	77.7				

3.3.4 Innovative Solutions in 2016-17

Across this portfolio of Innovative Solutions, looking ahead to 2016-17 we would expect that:

- Our Innovative Solutions for improving quality of supply (i.e. APRS and Bidoyngs) will see expanded deployments and benefits delivered (this may include, where successful, further innovative solutions currently undergoing trials)
- Our Innovative Solutions for improving network capacity and utilisation (i.e. Energy Storage, Demand Side Response, LPN Interconnection and Power Transformer Real Time Thermal Rating) will continue to deliver benefits, with some possible further additions expected
- LiDAR Vegetation Management will continue to deliver benefits (although the deployment cost of the LiDAR surveys is cyclical and the net benefits will be smaller in 2016-17 than in 2015-16)
- Overall benefits delivered to customers through reduced time and cost to connect will continue as further FDG zones are opened and energised, with further volumes and benefits expected
- Our asset condition-related solutions (i.e. Automated Power Restoration System modelling and Oil Regeneration) will continue to deliver benefits at a similar level
- The 11 solutions currently deployed by UK Power Networks will deliver similar or greater benefits, and several of our current Innovation Projects will additionally deliver benefits in 2016-17

Table 21 includes indicative volumes for 2016-17 for these projects.

3.4 Smart Metering

In our Smart Metering Strategy (developed as part of our RIIO-ED1 Business Plan submission of March 2014), we set out the key opportunities that UK Power Networks expects to realise from the rollout of smart metering. These are:

- Improved real-time data – Fault Management and Customer Service enhancements: The provision of real-time data on faults via the ‘last gasp’ facility and the ability to remotely test meter energisation status offer the opportunity to 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: The provision of detailed usage information from meters across the network, offers the opportunity to significantly improve network planning. It will afford much better targeting of low voltage (LV) refurbishment and should enable the avoidance of additional development to support some new connections and help reduce losses
- Improved real-time control – supporting the future network: The combination of real-time and asset data with greater real-time control will pave the way for the network of the future in RIIO-ED1. It will provide the information and capability to support the expansion of low carbon technologies (LCTs) and Time-of-Use Tariffs. It will be possible to undertake Active Network Management (ANM) and further avoid the need for network reinforcement/new investment. Smart meters will pave the way for a full smart grid in RIIO-ED2

In order to realise these benefits, we will:

- Adapt our call centre processes to take advantage of energisation status information, to ascertain if any loss of supply is related to a fault on our network or if it relates to a fault on the customer’s equipment
- Make improvements to our general fault management processes, and in particular to those associated with low voltage faults. We will use the information from smart metering alongside our existing diagnostics to more accurately identify faults and target appropriate crews
- Commence the move of our customer service operations from ‘inbound reactive’ to ‘outbound proactive’. We will use the information available to maximise the speed and quality of information available to the customer
- Invest in tools to aid interrogation and manipulation of smart metering data; the tools will also link to planned upgrades to the GIS system

The correct IT structure will be a key enabler both in delivering the smart meter installation programme and realising the benefits. Our strategy identified significant IT requirements to not only support the core smart metering rollout, but also

to build the necessary platform for late RIIO-ED1 and RIIO-ED2, to facilitate and actively manage Smarter Networks through to UK Power Networks' transition to a DSO.

Further information is provided in RIGs worksheet *E5 – Smart Metering* (please see Annexes and Appendices).

At a high level the solution comprises:

- One principal new system for all common smart metering functionality, interfaces and DCC integration (the 'DNO Smart Metering Head End') – on schedule to go live in the first half of 2017
- Specific modules and interfaces to support fault management and customer services – business case and functional requirements are currently under development
- Data warehousing for the processing, analysis and longer term storage of smart metering data – a proportion of this functionality will go live with the principal head end integration in 2017. Additional tools required will be identified after go live and, where necessary, further developed.
- Network analysis and planning tools to exploit this data and drive through to engineering conclusions – detailed requirements and business process design to be started
- Mandated changes to registration and associated systems – RDP completed and live
- Enhancements and increased capacity to scheduling/work management to support DNO interventions – detailed requirements and business process design to be started

Further detail on our Smart Metering Strategy can be found in our [Business Plan documents](#). Detailed information on how we expect to deliver the benefits can be found in sections 7 and 8. Detailed information on the smart metering IT strategy can be found in section 9.

Table 22 sets out the volumes of smart meters installed in 2015-16. The rollout has been slower than expected.

Table 22 – Volume of smart meter installations

Licence area	2015/16 smart meter volumes
EPN	117,821
LPN	63,847
SPN	80,252

As the communications infrastructure and provision of data services via the Data Communications Company (DCC) have not yet gone live, we have realised no benefits from smart metering so far; this was reflected in RIGs worksheet *E5 – Smart Metering* (please see Annexes and Appendices) for the first year of RIIO-ED1. We also expect there to be minimal realised benefits in 2016-17, due to low levels of deployment and the fact that the meters deployed up to that date will be SMETS1 meters, which do not have all of the functionality required to deliver the benefits described in our RIIO-ED1 Business Plan (March 2014).

While our realisation of smart metering benefits is dependent on the wider rollout of SMETS2-compliant meters and establishing access to smart meter data, we have continued to support the industry rollout of smart meters and are in the process of preparing our systems to receive their data. This expenditure, including our IT expenditure, is presented in Table 23 for the 2015-16 regulatory year.

Table 23 – Summary of 2015-16 smart metering-related expenditure

Type	Source	Category	EPN	LPN	SPN	Total
Inside Price Control (£m)	C22/E5	Smart Meter Communication Licensee Costs	0.97	0.61	0.61	2.19
Inside Price Control (£m)	C22/E5	Smart Meter Information Technology Costs	-	-	-	-
Outside Price Control (£m)	CV34	Smart Meter Interventions - On-site/Physical Activities	1.58	0.40	0.96	2.94
Outside Price Control (£m)	CV34	Smart Meter Interventions - Extra scheduling & call centre	-	-	-	-
Outside Price Control (£m)	CV34	Smart Meter Interventions - Smart Meter registration	-	-	-	-

4 Annexes and Appendices

4.1 EPN

[Environment and Innovation pack – tabs E1 through to E8](#)

[E4 Losses CBA \(GMT\)](#)

[E4 Losses CBA \(PMT\)](#)

[E6 innovative solutions CBA](#)

4.2 LPN

[Environment and Innovation pack – tabs E1 through to E8](#)

[E4 Losses CBA \(GMT\)](#)

[E6 innovative solutions CBA](#)

4.3 SPN

[Environment and Innovation pack – tabs E1 through to E8](#)

[E4 Losses CBA \(GMT\)](#)

[E4 Losses CBA \(PMT\)](#)

[E6 innovative solutions CBA](#)

4.4 UK Power Networks

[Environment and Innovation Commentary](#)

[E4 Losses CBA Grid Transformer](#)

[E4 Losses CBA Primary Transformer](#)

[E4 Losses CBA LV Cable](#)

[E4 Losses CBA HV Cable](#)