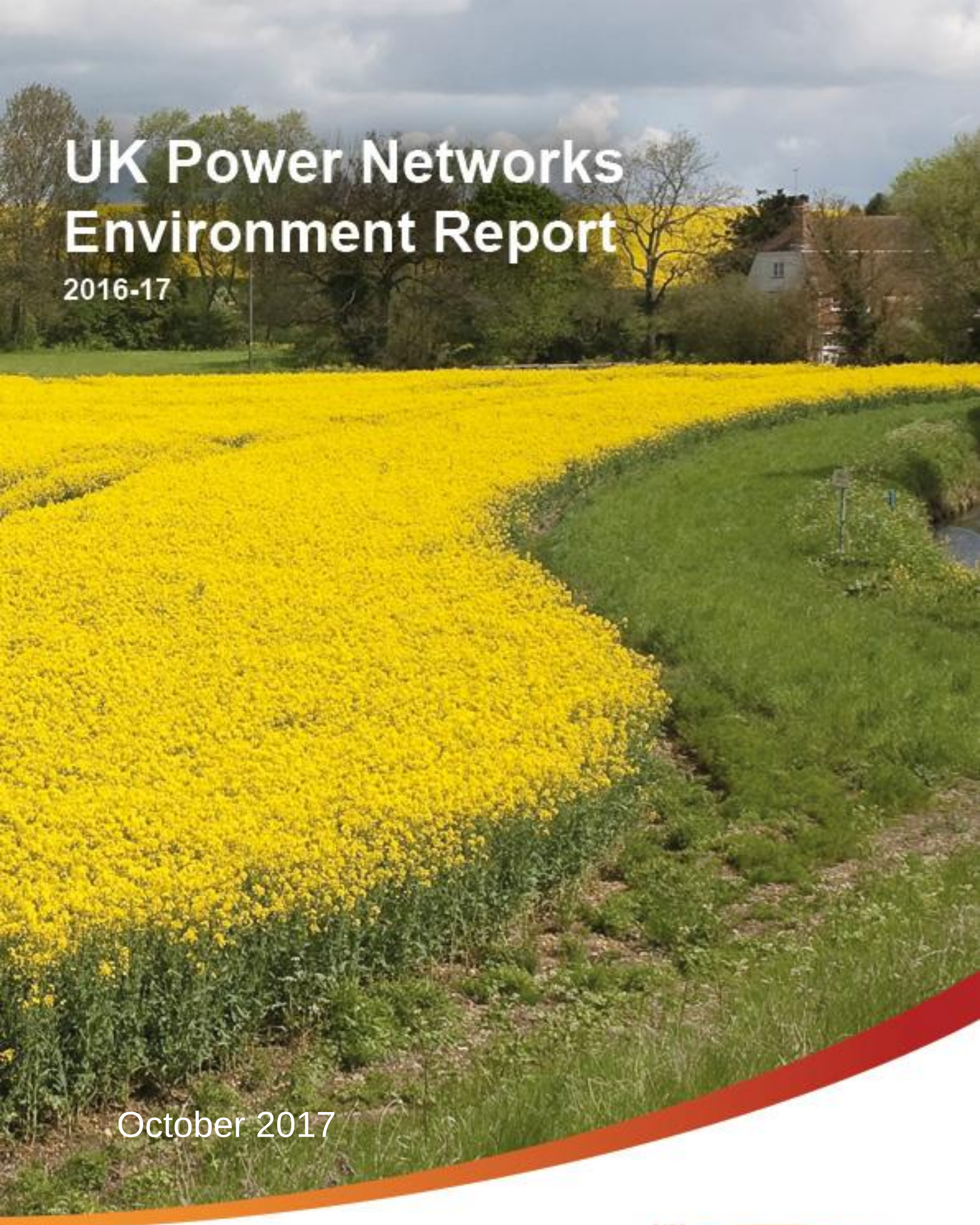


UK Power Networks Environment Report

2016-17

October 2017

ukpowernetworks.co.uk

UK Power Networks
Delivering your electricity

Contents

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 our activities during the 2016-17 regulatory year. We are pleased to update our stakeholders on our performance across the key environmental measures and the efforts that we as a business have put into delivering environmental benefits for our customers and the wider communities in the regions we serve.

We are committed to the environmental targets set out in our RIIO-ED1 Business Plan; they are part of our vision to be a Respected Corporate Citizen. We strive to make our operations as sustainable as possible and to reduce their impact on the surrounding area – from improving visual amenity in Areas of Outstanding Natural Beauty (AONB) to reducing our Business Carbon Footprint (BCF) and minimising oil leakage and SF_6 emissions from our network assets.

We have made positive progress in the following areas:

- Thanks to a series of initiatives, including upgrading many of the vehicles allocated to staff working on our networks, we have reduced our BCF by 11 per cent over the last two years – exceeding the target of 2 per cent per annum that we set ourselves in our RIIO-ED1 Business Plan. We are keen to build on this achievement and will explore how we can reduce our BCF still further.
- We are exceeding our targets for recycling waste from street works and for diverting the waste produced from our offices and depots from landfill. Our RIIO-ED1 Business Plan contained the commitment to divert at least 98 per cent of street works spoil (the waste left over from street works) and 70 per cent of office and depot waste from landfill. In 2016-17 the proportions of office and depot waste and street works spoil diverted from landfill were 86.5 per cent and 98.2 per cent, respectively. We will continue to focus attention in this area to ensure our performance continues to improve.
- We have forged strong relationships with stakeholders that ensure they have the final say in where we invest to remove overhead lines in AONB. We are a member of the Undergrounding of Overhead Lines Project Steering Group, which facilitates the completion of approved network underground projects within our operating area. At the request of this group, we have installed a searchable map on our website which allows stakeholders to view completed schemes and nominate areas which they believe would also benefit from the undergrounding of overhead lines. Our RIIO-ED1 Business Plan included the commitment to underground by 2023 the equivalent of 80km of HV overhead line on our South Eastern network and 96km of HV overhead line on our Eastern network in AONB and National Parks. In 2016-17 we removed 3.18km of overhead line in SPN and 1.47km in EPN.
- We are ensuring that we are in the vanguard of the drive towards a low carbon economy – leading initiatives that will take us and our customers into a world of smart networks and appliances, renewable energy sources, and consumers who are also producers ('prosumers'). Our commitment to a low carbon future is nowhere more evident than in our drive to transform UK Power Networks from a Distribution Network Operator (DNO) into a Distribution System Operator (DSO) capable of delivering a smart, flexible energy system that responds to customers' needs. In addition, our wide-ranging portfolio of innovative projects ensures we are well placed to explore new ideas and technologies that will make a low carbon future possible, whilst delivering value to the customers and local communities who rely on our networks for a secure supply of electricity.

We very much hope that this report will be of interest to our stakeholders and look forward to providing a further update on our performance in 2017-18.

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 – 28 per cent of the United Kingdom's population – via our networks in London, the East of England and South East England. Our three licensed companies 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 provide safe, reliable and efficient electricity supplies to existing customers and timely, cost-effective connections to new ones.

We serve 28% of the UK's population.

Figure 1 – UK Power Networks' operating area

The area we serve covers more than 29,250km^2, from Cromer in the East of England to Brighton on the South Coast. In operating and maintaining our electricity network we interact with the environment in a variety of ways. We must consider the design and construction of our infrastructure, the use of oil and other insulation products on our network, the energy used to light and heat our offices and depots, and the vehicles we use.

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

When installing new equipment on our network we ensure that we consult with relevant statutory authorities and other appropriate bodies at the earliest possible opportunity. Every effort is made to identify potential environmental impacts at the earliest planning and design stage of projects and mitigate any harm.

1.3 Purpose of the Report

This report describes our activities in relation to environmental matters during the 2016-17 regulatory year. It includes information on the following topics:

- Improving visual amenity
- Reducing oil leakage from our assets
- Managing and reducing our BCF
- Minimising SF_6 emissions from our assets
- Reducing technical and non-technical distribution losses from our network
- Managing and preventing waste
- Reducing noise pollution from our assets and fly-tipping around our substations
- Protecting our substations from flood risk

- Using innovative solutions to minimise the impact of our activities on the environment
- Exploring and realising the benefits of smart metering

In each of these areas we have documented progress against the environmental targets set out in our RIIO-ED1 Business Plan:

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

These targets are part of our drive to be a Respected Corporate Citizen and constitute a framework for our environmental activities.

The above topics are covered in detail in the remaining sections of this report.

2 Managing Our Environmental Impact

2.1 Introduction

As a key player in the energy industry, we are acutely aware of the impact our operations can have on the surrounding area and have robust policies and procedures in place to ensure we comply with all relevant environmental legislation.

Protecting the environment is part of our drive to be a Respected Corporate Citizen. The Electricity Act specifically requires us to consider natural beauty, flora, fauna and geological or physiographical features of special interest, and sites, buildings and objects of architectural, historic or archaeological interest, and do what we reasonably can to mitigate any effects. All other environmental legislation is assessed for relevance to our activities as a DNO. Relevant activities include environmental permitting, pollution prevention, waste management and the preservation of historic and natural habitats.

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.

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

We are progressing towards certification to the ISO 14001:2015 standard by April 2018 – moving our environmental systems up from their current, 2014 accreditation. Our Environmental Management System is implemented by relevant directorate leads and appropriate managers within our organisation who are responsible for identifying and mitigating their respective environmental risks, with guidance and assurance from our Environment team.

We consult with stakeholders, including statutory authorities and other appropriate bodies, to help mitigate the impact of our operations on the environment. At a local level, we seek to build good relationships with local authorities and work collaboratively on initiatives to help reduce the impact of issues such as noise pollution and litter, which can be a source of concern for local communities.

We also work with the industry to identify areas of best practice and ensure continuous improvement. Members of our Environment team represent UK Power Networks on the Electricity Networks Association (ENA) Environment Committee, helping to ensure that best practice is implemented from knowledge shared across the electricity and gas sectors.

2.2 Visual Amenity

For many years we have been a member of an Undergrounding of Overhead Lines Project Steering Group, which facilitates the completion of approved network underground projects within our operating area, 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 on a quarterly basis.

We hold the position of a non-voting member in this 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.

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. All new schemes undergo a two-stage approval process:

- Stage 1: This is an outline of the scheme which includes indicative routes and budget costs for consultation with stakeholders. The scheme budget is ring-fenced.
- Stage 2: This is triggered once stakeholders 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 referred to UK Power Networks so that we can acquire the necessary consents to deliver the works. During the consenting and delivery phases we work closely with each scheme's proposer on any material issues that arise, such as the re-routing of a proposed cable or substation.

All schemes are assessed against a range of scoring criteria before they can be considered for selection. During this process factors such as the impact on a landscape's character, the impact on visual amenity and the potential impact of undergrounding on features in the landscape (either biodiversity or heritage) are taken into account. To be eligible for selection a scheme must attain a minimum score of nine points out of a maximum of 48.

Schemes are nominally capped at a cost of £200,000 per kilometre. 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.

Scores, feedback and any supporting evidence are 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 – for example, whether the overhead line's removal is being carried out 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 2016-17 regulatory year.

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

Landscape	Scheme Name	Distance (km)	Current position
Kent Downs (SPN)	Birling	2.10	Completed
Dedham Vale (EPN)	Flatford Mill	1.47	Completed

Table 2 shows a further 28 schemes which are in progress. Some of these schemes 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 shared with 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	Broads Authority	Potter Heigham
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
EPN	Norfolk Coast AONB	Burnham Overy
EPN	Norfolk Coast AONB	Cley
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	Royal Military Canal
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
SPN	High Weald AONB	Sheffield Park

Charge Restriction Condition (CRC) 3J of the Distribution Licence allows DNOs to spend up to 10 per cent of their allocated expenditure on undergrounding lines which extend beyond the boundaries of Designated Areas. The Steering Group has been tasked with developing schemes that utilise the full extent of the allowance, with UK Power Networks working to ensure that the required consents for these schemes are obtained by the end of 2018. Two schemes, Sheffield Park and Royal Military Canal, are currently under development in the SPN region. UK Power Networks has provided Steering Group members with new underground cable routes and costings for these schemes so that they can undertake consultations with the wider public.

Achievements in the 2016-17 regulatory year are shown in our RIGs worksheet E1 – Visual Amenity (please see the Annexes and Appendices). During that year we removed 3.18km of overhead line in SPN and 1.47km in EPN. This included the removal of overhead lines from our Eastern network in Flatford in the Dedham Vale AONB and from our South Eastern network in Birling in the Kent Downs AONB.

In addition, following a request from the Steering Group, we added a searchable map to our website to provide stakeholders with a visual representation of completed schemes. We worked closely with Steering Group members to ensure they were fully involved in the design process. The finished product uses icons to provide a brief summary of each completed scheme and its location, including 'before' and 'after' photographs where available. It also enables stakeholders to make suggestions as to areas where they would like to see the allowance spent. The map is available to view here.

We have created a searchable map showing completed underground schemes.

2.3 Oil Leakage

One of the commitments set out in our RIIO-ED1 Business Plan is to reduce oil leakage from fluid-filled cables (FFCs) by 2 per cent per annum for the duration of the RIIO-ED1 price control period (April 2015–March 2023). Our RIIO-ED1 targets were recognised by Ofgem in its RIIO-ED1 Final Determination commentary as stretching and building on good practice already in place. This section explains our strategy for reducing oil leakage from FFCs, which currently account for 36 per cent of all cables running at 33kV, 66kV and 132kV in our three regions.

Cable fluid loss is measured by the total amount of fluid used to top up cables less any fluid recovered. Our strategy is to reduce cable fluid loss by investing in the network to refurbish and replace poor condition circuits. Where circuits develop new leaks we ensure we are at the forefront of new technology and best practice to identify and repair damage as swiftly as possible.

We have undertaken several initiatives to explore innovative solutions that will improve the performance of the underground cable network. Examples include online pressure monitoring, 'self-healing' cables, Perfluorocarbon Tracer (PFT) leak location, and partial discharge mapping. To offset the long-term leakage from FFCs, an innovative solution has been developed and deployed. A minute amount of PFT is added to the cable fluid. PFT introduced in this way is vented to the atmosphere at the point where a leak in the cable is present – where it can be detected using highly sensitive mobile equipment. This method greatly improves performance in the detection and resolution of leaking cable incidents – reducing cost of work, outage time and environmental impact. For more information about PFT leak location please see section 3.3.2.19.

Key reasons for reducing cable fluid loss 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 2016-17 Performance

A summary of 2016-17 cable fluid loss is provided in **Table 3** below. This has been extracted from the RIGs worksheet E2 – Environmental Reporting for each of our licensees. For more information please see the Annexes and Appendices.

In 2016-17, a total of 197,145 litres of oil were lost in our three regions – a significant reduction compared to average performance in the DPCR5 period and an improvement on our 2015-16 performance (208,248 litres). Our 2016-17 performance was in line with expectations, as schemes to reduce oil loss by cable replacement can take a number of years to yield benefits.

The data in **Table 3** demonstrates our commitment to reducing 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. The projects described in that document were reviewed in order to prioritise where circuit performance was known to be poorest.

Table 3 – Comparison of cable fluid lost in 2016-17 to historical performance in DPCR5

Licensee	Average annual cable fluid losses – DPCR5[1]	Cable fluid losses – 2016-17[2]	Difference (volume)	Difference (%)
EPN	48,435 litres	40,801 litres	7,634	16% reduction
LPN	122,384 litres	108,714 litres	13,670	11% reduction
SPN	52,729 litres	47,630 litres	5,099	10% reduction
Total	223,548 litres	197,145 litres	26,403	12% reduction

2.3.2 Initiation of Network Innovation Allowance (NIA) Projects

In our 2015-16 Environment Report we explained that some key innovation projects had started which if successful would directly contribute to a reduction in cable fluid loss. Good progress was made in 2016-17, at the feasibility-proving concept stage and in moving towards laboratory tests and field trials. Please see below for a short update on these key projects.

- **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. The current phase of the project is registered under the NIA project NIA-NPG-009 and started in March 2016.

  The project has resulted in several significant developments, both in regard to the self-healing cables themselves and the testing methods and facilities required for the technology to move to both FFC and network demonstration. Building on this initial success, a programme has been developed to move the technology readiness level, i.e. closer to commercialisation. The next phase will include laboratory tests of cable samples extracted from our networks and also a number of field trials to allow for a swift transition to business as usual. The scope is being considered by the participating DNOs with the help of the Energy Innovation Centre (EIC) and Gnosys, a multi-disciplinary science and technology development company. Additional elements have been included for the necessary laboratory work (thermal ageing, PFT compatibility etc.) and the work required to transition Self-Healing Cables to business as usual.

  If this project is successful, we anticipate that it will provide benefits from reduced cable fluid loss from 2021 onwards.

- **Pressurised Cable Active Control & Monitoring**

  This project reviews the operating systems for FFCs so that cables can be operated at lower pressures without the risk of customer interruptions. The project is registered under the NIA project reference NIA-UKPN-0012 and started in September 2015.

  Initial learning from the project demonstrates that the active control of pressurised cables is feasible, and is likely to lead to both a long-term reduction in leakage from FFCs and a potential extension of asset life.

  The first active pressure control (APC) unit prototype and test rig were designed and developed during the 2016-17 regulatory year. The initial APC unit design incorporates the various functions and safety features identified during the feasibility stage of the project. A fully contained unit measures fluid flow rates and pressure within an FFC and uses this data to operate a variable pressure valve (PRV).

  Testing to date suggests that this unit operates broadly as expected and, more importantly, is failsafe in the event that any parameters fall outside the specified design range (e.g. when the leak causes enough of a pressure reduction to fall below setting pressure).

  If the laboratory tests are successful, we propose trialling the second APC unit on single tanked systems on the live network to ensure no additional risk is placed on customers' power supplies. Work has begun to identify candidate FFC circuits in preparation for these trials.

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

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

If this project is successful, we anticipate that it will provide benefits from reduced cable fluid loss from 2019-20 onwards.

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.

2.3.3 Stakeholder Engagement

During 2016-17, UK Power Networks continued to work with key stakeholders to share best practice and work to target the poorest performing circuits. This work included:

- Ongoing engagement with the Environment Agency at six-monthly meetings of the ENA Fluid Filled Cable Liaison Group, where performance is reviewed and best practice is shared with the other DNOs
- Regular updates to the Environment Agency on the mitigation in place on specific projects and on the progress of capital replacement and refurbishment of FFCs more generally
- Enduring consultation/knowledge sharing with the other DNOs, on a six-monthly basis or as required. These meetings focused on the delivery of specific projects where there were opportunities to share learning. 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. In addition, network trials and workshops were arranged to demonstrate the new technology being developed under the Self-Healing Cables and Pressure Cable Active Control & Monitoring projects
- 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

As the above projects are funded through work streams which require project specific reporting in the RIGs (e.g. the NIA), they are not recorded under costs or volumes within our RIGs worksheet E2 – Environmental Reporting (please see the 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 12 per cent in the second year of RIIO-ED1 (2016-17) when compared to average loss during DPCR5. In 2016-17 we also met our annual RIIO-ED1 target to reduce cable fluid losses by 2 per cent. It is anticipated that by the third year of the current regulatory period (2017-18) the plans outlined above will enable the continued reduction of cable fluid loss in line with the 2 per cent year on year commitment made in our RIIO-ED1 Business Plan.

2.4 Carbon Impact and Climate Change

2.4.1 Business Carbon Footprint

In our RIIO-ED1 Business Plan we set ourselves an overall target to reduce our business carbon footprint (BCF) by 2 per cent in each year of the RIIO-ED1 price control period. Two years in we are pleased to report a reduction of 11 per cent, which is significantly ahead of this target.

We have reduced our BCF by 11% over the last two years.

We are constantly looking for ways to reduce our BCF and we monitor our progress closely. This section describes our BCF reporting process, the various elements of our BCF including how these are measured, and how we track our carbon emissions throughout the year.

Our results for the 2016-17 regulatory year are shown in our RIGs worksheet E3 – Business Carbon Footprint (please see the Annexes and Appendices).

2.4.1.1. Our BCF Reporting Process

In accordance with the Greenhouse Gas (GHG) Protocol, direct and indirect carbon emissions are categorised into three broad areas or '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 above (e.g. outsourced activities)

We publish an annual report of our BCF, which details the carbon emissions from our three licensees within these categories and presents our BCF with and without distribution losses (please see our website). Distribution losses constitute more than 97 per cent of our BCF and are the focus of a separate strategy. Focusing on our BCF without losses highlights the potential for sustainability improvements in other areas. Excluding distribution losses, the largest elements of our BCF are operational transport (38 per cent) and building and substation energy usage (36 per cent) – followed by temporary generation (16 per cent), business transport (6 per cent) and fugitive emissions (4 per cent). These elements are illustrated in **Figure 3** overleaf.

Table 4 shows our overall BCF excluding distribution losses for the regulatory years 2014-15 (our baseline measurement year as set by Ofgem) and 2016-17. For details of the individual components of our BCF excluding losses please see section 2.4.1.2. Distribution losses and UK Power Networks' Losses Strategy are covered in detail in section 2.4.3.2.

Table 4 – Our 2014-15 and 2016-17 BCF excluding losses

Licensee	2014-15 (tCO_2e)	2016-17 (tCO_2e)	% change
EPN	32,539.49	30,902.64	-5%
LPN	19,776.50	18,087.34	-8%
SPN	25,025.12	19,648.00	-21%
Total	77,341.11	68,637.98	-11%

To check progress against our RIIO-ED1 target, we prepare monthly BCF reports, at a company-wide level, using data received from internal and external sources. Any anomalies in the data are closely examined to establish the underlying reasons. Corrective actions are then implemented where necessary.

Monthly reports are received from various sources within UK Power Networks. These cover:

- Electricity and gas meter readings
- Fleet fuel usage
- Business mileage and transport expense claims
- Generator fuel usage
- Sulphur hexafluoride (SF_6) top-ups
- Headcount

We also receive monthly booking reports from our external travel provider and require our contractors to report on any work that is subcontracted or accumulated as a direct result of works undertaken on our behalf.

Our BCF reporting process takes into account carbon emissions from operational contractors who are involved in developing and operating our electricity networks and who have a significant spend threshold per annum (generally £250k or above). In this report the values representing UK Power Networks' and contractors' emissions are shown both separately and as a combined figure.

For elements such as the purchase of fuel for temporary generation, SF_6 top-ups, substation energy use and some of our building energy, data is apportioned directly to each of our three licensees wherever possible. However, a major programme of business transformation to maximise efficiency through the use of common systems in all three of our regions has meant that some data is captured centrally. Where this is the case we apportion the data between the licensees on a headcount basis. This approach is favoured over geographical apportionment as the LPN region only accounts for around 2 per cent of the total land area, which would result in an unrealistically small value.

The apportionment of data on a headcount basis accounts for the comparatively small change in EPN's tCO_2e values relative to those of LPN and SPN. In the EPN region, contracts for tree trimming and street works were brought in-house, resulting in the transfer of many staff working on the contracts under TUPE regulations. Accordingly, in 2014-15 (the baseline year we measure against), we saw EPN's apportionment increase by 6.5 per cent and SPN's reduce by 6 per cent.

For the last three years our entire BCF reporting process has been audited by UK Power Networks' Internal Assurance team. Elements have also been examined annually by the external auditors DNV-GL as part of UK Power Networks' ISO 14001 accreditation.

2.4.1.2. The Individual Elements of our BCF

Figure 2 and **Figure 3** show the relative proportions of the individual elements of UK Power Networks' BCF for the 2014-15 and 2016-17 regulatory years.

Figure 2 – 2014-15 BCF breakdown excluding distribution losses

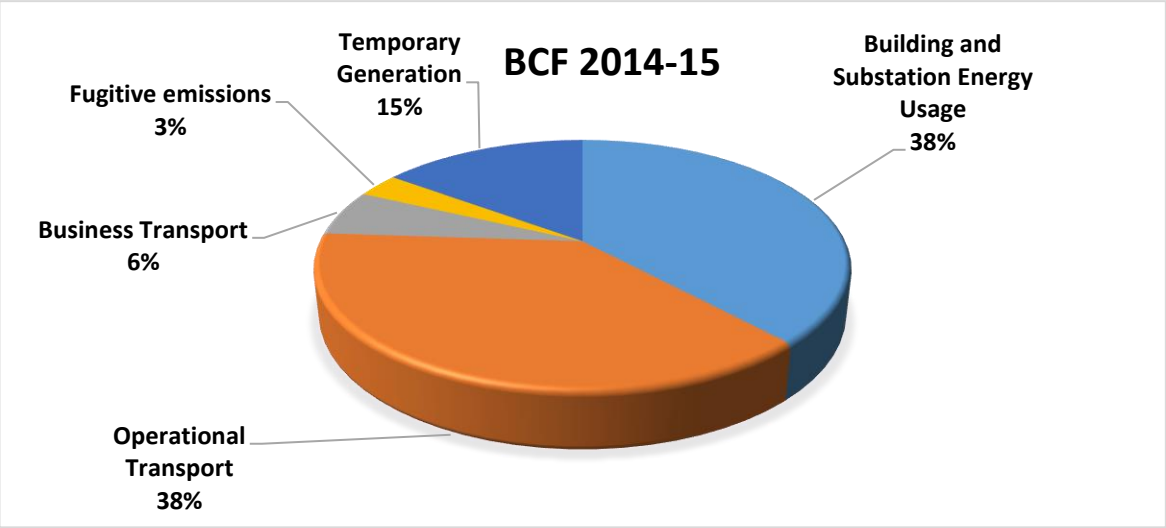
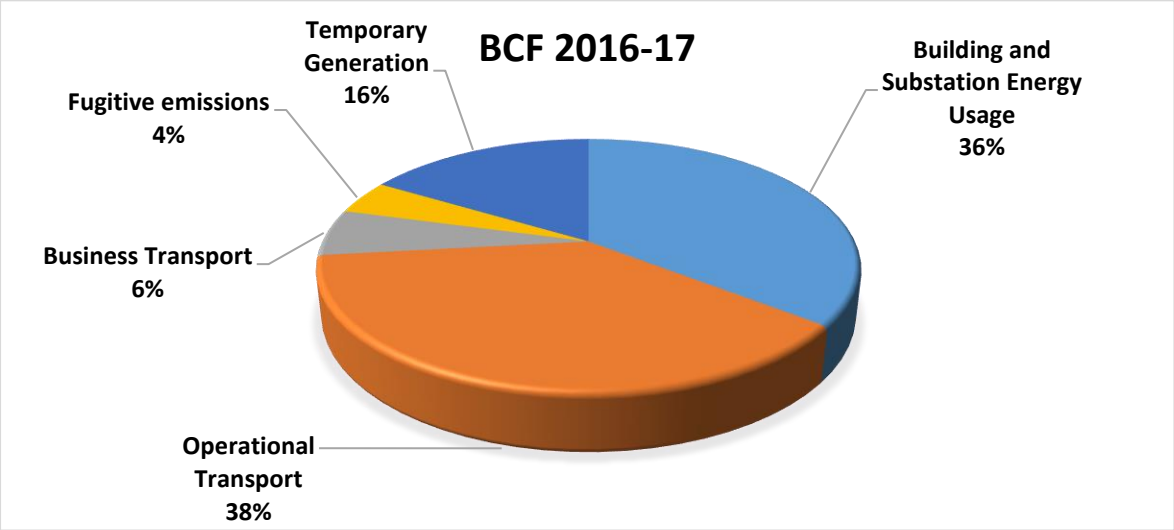


Figure 3 – 2016-17 BCF breakdown excluding distribution losses



Although our overall BCF is reducing, its relative proportions are broadly similar year on year, with operational fleet and building and substation energy usage remaining the largest elements. The most significant change has been the proportional decrease of 2 per cent in building and substation energy usage. A contributing factor is the alteration in the fuel mix making up the UK's electricity supply. The closure of coal fired power stations and increasing amounts of renewable energy connected to the network have led to a marked decrease in the carbon factor for UK electricity.

2.4.1.3. Operational Transport

This element of our BCF represents the fuel used by our fleet of vans, trucks and specialist vehicles which work directly on our electricity networks. We also report on the fuel used by our contractors' operational vehicles when working on our behalf. Fuel purchased for UK Power Networks' fleet vehicles is captured using fuel cards. Contractor transport data is obtained from contractor fuel cards submitted via a manual reporting process. In 2016-17, 99.36 per cent of fuel purchased was diesel and hence the diesel factor has been used for conversion purposes. A small quantity of diesel for temporary generation is also purchased using fuel cards, but this is recorded separately and is reported as part of our Temporary Generation carbon footprint.

Table 5 shows the levels of tCO2e emitted by UK Power Networks' operational fleet and contractors when working on our networks. As previously mentioned, we apportion fuel usage on a headcount basis as we believe this is a more accurate method than geographical apportionment which is based on square kilometres. The larger apportionment for EPN is the result of bringing our tree trimming and street works contracts in-house.

Table 5 – Levels of tCO_2e emitted by UK Power Networks' operational fleet and contractors working on our networks

Licensee	Direct operational staff	% of staff	2014-15 – total (tCO_2e)	2016-17 – our fleet (tCO_2e)	2016-17 – contractor (tCO_2e)	2016-17 – combined (tCO_2e)	% change
EPN	1,167	43%	11,450.84	6,906.11	4,361.57	11,267.68	-1%
LPN	797	29%	9,284.47	4,715.89	2,978.33	7,694.22	-17%
SPN	717	26%	10,212.92	4,242.32	2,679.25	6,921.57	-32%
Total	2,680	100%	30,948.23	15,864.32	10,019.15	25,883.47	-16%

2.4.1.4. Building and Substation Energy Usage

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

Table 6 shows the levels of tCO_2e emitted from our offices, depots and substations.

Table 6 – Electricity usage at UK Power Networks' sites

Licensee	2014-2015 – total (tCO_2e)	2016-2017 – total (tCO_2e)	% change
EPN	13,574.67	11,184.28	-17%
LPN	6,942.63	7,946.40	+14%
SPN	6,648.78	5,257.71	-20%
Total	27,166.08	24,388.39	-10%

2.4.1.5. Temporary Generation

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

- From external contractors reporting the monthly fuel usage of standby diesel generators: invoices for diesel fuel are used to collate the monthly fuel usage by licence area. Though provided by external contractors on an ad hoc basis, these are classed as Scope 1 rather than Scope 3 emissions, as they are in direct use on our networks
- From fuel cards capturing the amount of fuel used by company owned plant and equipment
- From invoices submitted by the tanker company that fills the bowsers at several of the sites used to fuel our own generators

As the source data is captured by region, no headcount conversion needs to be applied.

Table 7 shows the levels of tCO_2e emitted from temporary generators and plant and equipment used on our networks.

Table 7 – tCO_2e emitted from temporary generators and plant and equipment used on our networks

Licensee	2014-15 – total (tCO_2e)	2016-17 – UK Power Networks (tCO_2e)	2016-17 – contractor (tCO_2e)	2016-17 – combined (tCO_2e)	% change
EPN	4,321.55	4,266.72	331.94	4,598.66	+6%
LPN	1,717.71	724.71	226.67	951.38	-44%
SPN	6,328.58	5,516.29	203.90	5,720.19	-9%
Total	12,367.84	10,507.72	762.51	11,270.23	-10%

2.4.1.6. Business Transport

This element is concerned primarily with employees' business mileage and public transport (attending meetings etc.), which constitute indirect operational emissions.

We obtain data from the following sources:

- Our SAP (financial management) system which enables us to determine business mileage and travel claimed through staff expenses
- Our external travel provider
- Corporate credit cards
- Fuel cards (fuel card holders' private mileage is declared in miles and deducted from mileage expense claims in our SAP system)

Business travel data is recorded by mode of transport used (e.g. air, rail and road). It is not recorded by licensee and therefore the total business mileage is apportioned based on the number of indirect staff employed in each region. Business kilometres are based on the actual kilometres claimed. Fuel card usage is based on the actual litres used.

For vehicles that are owned by UK Power Networks or purchased through our business needs self-purchase scheme, we use the actual CO_2 rating to calculate each vehicle's contribution to our BCF and this provides us with more accurate data. Where employees claim business mileage for privately owned vehicles, the government's unknown vehicle average conversion factor is used.

An increasing number of our employees are issued with fuel cards and this provides a more accurate measure from a BCF perspective. Fuel data can be captured in terms of the quantity of fuel used, eliminating the wide variations between cars and drivers in actual carbon used per kilometre.

We continue to encourage our staff to use teleconferencing facilities as an alternative to business travel. As **Table 8** demonstrates, our overall business mileage figures maintained the 4 per cent improvement on the previous year shown in our 2015-16 results.

Table 8 – Business mileage summary showing the levels of tCO_2e emitted by UK Power Networks' staff and contractors when travelling on company business

Licensee	Indirect staff	% of staff	2014-15 – total (tCO_2e)	2016-17 – UK Power Networks (tCO_2e)	2016-17 – contractor (tCO_2e)	2016-17 – combined (tCO_2e)	% change
EPN	1,108	38%	1,651.60	1,469.09	125.73	1,594.82	-3%
LPN	885	30%	1,339.13	1,042.41	85.86	1,128.27	-15%
SPN	961	33%	1,473.05	1,295.09	77.24	1,372.33	-6%
Total	2,953	100%	4,463.78	3,806.59	288.83	4,095.42	-8%

2.4.1.7. Fugitive Emissions

Sulphur hexafluoride (SF_6) is an electrical insulating gas commonly found in modern electrical switchgear. This gas can leak following faults or from old equipment.

From a BCF perspective, we measure and record the quantities of SF_6 lost as fugitive emissions. **Table 9** shows the levels of SF_6 emissions reported by our three licensees in 2014-15 and 2016-17.

Table 9 – Levels of tCO_2e emitted from leakage of SF_6 from switchgear

Licensee	2014-15 – total (tCO_2e)	2016-17 – total (tCO_2e)	% change
EPN	1,540.83	2,257.20	+46%
LPN	492.56	367.08	-25%
SPN	361.80	376.20	+3%
Total	2,395.19	3,000.48	+25%

Consistent with the approach used for previous years' BCF submissions, we have not included emissions from air conditioning in the values reported above.

We continue to actively monitor our assets and have procedures in place to minimise the escape of SF_6 to the environment. Please see section 2.4.2 for more detailed information about these procedures and our annual performance.

2.4.1.8. Distribution Losses

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

Our results for the 2016-17 regulatory year are shown in our RIGs worksheet E4 – Losses Snapshot (please see the Annexes and Appendices).

Overall losses performance is presented in **Table 10** and **Table 11** below. The figures are correct at the time of submission but may be subject to further updates given the standard reconciliation cycle in the settlements process.

Table 10 – Levels of tCO_2e emitted from direct losses as the electricity travels through our networks

Licensee	2014-15 – total (tCO_2e)	2016-17 – total (tCO_2e)	% change
EPN	1,178,315.84	1,016,939.40	-13%
LPN	913,866.74	779,598.60	-14%
SPN	663,791.18	541,021.65	-18%
Total	2,755,973.76	2,337,559.65	-15%

Table 11 – Our overall BCF including distribution losses in tCO_2e

Licensee	2014-15 (tCO_2e)	2016-17 (tCO_2e)	% change
EPN	1,210,855.33	1,047,842.04	-13%
LPN	933,663.24	797,685.94	-14%
SPN	688,816.30	560,669.65	-18%
Total	2,833,334.87	2,406,197.63	-15%

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

2.4.2 Sulphur Hexafluoride Emissions (SF_6 Emitted)

Sulphur hexafluoride (SF_6) is a hazardous material which can have a significant impact on the environment. (It is 22,800 times more harmful to global warming than Carbon Dioxide.) Reducing SF_6 leakage from our network assets is key to our vision of being a Respected Corporate Citizen. In our RIIO-ED1 Business Plan we signalled our commitment to maintain SF_6 leakage at less than 0.2 per cent as a proportion of SF_6 in service throughout the RIIO-ED1 price control period, in all three of our regions. Where SF_6 leaks occur we act in strict accordance with the EU F-gas Regulations to ensure they are rectified without undue delay.

We use SF_6 in our switchgear as an insulation medium, an arc extinction method or for both functions, from 11kV up to 132kV. SF_6 leakage is measured in kilogrammes as the amount of SF_6 that is used to top up our gas filled switchgear.

The total capacity of SF_6 utilised in assets on our network is just over 100,000kg across our three regions – please see the corresponding breakdown in **Table 12** below.

Table 12 – Installed SF_6 capacity per licensee

Licensee	Installed capacity (kg)
EPN	36,921
LPN	42,305
SPN	21,124
Total	100,350

Gas circuit breakers are becoming more prevalent on our network as more oil switchgear is removed, and there will be a subsequent increase in SF_6 filled switchgear on the network to replace them. This is especially true at the 132kV voltage level where SF_6 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 SF_6 capacity on our network is forecast to increase in RIIO-ED1 by approximately 5,000kg[3]. The figures presented in our RIGs worksheet E2 – Environmental Reporting (please see the Annexes and Appendices) demonstrate that over the last two years, in our LPN and SPN regions, we have comfortably met the SF_6 leakage targets set out in our RIIO-ED1 Business Plan. Although we met the target in EPN in 2015-16, we did not do so in 2016-17. We are focusing our efforts in this area so that we meet the target in all three of our regions going forward.

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' SF_6 bank.

2.4.2.1. Our Strategy

We are taking action to minimise SF_6 emissions in order to:

- Remain compliant with the EU F-gas Regulations
- Minimise our impact on the environment and achieve our vision of being a Respected Corporate Citizen
- Minimise the network 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 – improving network performance
- Minimise the risk of exposure to SF_6 for our operational staff when working on the network or handling this substance

Where SF_6 leaks occur our approach is to instruct the manufacturer to carry out leak detection works on the affected unit, scope out the works and complete all refurbishment works required to mitigate the leak. This often constitutes an on-site refurbishment or factory refurbishment. In these situations 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 considered.

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

- Low gas pressure alarm automatically received by Network Control
- Top-up work order automatically raised when low gas alarm is received
- Competent Person (holding a valid SF_6 handling certificate) tops up the asset to within the manufacturer's recommended pressure range; the magnitude of the top-up is a mandatory input field to close the work order

SF_6 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 SF_6 or the operation of any switchgear containing this substance. One of these documents is Engineering Design Standard EDS 03-0036 – Management

[3] This is an estimate based on the average kilogrammes of SF_6 in a new GIS bay (F35), the average capacity of an AIS SF_6 circuit breaker (DB145) and a prediction of the scope of works that will be completed for switchgear projects currently in our RIIO-ED1 plan.

of Switchgear Containing SF_6, which offers guidance on the management of switchgear containing SF_6 from voltages of 6.6kV up to 132kV. More specifically, it details the processes followed in identifying and managing SF_6 filled switchgear that may be leaking. This policy applies to all UK Power Networks plant and staff, including contractors who work on the network on our behalf.

In 2016-17 we successfully completed the refurbishment of a live-tank 132kV SF_6 filled circuit breaker at Kemsley Grid (SPN) which was known to have leaked SF_6 in the past. A complex programme of work was undertaken to replace the circuit breaker stacks on all three phases of the circuit breaker and since completing this work we have identified no further leakages of SF_6 from this asset.

Our 2017-18 plans include investment targeted at the most significant contributors to SF_6 leaks on our 33kV and 132kV switchgear.

2.4.2.2. Our Stakeholders

Key stakeholders in this area are the parties who are directly affected by an SF_6 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 SF_6 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' SF_6 handling policy.

2.4.2.3. Our Programme to reduce SF_6 Emissions

Our 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 SF_6 topped up is recorded automatically during the completion of top-up work orders. As previously mentioned, these work orders are created automatically when a low SF_6 gas alarm is detected.

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

2.4.2.4. Looking Ahead: Our Future Strategy

We are launching a new innovation project focused solely on improving our end-to-end processes relating to SF_6. This is scheduled to start in early 2018 and its aim is to highlight any areas for improvement in our SF_6 process, examining feasible solutions and implementing those solutions. The key areas that will be explored are:

- Gas carts – providing operational staff with the correct tools with full functionality to complete the required works (degassing, vacuum pump, re-gassing) in outdoor electrical compounds
- Improved recording of SF_6 assets and gas bottles – the link between procurement and ownership of the assets/gas bottles from our Network Operations directorate
- Cost savings – exploring opportunities to save on material and maintenance costs as well as the business case for purchasing indoor gas carts for new substations (using the existing fleet)
- Alternatives – exploring the use of SF_6 alternatives, such as G3, and commissioning these assets on our network
- Minimising network risk – investigating the use of devices that enable in-service topping to minimise outages and exploring the feasibility of live topping-up of SF_6 filled assets

The review will be extensive and hence the list above does not include all of the issues to be addressed. In addition we would consider the equipment in use, the business process and contractual arrangements in place with suppliers to improve the quality and accuracy of data recording, and administer appropriate checks for assurance purposes. Training packages and reference material will be required to support roll-out to the relevant teams.

Our RIIO-ED1 Business Plan showed that four new GIS boards and 94 132kV AIS breakers with SF_6 arc extinction were expected to be installed during the RIIO-ED1 period. This constitutes approximately 5,000kg of additional SF_6 capacity in assets on our network.

We keep abreast of all innovations related to SF_6 as an insulation medium, including the exploration of SF_6 alternatives. Alstom and National Grid have worked collectively to develop G3 as a viable alternative to SF_6; we remain in contact with both parties and continue to monitor the development of this technology.

Achievements in the 2016-17 regulatory year are shown in our RIGs worksheet E2 – Environmental Reporting (please see the Annexes and Appendices).

In our SPN region, the successful completion of the project at Kemsley Grid helped contribute to a reduction in leakage from 17.6kg to 16.5kg. However, there was an increase in leakage from assets in our other two regions, from 9.6kg to 16.1kg in LPN and from 66.9kg to 99kg in EPN. We are focusing our efforts in these two regions and five leak rectification projects are being progressed.

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 losses[4]. Non-technical losses are covered in detail later in this section.

2.4.3.2. Our Losses Strategy

The focus of UK Power Networks' Losses Strategy remains the same as our original strategy – published as an annexe to our RIIO-ED1 Business Plan. 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. Our work with Imperial College London, highlighted in our Losses Discretionary Reward (LDR) tranche 1 document (29 January 2016), details how we are gaining that required knowledge. The remainder are dependent on new technologies or methods of operating the network and will be implemented once it is feasible to do so. Again, we expect that many of the activities detailed in our LDR tranche 1 document will enable us to begin effectively implementing the focus of our Losses Strategy, and as a result of the LDR work we also expect to be able to better target our focus on networks which are prone to higher network losses.

[4] 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)

Activities that are currently under way are detailed in our RIGs worksheet E4 – Losses Snapshot (please see the Annexes and Appendices). At a high level, the overall split is as follows:

Current activities:

- We continue to replace existing transformers with ECO2015 specification equivalents which will reduce the fixed iron losses that are constantly present on the network, irrespective of the current passing through it. A significant number of transformers are installed each year which have lower losses than the units they replace. The benefits of many of these installations are not captured through the E4 RIGs reporting process as the installation cannot be justified solely based on the results of cost benefit analysis (CBA). However, we estimate that losses on the network reduced by 9,249MWh as a result of the work that was undertaken.
- We are replacing existing transformers with larger units where the saving in copper losses (variable) outweighs the increases in iron losses (fixed). Over the last 12 months we have increased the transformer size at 22 sites where CBA demonstrated a positive NPV, yielding improvements of approximately 80MWh per annum.
- We are installing larger cross-section conductors to reduce resistance and hence variable I2R losses. There has been a significant shift in the cable sizes being installed, with a reduction of 95mm^2 in LV cable and a corresponding increase in 185mm^2 and 300mm^2 cable. In total, more than 2,700MWh per annum were saved by installing 80km less 95mm^2 cable than in the previous year.
- We are amending 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:

- We will develop our understanding of the impact that inefficient use of the network has on losses. Factors which 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. Working with Imperial College London, we are identifying which of these factors create the most losses and which networks they particularly affect.
- We will explore the possibility of reconfiguring 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.
- We will consider 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:

- We will consider the impact that the transition from DNO to DSO has on network losses, and identify 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), Energy 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.
- We will keep abreast 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 us to undertake our current focus more efficiently. It may also highlight new areas that we can focus on to target losses.

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

Table 13 – Summary of losses

	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Total Losses (tCO_2e)[5]						
EPN	1,049,245	1,152,525	1,112,211	1,178,316	1,034,381	1,016,939
LPN	794,489	843,139	839,961	913,887	880,009	779,598
SPN	659,789	675,935	611,716	663,791	559,249	541,021
Total Losses (GWh)						
EPN	2,546	2,797	2,699	2,860	2,238	2,468
LPN	1,928	2,046	2,038	2,218	1,904	1,892
SPN	1,601	1,640	1,485	1,611	1,210	1,313
Total units distributed (GWh)						
EPN	34,093	35,108	33,794	32,882	32,721	33,295
LPN	28,492	28,722	28,006	27,632	27,442	27,266
SPN	20,813	20,994	20,508	19,713	19,413	19,468
Total losses (%)						
EPN	7	8	8	9	7	7
LPN	7	7	7	8	7	7
SPN	8	8	7	8	6	7

Table 14 shows the losses improvements reported through our RIGs worksheet E4 – Losses Snapshot for the regulatory year 2016-17 (please see the Annexes and Appendices). 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	1,614.8	464.9	660.6
HV Cable	0	0	0
Distribution Ground Mounted Transformer	34.9	24.4	17.5
Distribution Pole Mounted Transformer	0	0	0
Primary Transformer	0	0	0
Grid Transformer	0	0	0
Total	1,649.7	489.3	678.1

- 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.
- Distribution transformer replacement – through using ECO2015 specification transformers and installing larger units, where justified by CBA, fixed (and variable) losses associated with distribution transformers have reduced as a result of the activities undertaken.

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 our 2016-17 RIGs worksheet E4 – Losses Snapshot (please see the Annexes and Appendices), a total of 2,817.1MWh of improvements were made over the 12-month period. This equates to 6,837.6 tCO_2e in the year.

[5] We have used the following conversion factor in producing this table: 1kWh = 0.41205 $kgCO_2$.

2.4.3.3. Our Assessment of Progress in developing the Tools and Methodology for Distribution Losses

UK Power Networks' LDR tranche 1 submission 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. 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 our three regions.

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

- Develop a holistic network modelling tool with Imperial College London – this will allow the prompt assessment of a wide range of approaches across our three regions and will also help us to focus particular activities in specific areas where they are proven to deliver maximum benefits efficiently
- Develop 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 regions and in relation to other DNOs
- Develop an innovative approach to identifying losses, through the use of a Mobile Asset Assessment Vehicle
- Employ 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 proven 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 (2016-17)			RIIO-ED1
	Distributed losses – justified cost	Reduced losses	Reduced emissions associated with losses	Cumulative reduced losses to date
	£m	MWh	tCO_2e	MWh
LV Cable	0.295	2740.3	6,651.2	3,684.5
HV Cable	0	0	0	0
Distribution Transformers	0.04	76.8	186.4	351
Primary Transformers	0	0	0	0
Grid Transformers	0	0	0	0

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 (2016-17)	Forecast volumes for Following Regulatory Year (2017-18)[6]
LV Cable	km	80.7	N/A
HV Cable	km	0	N/A
Distribution Transformers	ea	22	N/A
Primary Transformers	ea	0	N/A
Grid Transformers	ea	0	N/A

[6] 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.

2.4.3.4. Non-technical Distribution Losses

Distribution networks suffer non-technical losses from the under-recording or non-recording of electricity consumption. Responsibility lies primarily with electricity suppliers, who must accurately read meters, record consumption and resolve situations where customers tamper with or 'bypass' 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. Within the electricity industry this is known as theft in conveyance (TiC).

Tackling TiC is an important part of a DNO's responsibilities. UK Power Networks has both a licence obligation and a broader legal, social and moral imperative to investigate and resolve TiC. Our operations also identify and resolve the dangerous situations that are frequently associated with unauthorised connections. UK Power Networks is helping to protect the occupiers of such premises, their families, neighbours, employees, customers and the general public at large from the risk of serious harm.

During the 2016-17 regulatory year, our programme of work led to 153 cases of theft being resolved in our three regions. A further 134 cases investigated during the year remained 'in progress' – where UK Power Networks was working with property owners to ensure the appropriateness of their connection arrangements, delivering service upgrades where necessary, or waiting for the customer's chosen supplier to carry out MPAN registration actions.

The vast majority of cases are resolved through the customer making an application to an electricity supplier and the subsequent registration of the metering point in settlement. However, in a small number of cases it becomes necessary for UK Power Networks to disconnect the unauthorised supply. In the absence of safety concerns we seek to avoid enforced disconnections and employ these only as a last resort.

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

Table 17 – Summary of losses costs and benefits from resolved TiC cases in RIIO-ED1

Programme/project title	Regulatory Reporting Year (2016-17)			RIIO-ED1
	Distribution Losses- Justified Costs	Estimated Reduced Losses	Reduced Emissions associated with Losses	Cumulative Reduced Losses to date
	£m	MWh	tCO_2e	MWh
Countering Theft in Conveyance	0.12	612	308	3,012

Table 18 – Summary of TiC losses activities in the 2016-17 Regulatory Reporting Year

Programme/project title	Description of unit	Volumes in 16-17 Reporting Year
Countering Theft in Conveyance	Resolved TiC Case	153
	'In Progress' Case	134

2.5 Other Environment-related Activities

2.5.1.1. Waste/Landfill/Recycling

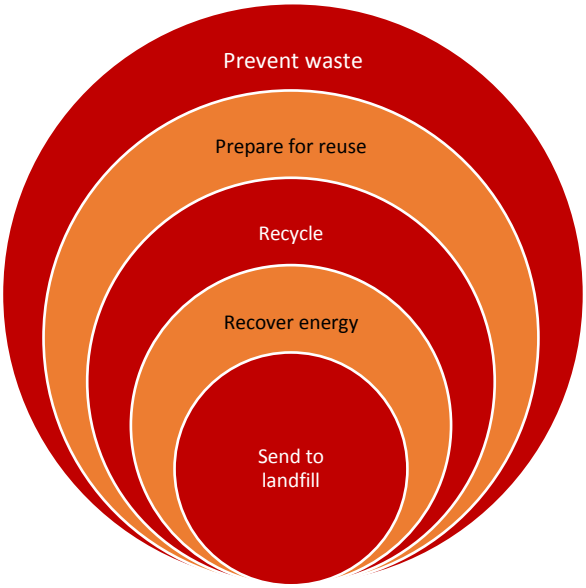
Waste prevention is hugely important from both an environmental and an economic perspective and we are committed to managing it effectively.

We have set ourselves challenging targets of diverting 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) from landfill. In 2016-17 the proportions of office and depot waste and street works spoil diverted from landfill were 86.5 per cent and 98.2 per cent, respectively.

We are exceeding our targets for recycling waste from street works and for diverting the waste produced from our offices and depots from landfill.

We manage our waste streams using the 'waste hierarchy' shown in **Figure 4** below.

Figure 4 – Our waste hierarchy



Underpinning this approach are various initiatives focused on preventing waste:

- '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

Spoil heaps are collected from our street works sites as soon as they are produced and are taken to recycling centres where the aggregate is graded and sorted. Fresh aggregate is taken to the site of the street works when the works are complete to make good the road repair.

In addition, we ensure that all major projects are assigned a Project Waste Management Plan. This identifies the person responsible for implementation and also describes the expected waste streams, how they will be managed, the contractors to be used and how the quantities of waste will be recorded.

2.5.1.2. Reducing Noise Pollution

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, substations and generators. In 2016-17 we received 42 complaints which were reported in our RIGs worksheet E2 – Environmental Reporting (please see the 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 our LPN region where properties are often sited directly above our equipment. Airborne noises can be blocked by a physical barrier – typically a metal screen with insulation.

Because of its long wavelength, it can be difficult to block the 100 hertz tonal noise produced by transformers. Traditional noise screens and enclosures insulate against the noise but this can cause issues as heat cannot easily escape from the enclosures and can effectively down rate the capability of the transformer. It is possible to install a forced ventilation system but this in turn introduces another noise source.

To determine if our equipment is causing a 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 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, such as 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 determine an appropriate course of action.

It is important that we keep abreast of new noise mitigation techniques and we have been working with Sonobex, a noise control specialist, to design a noise screen that could be used at our substations. An example of this equipment is shown in **Figure 5**. It uses coupled resonator elements to attenuate airborne noise and allows air to pass through the screen, thus avoiding the need for additional ventilation. We have identified a suitable site in our LPN region where this noise mitigation technique can be trialled next year.

Figure 5 – Demonstration of the Sonobex system in an anechoic chamber at the British Research Establishment

We operate in 127 local authority areas and in the course of a year we will have many interactions with local Environmental Health Officers (EHOs) on topics such as noise and fly-tipped waste (see the next section).

During 2016-17 we worked with EHOs in Kent (in our SPN region) to prepare presentation material that provides a better understanding of how the electricity network operates. We intend to develop this as a wider initiative which can be offered to EHOs across our operating area.

2.5.1.3. Tackling Fly-tipping

In December 2016 we were contacted by one of the councils in our operating area, who was concerned about the condition of one of our substations. The substation was becoming the focus of anti-social behaviour and was often heavily littered. Situations such as this are often subject to a formal legal notice. Initially the council was insistent that a cage was needed – however, this was not considered to be viable on the basis that it would only cause litter to accumulate adjacent to the site.

After further discussion it became apparent that this was to be part of a wider scheme by the council to address anti-social behaviour. It was agreed that signage should be trialled and we worked closely with the council to provide this, based on a design from the council's communications team. The posters were installed in December 2016 and have been positively received by the council, leading to wider engagement with local authorities.

2.5.1.4. Environmental Employee Awareness Schemes/Incentives/Practices

In 2017 our environmental training course 'Working with the Environment in UK Power Networks' was assessed and successfully accredited by the Royal Society for the Prevention of Accidents (RoSPA).

2.5.1.5. 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 (*Clinopodium calamintha* (Lesser Calamint) which was found at our Belchamp substation in 2012), 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.

2.5.1.6. Joint Partnership Agreements

Since 2011 we have supported the nine Wildlife Trusts in our three regions, both financially and through providing a volunteer workforce. This mutually beneficial arrangement provides a source of income for the Trusts and the volunteer work parties help us with team building and developing staff skills. In addition, we utilise the expertise of Wildlife Trust ecologists to create habitat management plans for selected major substations, many of which have undeveloped areas that provide a home for wildlife.

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.

2.5.1.7. Adaptation/Flood Preparedness

At UK Power Networks we are committed to understanding and protecting our substations from flood risk. During RIIO-ED1 we expect to protect 78 substations from flooding.

Our flood protection programme is supported by two key documents: our policy and design guidance document, EDS 07-0106 – Substation Flood Protection (EDS 07-0106 (Substation Flood Protection), which is available for use by internal and external parties; and the industry best practice document ETR138 – Resilience to Flooding of Grid and Primary substations (ETR138 – Resilience to Flooding of Grid and Primary substations). UK Power Networks has been an active participant in the ongoing review of the latter document to ensure consistency in its approach and compliance to the best practice document.

We are committed to working closely with our stakeholders, including the Environment Agency, Local Authorities and National Grid. We share information and play an active role in developing solutions at shared sites that are vulnerable to flooding; through regular liaison, suitable solutions have been implemented to protect parties' vulnerable equipment.

Surface water (pluvial) flood risk has been the subject of extensive research over the last few years, with previous flood events (e.g. the flooding incidents in Tooley Street, London in April 2008 and May 2009) highlighting the risk that substations (particularly subterranean sites) are at from surface water flooding. As a result, LPN's flood programme has focused primarily on surface water flood protection at sites with plant and equipment below ground level. Following site-specific assessments, over 20 substations were identified as being at risk of flooding. To mitigate this risk, flood protection measures in the form of bunding, floodgates and sealing of duct and cable entries have been implemented during the past few years.

We have sought to provide flood protection measures that are cost-efficient and deliver the maximum risk reduction to improve the number of customers protected. Resilience in the supply network means that customer supply can often be very quickly re-established at minimal inconvenience following flooding of critical equipment. Flood

mitigation of vulnerable sites is prioritised where there are high numbers of unrecoverable customers[7] connected to a vulnerable site.

Where substation sites are developed and new buildings and plant are installed, guidance documents are available to assist engineers and third parties in identifying flood risk and protecting new plant and equipment. This will normally be achieved by raising critical equipment above the 1:100 or 1:1,000-year flood level set by the Environment Agency, allowing for a climate change factor and incorporating a 300mm freeboard allowance.

In the EPN region, there was a continued focus in 2016-17 on managing risk, planning, and implementing flood protection work at Eastern Esplanade (Southend-on-Sea) which provides the supply to the adjacent Anglian Water pumping station. This in turn protects the local area from pluvial flooding. Flood protection measures have also been implemented at a primary substation in Knapton (Norfolk), protecting both the local supply and adjacent properties from flooding. Design and planning work has been ongoing in readiness for several proposed future flood mitigation schemes. Twenty detailed flood risk assessments with topographical and level surveys were carried out across the region, helping to drive and direct the forward programme of targeted and best value flood mitigation projects.

In the LPN region, achievements in 2016-17 included the completion of three detailed flood risk assessments. The surveys are invaluable to UK Power Networks in understanding, prioritising and reacting to flood risk across a large and diverse estate of substations. Further detailed analysis and calculation of the precise flood risk to the primary substation at Montford Place has resulted in protection for a 1:100-year event when taking account of the topography of the site and flood mitigation already in place locally. Design and planning work has been ongoing for future mitigation projects across the region.

Flood mitigation work in 2016-17 resulted in the installation of permanent flood protection measures at Old Woking Primary substation in the SPN region. Flood protection of a switch room building, relay building, battery room and two transformers has resulted in a high level of protection for over 8,000 customers to a 1:1000-year event. Twenty one detailed flood risk assessments with topographical and level surveys were carried out across the SPN region – underlining UK Power Networks' commitment to understanding and reacting to the risk of substation flooding. As a result of this analysis, a number of sites have been identified for cost-effective targeted protection in 2017-18.

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

[7] This term is used to describe customers who remain without a power supply following the application of HV back-feeds. The distinction is made to ensure that customers who cannot have their supplies quickly re-established through switching are given the highest priority for flood mitigation projects.

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

3.1 Introduction

This is a time of unprecedented change in the electricity industry – bringing with it new challenges and opportunities. At UK Power Networks we are clear about wanting to be the most innovative of all the DNOs. It is part of our drive to be a Respected Corporate Citizen and to be sustainably cost-efficient. We are embracing the changes ahead and working to ensure we are at the forefront of new developments and ideas.

In recent years we have seen numerous changes, including:

- **The emergence of renewable energy installations, such as wind and solar farms, as key contributors to the future energy framework.** Solar generation in particular is becoming ever more prevalent. Over the weekend of 9-10 April 2016, solar generators provided more electricity than coal for the first time in the UK[8], a symbolic milestone that highlights the major changes occurring in the electricity industry. The power system now boasts 11GW of solar generation and 14GW of wind capacity – sufficient to exceed consumer demand at certain times during the summer. DNOs are at the forefront of this change, with 90 per cent of solar energy alone connecting directly to the distribution system. At UK Power Networks we are proud to have played a part in enabling these developments – 8.5GW of distributed generation (DG) is connected to our networks, accounting for one-third of all connected DG in the UK.

Over the weekend of 9-10 April 2016, solar generators provided more electricity than coal for the first time in the UK.

- **The increased use of grid-scale storage, prompted by advancements in electricity storage technology.** At the time of writing UK Power Networks alone had received just over 17GW of applications for battery storage, with 1GW of connection offers accepted.
- **A growing demand for electric vehicles (EVs).** By 2030 we predict that 1.2-1.9 million EVs will have connected to our networks.

In addition, DNOs will play a significant role in facilitating the achievement of the 2050 Climate Change targets – ensuring there is sufficient capacity to meet the future demand requirements from technologies such as EVs or to connect renewable generation.

In this changing landscape, innovation will be pivotal to our preparations for a low carbon future whilst helping us ensure that security of supply is delivered cost efficiently and that our service to customers continues to improve.

Our key objectives for innovation are:

- **To be future-ready** – a future-ready distribution business providing new services which meet the needs of tomorrow's customers
- **To be efficient and effective** – the best DNO group delivering value through innovation and the benchmark for best practice
- **To be low carbon-ready** – consistently credited as an active facilitator of the low carbon transition

We will achieve these objectives by:

- **Delivering good business value** – maximising the smart savings we deliver and ensuring we have a strong conversion rate for transitioning innovative solutions into business as usual
- **Delivering measurable social, environmental and safety benefits through our innovation projects** – including reduced customer interruptions, customer minutes lost and carbon emissions and improved safety performance

[8] https://www.theguardian.com/environment/2016/apr/13/solar-power-sets-new-british-record-by-beating-coal-for-a-day

- **Being recognised as a collaborative thought leader in innovation** – evidenced by the number of opportunities we have created for dissemination, the number of innovation projects delivered jointly with our peer DNOs, external recognition achieved and our industry working group involvement
- **Facilitating a low carbon system** – improving network access through reducing time and cost to connect low carbon load, generation, and storage technologies
- **Demonstrating expertise in identifying and delivering the right solutions**
- **Being the benchmark for innovation and best practice** – demonstrating trials on DSO capabilities to ensure safe, reliable and cost-effective networks

For more information please see our Innovation Strategy and section 3.2 of this report.

3.1.1 Engaging with our Stakeholders

At this time of unprecedented change in our industry – and in society generally – it is more important than ever that we listen, collaborate and share. Engagement is key as it provides us with valuable insights into the thinking, expectations and priorities of all our customers and stakeholders – ranging from end-user consumers through to suppliers, from regulators through to the media. For further information about our stakeholder engagement activities please see our 2016-17 Stakeholder Engagement and Consumer Vulnerability submission which is available here.

3.1.2 The Role of Networks in a Changing World

The nation's journey to a low carbon economy is revolutionising the way we produce, distribute and consume electricity. UK Power Networks has experienced these changes first-hand; we have seen how our customers, motivated by efficiencies, new technologies and government policies, can drive radical changes such as the sudden and widespread connection of renewable generation to our networks.

To support these changes and make the transition to a more flexible and agile energy system, we recognise that our traditional role must evolve. We will transform from a DNO which simply manages the network to a DSO which is proactive and enables a smart flexible system that responds to customers' needs.

Our focus to date has been on laying the foundations for a successful transition to a low carbon economy. Since 2010 we have invested heavily in innovation and our successful innovation projects are helping us to develop key capabilities across our business. To continue on this journey we have set our vision for the DSO and our view on the roadmap to achieve it. This will make a vital contribution towards ensuring that we continue to deliver a first-class service to our customers, both now and in the future.

3.1.3 The Low Carbon Challenge

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 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 2032:

- 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. 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 125gCO_2/km to 102gCO_2/km by 2020 and 86gCO_2/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 zero emission
- 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

At UK Power Networks we believe that we have an important role to play in facilitating achievement of these targets – for example, by ensuring there is sufficient capacity to meet future demand from technologies such as electric vehicles (EVs) or to connect renewable generation. The following sections describe the work we are undertaking to prepare our business for a low carbon future.

3.1.4 The Generation Challenge

The most significant challenge in recent years has been the growth in renewable generation, particularly solar. National Grid's data for 7 June 2017 showed that solar panels produced around 7.6GW of electricity, while wind farms generated 9.5GW of power. In addition the UK burnt 2GW of renewable biomass (made from waste wood) and produced a modest amount of hydroelectricity, resulting in Britain achieving a renewables peak record of 19.3GW.

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 have seen reduced growth rates over the past year in comparison to the period 2013-2016.

Over 8.5GW of generation connected to our network.

Currently we have over 8.5GW of generation connected to our network in our three regions – with solar generation being the largest contributor. Under our Low Carbon Network Fund (LCNF) Tier 2 project Flexible Plug and Play (FPP), we developed a flexible DG service – FDG – which connects power sources such as wind or solar to constrained areas of network, delivering cheaper and faster connections and enabling schemes that would have been financially unviable under a traditional connection approach to go ahead. As shown in our RIGs worksheet E6 – Innovative Solutions (please see the Annexes and Appendices), in RIIO-ED1 alone this service has saved our connection customers over £73m. It has been offered as a business-as- usual service, under the FDG banner, since 2015.

Our flexible DG service, FDG, has saved our connection customers over £73m in RIIO-ED1.

In the drive to further increase accessibility to our network, we are developing a 'timed connection' offering. This will provide customers with access to a more local connection point, by means of contractually agreeing an import or export capacity aligned to the time of day when the existing network can accommodate such a capacity requirement, as opposed to upstream reinforcement to accommodate the full capacity 24/7. This product will reduce the average cost to connect, in return for the customer managing time of usage in accordance with an agreed energy usage profile. For more information about our FPP service and our proposed timed connection offering please see section 3.3.

To facilitate the decarbonisation of heat targets and maintain our assets within a safe fault level operating range, we developed the innovation project Powerful-CB, which aims to demonstrate that fault-limiting circuit breakers (FLCBs) can enable us to connect more distributed generation (DG) to our 11kV distribution networks.

An FLCB is a solid-state circuit breaker that operates 20 times faster than traditional circuit breakers. This high-speed operation can mitigate fault level contributions from DG, allowing us to connect greater quantities of DG (particularly combined heat and power units) to fault-level constrained networks in dense urban areas. This will help accelerate the decarbonisation of heat, a key element of the government's Carbon Plan.

We are working with our technology partners, ABB and Applied Materials (AMAT), to develop two types of FLCB. ABB will develop an FLCB for use at a primary substation – known as Method 1. AMAT will develop an FLCB for use at a customer's premises – known as Method 2. We believe that Method 1 will be the world's first demonstration of an FLCB with a fast commutating switch and Method 2 will be GB's first demonstration of an FLCB – or any kind of Fault Level Mitigating Technology (other than an Is-limiter) – at a customer's premises.

3.1.5 The Electric Vehicle Challenge

We are starting to see an increase in electric vehicle (EV) sales. As at the end of March 2017, approximately 100,000 EVs had been sold in the UK. By 2030 we predict that 1.2-1.9 million EVs will have connected to our networks.

EVs are increasingly becoming a topic of debate – driven primarily by the need for improved air quality, a key ambition for the Mayor of London's administration. With targets from companies like Tesla and countries like China and India already driving down EV prices, manufacturers are improving the driving range on EVs such that it is now more akin to traditional vehicles, and this is likely to increase the appeal of EVs going forward.

Transport for London (TfL) specifically has set targets for EV taxis and buses. Under these targets, all taxis (black cabs and private hire vehicles) will be zero emission capable by 2033, with any new taxi vehicles required to be low emission capable from 2018. All single decker buses will be required to be zero emission by 2020 and from 2020 onwards an ultra-low emission zone (ULEZ) will encourage residents to start using EVs. To this end:

- The Office of Low Emission Vehicles (OLEV) will invest over £900m up to 2020 (including grants) – funding targeted at facilitating EV uptake
- Under the Go-Ultra Low City Scheme (GULCS), charging network operators (CNOs) have a keen interest in growing a network of fast and rapid EV charge points. Local authorities have ambitions to help 66 per cent of residents in London with no off-street parking to gain access to EV charging

At UK Power Networks we have taken the EV challenge seriously. In early 2017 we established a dedicated EV working group comprising staff from key departments across our business. The group has identified three categories of EV: Commercial Fleets, Public On-Street and Residential. These categories are presented in **Table 19**.

Table 19 – EV categories

Commercial – "at work"	**On-street "on route"**	**Residential "at home"**
Charge points for commercial EV fleet users at properties with existing connection	Charge points installed for use in on-street spaces requiring new points of connection	Private EV users with dedicated EV charge points at home
Stakeholders: fleet operators like UPS, retail car parks, work place charging, motorway service parks and bus garages	**Stakeholders:** local authorities and taxi companies	**Stakeholders:** single properties, housing developers and charge point installers

For each category we have formulated an 18-month rolling action plan to ready our business for the increased demand on electrical infrastructure and innovate smart solutions for our customers to achieve faster and more affordable connections. The plan is based on a foundation of market intelligence and prediction models in the uptake of EVs, which we monitor on a regular basis.

With the uptake of EVs exceeding most forecasts it is key that we engage with our stakeholders, and we have seen considerable interest from various parties involved in this developing market. During 2016-17 we were involved in a range of activities to help facilitate EV uptake. These included:

- Our ongoing work with OLEV on the Plugged in Car grant notification process
- The publication of smart charging infrastructure guidance for local authorities
- Our continued active participation in a range of TfL activities – for example, our work with the Ultra-Low Emission Vehicle working group and the LoCity programme
- Hosting connection working sessions with London bus operators and the TfL rapid charge point team to develop the energy requirements for the transportation electrification transition
- Holding connection-related "Ask the expert" surgeries with major fleet operators such as Hertz and the London Taxi Company (LTC)

3.1.6 The Heat Pump Challenge

We have seen a relatively small take-up of heat pumps in 2016-17; only 1,088 heat pumps were connected to our network during the year. National Grid notes in its 2017 Future Energy Scenarios that decarbonisation of heat is the area where the biggest change needs to occur in order to achieve the 2050 carbon target documented by the Committee on Climate Change. Policy change will be key in driving the necessary changes in this area.

3.1.7 The Electricity Storage Challenge

Interest in electricity storage is increasing in line with the need for greater system flexibility. Storage can bring customers a number of benefits, such as reducing the need to reinforce the network, balancing supply and demand, and storing renewable energy, such as solar, to use at night time.

Over the last 18 months, grid-scale storage has emerged as an area of major commercial interest for developers, manufacturers, construction partners, regulators and government. As at 11 July 2017 we had received 958 applications to connect battery storage for a total capacity of just over 17GW – see **Figure 6** and **Figure 7** below.

We have received 958 applications to connect battery storage for a total capacity of just over 17GW.

Figure 6 – Formal storage capacity

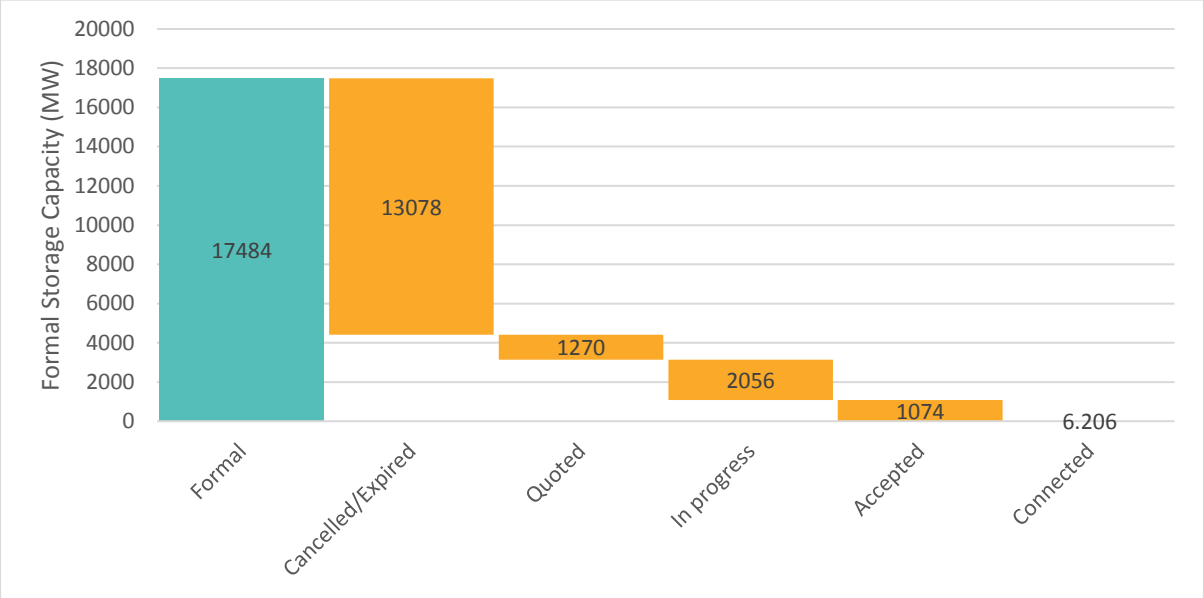
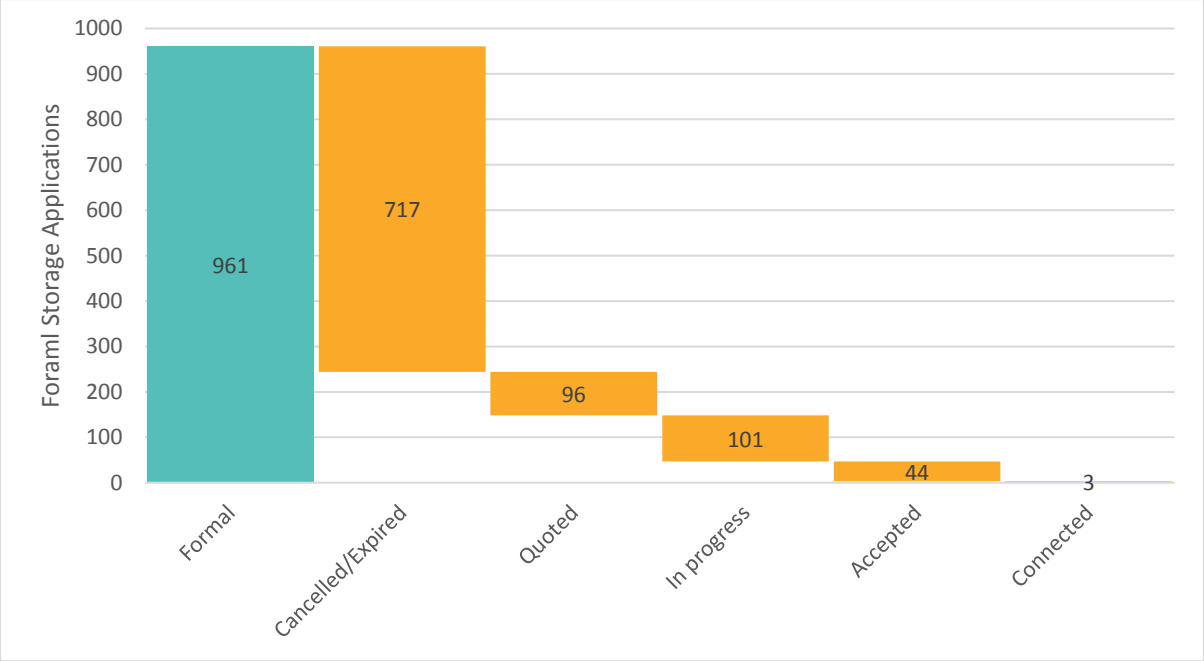


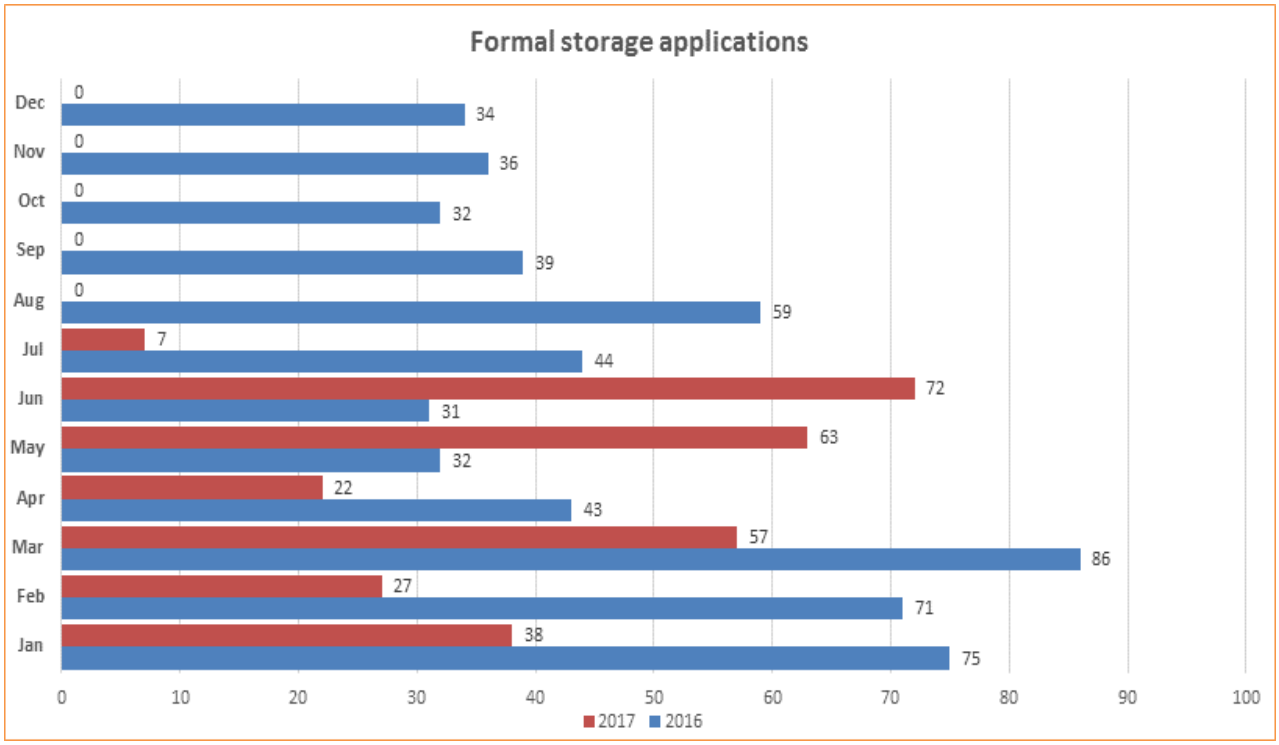
Figure 7 – Formal storage applications



The rate of acceptance versus application remains at a low level (4.6 per cent). This is mainly attributable to the pre-requirements of a competitive grid connection when bidding in the capacity market.

While the volumes of applications do not follow a set annual trend, they do track the market incentives. On balance, the overall volumes remain similar between the regulatory years, with different time profiles – see **Figure 8** below.

Figure 8 – Comparison of formal storage applications received in 2016 and 2017



3.1.8 Key Emerging Opportunities

3.1.8.1. Transition to a DSO

Our transition to a DSO has already begun. We have been developing our DSO capability since 2010, when we launched our Low Carbon London project. We have also delivered the largest and most successful portfolio of innovation projects across DNOs, investing £88m between 2010 and 2016, which has helped us to trial and demonstrate the foundation capabilities underpinning a DSO.

We have continued our focus on DSO capabilities in RIIO-ED1. Our RIIO-ED1 Business Plan included ambitious smart grid and innovation strategies, committing UK Power Networks to £111m of network reinforcement savings based on our innovation portfolio and around £30m of ongoing and continued savings from practices we are following which are already 'Smart'.[9]

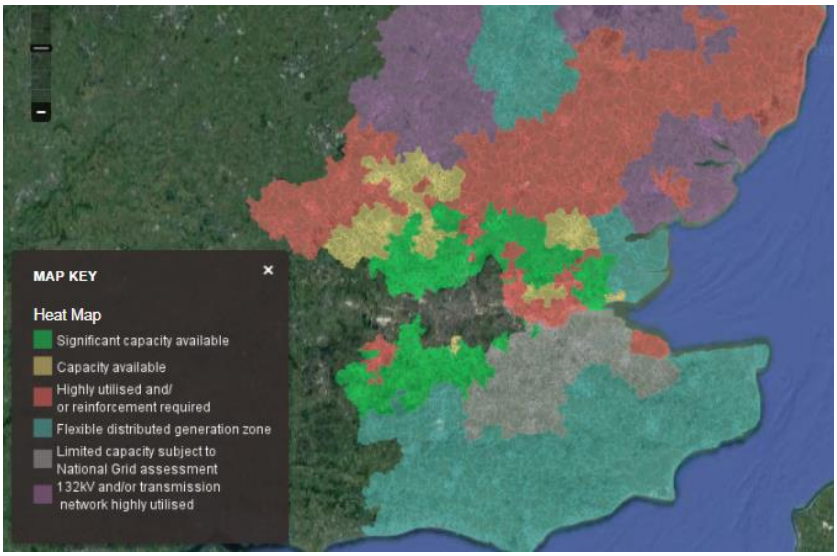
[9] https://library.ukpowernetworks.co.uk/library/en/RIIO/Main_Business_Plan_Documents_and_Annexes/UKPN_Smart_Grid_Strategy.pdf

We have already identified a number of activities that DNOs can undertake, or are undertaking, that will enable us to assume a more active DSO role in the future. These are described below.

- **New Customer Propositions for Faster and Cheaper Connections**

  Significant progress is already being made to reduce the cost and increase the speed of making new connections to the distribution network. The publishing of 'heat maps' is helping Distributed Energy Resources (DERs) to identify suitable connection locations, and flexible connections provide an alternative to the network reinforcement costs that developers can otherwise face. **Figure 9** presents a snapshot of our FDG heat map which shows where loading is available on the network and where there are possible constraints. Further detail on our FDG service is provided later in this section.

Figure 9 – A snapshot of our FDG heat map



Efforts are also being made to facilitate consortium connection applications to share reinforcement costs, and DNOs are working with the System Operator (SO) to ensure that transmission constraints do not delay new connections to the distribution network.

In transitioning to a DSO, these activities need to continue and be taken further. We have already begun to roll out active network management using the knowledge gained from our flagship innovation project Flexible Plug and Play (FPP), which was offered as a business-as-usual service, under the FDG banner, from 2015. This cutting-edge service connects power sources such as wind or solar to constrained areas of the network, delivering cheaper and faster connections, and makes previously commercially unviable schemes feasible.

In addition we are deploying Flexibility as a service for peak load shaving, as a new offering that demonstrates existing market services benefits as opposed to traditional built infrastructure services. The interaction between the SO and the DNO is already becoming more sophisticated under Regional Development Programmes and under innovation projects such as Power Potential. As the DNO transitions to a DSO, this interaction is expected to become increasingly important. Potential connectees are expected to be provided with 'generation indices' which indicate how well each network location is positioned to offer different types of constraint management services – giving them the information they need to build a robust business case and maximising the value of new connections to the system as a whole.

- **Keeping Costs down for General Customers through More Effective and Efficient Utilisation of Network Assets**

  Removing some of the hurdles associated with new connections is good for connecting customers and (indirectly) for consumer bills through reduced asset operating costs, but taking a more active and flexible approach to network management more generally can directly benefit a DNO's customers. Load-related expenditure is a substantial component of customers' Use of System charges. DNOs are already using demand side response, flexible generation and grid-scale batteries as an economical alternative to conventional expenditure.

  At UK Power Networks we are seeking to formalise the procurement of such flexibility through the use of tender rounds. In the future, with the increased use of the electricity network for transport and heating, it is expected that need for this flexibility will increase.

  As the DSO role develops it is expected that conventional reinforcement will be just one option among many. Flexibility could become the default option for managing the unpredictable demand patterns that we are likely to see in the future.

- **Bringing New (Smaller Scale) Sources of Flexibility to the Market to reduce System Balancing Costs**

  In Great Britain the market for balancing services is approximately £1bn per year – a figure which is expected to rise. Consumers pay this sum to keep the system in balance in real time and to manage network constraints. It is becoming increasingly clear that there are significant benefits in allowing DERs to offer these services:

  - A larger pool of potential providers means more competition and hence lower costs
  - As the energy system decarbonises, there is reduced availability of thermal 'spinning' reserves and we must consider alternative technologies to provide the same capabilities, to maintain fault current and, ultimately, stability of system frequency
  - Some flexibility providers (e.g. demand side response) may be a cheaper option than keeping generators in a state of readiness
  - Other flexibility providers typically connected to the distribution network (e.g. batteries) may have faster response times or other enhanced capabilities that make them valuable to the SO

  The DSO will need to ensure that such flexibility providers are able to connect to the distribution network on reasonable terms. UK Power Networks is developing market-based flexible connections that will allow DERs to connect to constrained parts of the network without the cost and delays associated with reinforcement. Such connections would be complemented by the operation of a local flexibility market that would effectively allow DERs to trade any curtailment obligations with neighbouring flexibility providers, so that any constraints could be managed at the lowest possible cost.

  On operational timescales, various models are being considered to allow DERs to provide system services:

  - **DSO as information provider**: conveying the state of the network to the SO, DERs or third party aggregators so that they know whether a service can be delivered as intended
  - **DSO as market facilitator**: providing a platform to support DER-DER flexibility trading behind a distribution constraint and providing the SO with access to that platform in order to tap into the balancing capabilities that those assets may have
  - **DSO as shared market platform participant**: DERs could offer their flexibility via a shared platform, with the SO, DSOs, aggregators and suppliers competing for that flexibility. Under this model, the DSO would be responsible for procuring the required flexibility to manage its local constraints

  One or more of these models may be applicable to a given licence area but in each of these cases the DSO would need to take an active role to ensure that constraints are managed and the whole system is balanced in a way that is efficient, fair and secure.

- **Enabling a Coordinated Approach to Investment and Balancing across the Transmission and Distribution Networks**

  The increasingly active relationship between the DSO, customers, distribution network connectees and the SO requires additional coordination between the SO and DSO to ensure a beneficial whole-system approach to managing the local and national electricity networks.

  The SO needs to balance the system on a second-by-second basis. A significant proportion of the DER is both unpredictable and invisible to the SO, making this balancing more difficult and more costly. Many of these DERs are themselves capable of providing balancing services, but doing so can conflict with the management of distribution constraints. As the distribution network itself becomes more heavily utilised and actively managed there is a need for a coordinated approach. This needs to ensure that constraints are not violated, that contracted services can be delivered, and that service participants and customers are treated fairly and equitably.

  Coordination is also required at the connection and planning stage. On some parts of the network the volume of DER is such that for parts of the year generation exceeds local demand, resulting in reverse flows onto the transmission network. If these reverse flows become sufficiently large they can lead to transmission constraints and, ultimately, the need to reinforce the transmission network.

  A reinforcement decision by the DNO can impose costs on the SO which if considered on a whole-system basis could have resulted in a different course of action. Similarly, the need for transmission reinforcement can in some cases be alleviated by using DERs or reconfiguring the distribution network itself. It may also be that transmission actions can be taken to resolve distribution constraints. As the DSO role evolves it will be important that this interface between the DSO and SO develops further.

  To fulfil these new roles will require new technology, skills and processes that can only be brought about by a significant advancement of a DNO's capabilities. To ensure we are prepared, we have developed a DSO Future Smart Strategy which is available here.

  Several major activities in this area include: our FDG programme, our Demand Side Response programme, and our Network Innovation Competition (NIC) projects Power Potential (to be delivered in collaboration with the SO) and Kent Active System Management (KASM). Further information can be found on our innovation website.

- **Our Flexibility Offering**

  As consumer demand for electricity grows, UK Power Networks would traditionally upgrade and reinforce network assets, such as installing new transformers. Demand growth is uncertain, and in some cases may not materialise, resulting in upgrades that could have been avoided.

  To manage this uncertainty, we will use flexibility from distributed energy resources to decide on the timing and sizing of our network upgrades. Customers will benefit where this results in no, or a deferral of, costly reinforcement works. The environmental impact of construction and disruption to customers and businesses is avoided or minimised.

  UK Power Networks intends to run a procurement event this year for flexibility contracts starting as early as winter 2017-18, with ongoing procurement thereafter.

3.1.9 Volumes of Low Carbon Technologies deployed in 2016-17

Table 20 details, by licensee, the volumes of each Low Carbon Technology deployed in 2016-17. Further information is provided in our RIGs worksheet E7 – LCTs (please see the Annexes and Appendices).

Table 20 – Volumes of Low Carbon Technologies deployed in 2016-17

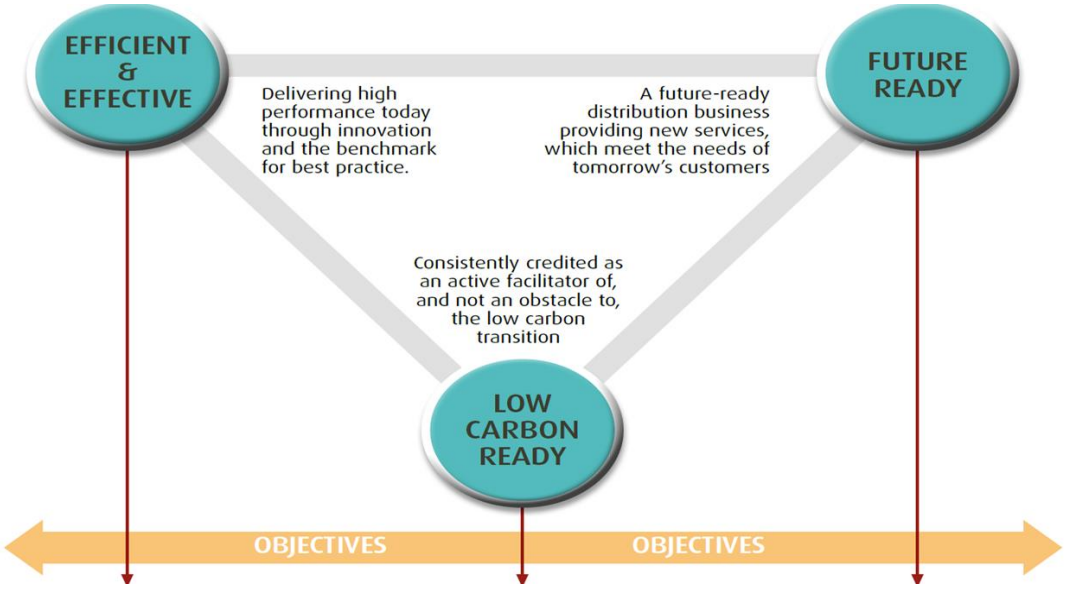
Technology type	EPN	LPN	SPN	Total
Heat pumps	836	17	235	1,088
EV slow charge	66	14	42	122
EV fast charge	466	104	296	866
PVs (G83)	1,964	300	977	3,241
Other DG (G83)	-	-	-	-
DG (non G83)	58	20	46	124
Total	3,390	455	1,596	5,441

3.2 Progress of the Innovation Strategy

In response to the rapidly changing environment in which we are working, we have committed to update and refresh our Innovation Strategy every two years. The current version was published early in 2017 and is available here.

The key change we have made since submitting our RIIO-ED1 Business Plan was to review the focus areas and realign them to the changing industry. These are illustrated in **Figure 10** below.

Figure 10 – Focus areas of our strategy



- **Deliver good business value** – by maximising the smart savings delivered for customers
- **Deliver measurable social, environmental and safety benefits through our innovation projects – including CI, CML, carbon emissions and safety performance**
- **Facilitate a low carbon system** – by improving network access through reducing time and cost to connect low carbon load, generation, and storage technologies
- **Be recognised as a collaborative thought leader in innovation**
- **Demonstrate expertise in identifying and delivering the right solution**
- **Be the benchmark for innovation and best practice** – by leading trials on DSO capabilities

Of the 33 ongoing innovation projects, 26 have been funded under the NIA, four have been funded as Tier Two projects under the NIC and three have received other funding.

Our 2016-17 NIA Annual Summary can be found here. This lists all ongoing NIA funded projects, detailing how they align to our innovation themes and hence our overall strategy. Further information about UK Power Networks' expenditure under the NIA can be found on our website or on the Smart Energy Portal.

Our LCNF Tier Two and NIC projects are larger, covering multiple innovation themes. **Table 21** provides further information about each of these projects, including the licensee conducting the trials, the planned year of completion and 2016-17 expenditure.

Table 21 – Summary of UK Power Networks' LCNF Tier 2 and NIC projects

Project	Licence area where trialled	Start date	Planned end date	Total budget	2016-17 expenditure
SNS	EPN	January 2013	December 2016	£17,525,395	£800,208
FUN-LV	LPN and SPN	January 2014	December 2016	£8,349,197	£517,185
energywise	LPN	January 2014	August 2018	£4,246,417	£761,702
KASM	SPN	January 2015	December 2017	£3,852,501	£725,147
Powerful CB	LPN	January 2017	April 2020	£5,301,041	£25,957.63
TDI 2.0	SPN	January 2017	December 2019	NG led	NG led

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 have successfully deployed 19 Innovative Solutions since the start of RIIO-ED1 – 11 in 2015-16 and 8 in 2016-17. These solutions were reported to Ofgem in our 2016-17 RIGs submission and the 2016-17 solutions are also presented in this report. Further information is provided in our RIGs worksheet E6 – Innovative Solutions (please see the Annexes and Appendices).

The Innovative Solutions are at various stages of roll-out. Throughout their life cycle they undergo a process of assessment, development and monitoring through to a completed roll-out to business as usual. This process comprises the following activities:

- Capture, assessment and development of innovative ideas through to innovation mandates:
    - This includes the capture of internal and external innovation activities (including innovation projects delivered by other 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 NIC funding to ensure we are fully informed of ideas that will help benefit our customers
- Readiness and benefits performance assessment:
    - This includes the development of a detailed 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 (Innovative Solutions) 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
    - This tracking is conducted on three occasions during the regulatory year to ensure the solution is delivering benefits aligned to the closeout CBA forecast and any drift is secured and corrected where required

3.3.2 Our 2016-17 Innovative Solutions

The following pages provide an overview of each of the 19 Innovative Solutions delivered within one or more of UK Power Networks' regions during the 2016-17 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
- Links to the detailed CBA assessing the solution performance

3.3.2.1. Power Transformer Real Time Thermal Rating (benefit: increases network capacity/optimises utilisation)

Dynamic Transformer Rating (DTR) allows additional capacity to be made available from existing assets, deferring reinforcement by three years or more. It is estimated that transformers can be loaded up to 20 per cent above the static seasonal rating.

Changes in environmental conditions have a dramatic effect on transformer loading. In urban areas, due to a rise in air conditioning installations, existing summer or winter firm ratings may not be fully representative of the situation at particular sites. This seasonal increase in loading could lead to premature network reinforcement decisions.

Benefits from DTR are achieved by retrofitting a Transformer Management System (TMS) onto existing assets to provide real-time monitoring of the transformer's health and continuously calculating the transformer thermal capacity, thereby safely loading the transformer close to the maximum top oil temperature less 2° Celsius allowed by design nameplate.

An increase in capacity is achieved through:

- Installing an active TMS, monitoring ambient and top/bottom oil temperatures
- Installing additional fans, modifying cooling set-points and enabling pre-cooling
- Initiating pre-cooling in the event of loss of one transformer (N-1 scenario)
- Using the TMS to continually ensure design limits are not exceeded and calculating the impact on degradation

Greater understanding and visibility of asset performance leads to a reduction in asset replacement, facilitating the connection of additional loads and low carbon technologies.

More information about this Innovative Solution can be found here. A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.2. LPN Interconnection (benefit: increases network capacity/optimises utilisation)

This solution is the advanced design philosophy for interconnected 11kV feeder groups in the LPN network. It includes a relatively high number of feeders per feeder group to support higher utilisation while maintaining N-1 resilience such 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 arrangement allows for these higher circuit utilisation levels since 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 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 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.3. Energy Storage (benefit: increases network capacity/optimises utilisation)

This solution involves the deployment of utility-scale batteries for providing ancillary services (i.e. load following) as well as peak loping to reduce distribution reinforcement need. The implementation of this solution is being considered under two mechanisms: (1) enrolment of a third party storage device in a DSR program and (2) deployment of a UK Power Networks owned device onto the distribution system. Batteries used for bulk storage (i.e. load shifting) are separate from this solution and should instead be included in the DSR solution line item.

This solution is regarded as an Innovative Solution for providing network capacity whilst 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 project are provided here. A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.4. FUN-LV (benefit: increases network capacity/optimises utilisation)

The Flexible Urban Networks – Low Voltage (FUN-LV) project was funded under Tier 2 of the LCNF. Its overarching aim was to explore the use of power electronics to enable the deferment of reinforcement and facilitate the connection of low carbon technologies and distributed generation in urban areas. This was achieved by meshing previously unmeshed networks and by breaking down boundaries within existing meshed networks.

The FUN-LV project trials demonstrated three different methods with increasing levels of capacity sharing functionality. Method 1 (M1) used remote control circuit breakers and link box switches developed by TE Connectivity and supplied under licence by EA Technology Ltd. The link box switch replaces a solid link in the link box and the equipment joins substations together, providing uncontrolled levels of current flow.

This equipment was already approved for use on the LV network. However, joining two radial circuits required an additional tripping unit to monitor reverse power flow through the transformer and send a trip signal to the circuit breakers in the event of an HV or transformer fault, to prevent continued fault current flow from the donor circuit.

Method 2 (M2) and Method 3 (M3) consisted of two or three back-to-back power inverters respectively, with a common DC busbar. The inverters were controlled by an autonomous control system (developed by our project partner, Imperial College London) which took measurements from various points in the system and calculated the level of power flow required across the DC busbar. Each inverter was able to import or export real and reactive power between different AC LV networks and the DC busbar, depending on how the inverter was switched. M1 and M3 are installed within distribution substations, whereas M2 is installed as a piece of street furniture.

External documents describing the solution are held on the project innovation site. The methodology is outlined in the Close Down, SDRC 9.2 and SDRC 9.4 reports.

A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.5. Demand Side Response (DSR) (benefit: increases network capacity/optimises utilisation)

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. A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.6. Common Network Asset Indices Methodology (CNAIM) (benefit: improves asset management lifecycle management)

The Common Network Asset Indices Methodology (CNAIM) was introduced in RIIO-ED1 and requires DNOs to report information relating to asset health and criticality. This requirement provides the capability to 'trade off' the financial and technical consequences of future decisions to replace assets, refurbish assets or introduce an enhanced maintenance regime.

UK Power Networks actively manages a pool of health indices 4 and 5 assets which are closer to service failure than may be the case for other DNOs with different asset replacement methodologies where assets could potentially be retired too early.

The CNAIM models are another example of modelling innovation. These models use a combination of information relating to an asset's age, environment, duty and specific condition and performance information to calculate network risk. This can inform investment decisions as to when an asset requires intervention (replacement, refurbishment, retrofit or other appropriate action) and how to prioritise the order of such interventions to ensure value for money.

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 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.7. Joint Shell (benefit: improves asset management lifecycle management)

LV lead cable 'T' joints that are identified during cable pit inspections as being in poor health and at risk of weakening due to water ingress will have a new shell applied together with associated earthing improvements. The shell is filled with resin, which gives the joints an extra layer of protection and reduces the probability of failure.

The extra layer of mechanical shell protection on joints will prevent any water ingress from potentially triggering a failure. Using this solution will extend the life of a joint, as previously the only option available was to undertake a replacement of the joint asset. This innovative approach will allow us to defer our asset replacement investment policy and reduce customer interruptions and customer minutes lost caused by joint failures.

In 2016-17 we installed 108 units on our network. As we continue with cable pit inspections and other maintenance and inspection activities on our underground cable assets, any poor condition LV lead 'T' joint identified will have the new joint shell installed to avoid failure due to water ingress.

The estimated cost savings per joint are shown below:

- £2.8k per joint – reflecting the reduced opex cost of fault repair over proactive planned repair
- £1.5k per joint – reflecting customer interruptions and customer minutes avoided (i.e. those that could have occurred due to joint failure)

A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.8. Oil Regeneration (benefit: improves asset management lifecycle management)

This solution extends the working life of a transformer by 'regenerating' the oil it contains. 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 to remove acidity and sludge from the transformer oil and moisture from the winding papers. It also helps to remove sludge deposits in the transformer and cooler. By restoring transformer oil to its original condition, oil regeneration can extend the serviceable life of a transformer by 16 years.

This solution is considered across the industry as an innovative way to cost-effectively extend 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 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.9. LV Re-energising Devices (benefit: improves network performance)

During 2016-17 two different types of LV re-energising device were operated on the network:

- The Bidoyng
- The ALVIN Reclose

The Bidoyng uses two fuses – primary and secondary – in parallel as a single shot auto recloser. 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 customers will remain off supply until we manually fix the fault.

The ALVIN Reclose is a solid state low voltage (LV) circuit breaker. When a fault occurs the circuit breaker will operate and open. The ALVIN Reclose will then test the power cable (using modulated power pulses) for the presence of a sustained fault before attempting to energise the circuit again. If the fault has been cleared (i.e. it was intermittent rather than sustained), the ALVIN Reclose will automatically reclose, restoring supply to customers.

Both of these LV re-energising devices are used at secondary substations in all three of our regions in order to reduce CIs and CMLs. They are both installed on LV boards, directly replacing fuses.

1,108 LV re-energising devices were deployed in 2016-17 and now operate on UK Power Networks' distribution network. Thirty four of these are ALVIN Reclose devices and the rest are Bidoyngs.

Further details of this Innovative Solution are provided here and are held on the shared industry Smarter Networks Portal. A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

- Further information about the Bidoyng is available here and here
- Further information about the ALVIN Reclose is available here

3.3.2.10. Automated Power Restoration System (benefit: improves network performance)

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 the network. 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 considered as an Innovative Solution for the deployment of APRS as it delivers advanced smart grid functionality previously not available to UK Power Networks. A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.11. Public Safety (benefit: improves safety)

This Innovative Solution targets safety efforts in the EPN and SPN agricultural areas to prevent injuries to members of the public through coming into contact with live overhead equipment. It is delivering benefits through detailed knowledge sharing at strategic venues and ultimately by reducing the number of incidents where the public come into contact with our assets.

We believe that the efforts of the dedicated team for public safety will lead to a reduction of one fatality over the duration of RIIO-ED1. This is a conservative estimate based on the large audience reached with our public safety campaign. We also assume that this will lead to a reduction of 5.67 injuries to members of the public over the duration of RIIO-ED1. This preserves the current ratio of public safety injuries to fatalities.

A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.12. LiDAR Vegetation Management (benefit: improves vegetation management)

LiDAR Vegetation Management was originally trialled by Scottish Power Energy Networks as part of an NIA innovation project. It uses helicopters or light aircraft equipped with LiDAR (aerial laser imaging/surveying) to identify critical clearances, danger and hazard vegetation and abnormal line states along the right of way of the distribution system. This provides improved visibility of the relative risks posed by vegetation growth on overhead line routes and so enables more targeted vegetation cutting.

This solution will enable us to target and minimise tree-related faults more effectively. It also helps to reduce the amount of cutting required to achieve at least equivalent levels of fault prevention.

Further details of this Innovative Solution are provided here and are also held on the shared industry Smarter Networks Portal. A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.13. Flexible DG (FDG) (benefit: improving connection performance)

This solution was initially implemented through our LCNF Tier 2 funded project Flexible Plug and Play (FPP) and has since been deployed as the business-as-usual service Flexible DG (FDG).

It is a technical and commercial arrangement whereby customers' DG devices are subject to temporary UK Power Networks control to reduce power export, to ensure network voltages, currents and power flows are maintained within operational limits. This solution is used whenever the network experiences constraints to accommodate the connection under abnormal running conditions.

FDG is operated by an Active Network Management (ANM) solution and is available on a 'Last-In First-Out' (LIFO) principle whereby each generator is assigned a position within a global priority stack. When new generators apply for a connection in the area they are given a position at the bottom of the priority stack and are curtailed first during a constraint event.

The solution is being used to connect DG customers to the grid at a lower connection cost which allows for these customers to be curtailed at times of network stress. Without FDG these customers would only have had the option of more traditional connection costs that include the cost of reinforcement projects required to connect the customer to the network. The FDG offering also has a shorter lead time and allows DG customers to connect to the network faster.

Further details of this innovation project are provided here. A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.14. Load Blinding Relays (benefit: improving connection performance)

This solution uses protection relays with 'load blinding' functionality to manage constraints and maximise network utilisation by connecting more DG. Load blinding relays allow 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 a fault on the 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 a relatively simple tried and tested philosophy for the protection settings.

This solution is considered as an Innovative Solution as it was developed through UK Power Networks' LCNF Tier 2 funded project Flexible Plug and Play (FPP). Further details of this project are provided here. A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.15. Distribution Network Visibility (DNV) application (benefit: improving connection performance)

DNV is a web-based application that allows multiple data sources (including SAP, PowerOn Fusion, analogue outputs from secondary and primary RTUs and weather stations) to be integrated and made available to users via a simple visual interface.

This application has been offered as a business-as-usual service since late 2012/early 2013. It is primarily used to inform network planning decisions and proactively manage UK Power Networks' distribution network. DNV has delivered several benefits to date; it is used by our distribution planners to assess connection requests, saving them approximately eight hours per week. More information on this Innovative Solution is available here.

3.3.2.16. Point of Connection (PoC) Mast and Underslung Air Brake Switch Disconnector (ABSD) (benefit: improving connection performance)

The POC mast and underslung ABSD mast are both new methodologies that can be used for customer cable connections at 33kV suspension towers where other traditional solutions are not technically possible. These Innovative Solutions provide a cost-effective alternative for customers wishing to connect to the network and avoid the expensive and complicated option of complete tower replacement. Both consist of steel poles located to the side or underneath the tower that is being connected to and have jumpers connected to the tower circuit. An ABSD and cable termination are located on the steel pole and signal the point of connection for the customer.

The POC mast design includes a hinge at the base so that work can be carried out at ground level before the mast is erected. This allows outage work to be kept to a minimum, as the only work required is the connection of the jumpers between the mast and the tower.

The POC mast and underslung ABSD mast complement the suite of solutions available to UK Power Networks for making connections to tower lines. Although they may not be used as the first option for all connections, they offer a lower-cost alternative in cases where an expensive tower replacement would otherwise be required.

A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.17. Timed Connections (benefit: improving connection performance)

This solution is currently under development and is NIA registered and funded. It is a profiled 'timed connection' arrangement offering customers time-dependent connections which allow a higher MVA level to be taken in periods of reduced network demand. It has been trialled at Europe's largest electric bus garage at Waterloo in London. The garage's electric buses are charged at night, when demand is otherwise low, so they can run through the day when they are needed. This has delivered a smart solution as opposed to the traditional reinforcement option. The project will now develop the tools further in a real-life scenario, with the electrification of the UPS fleet in London. Error! Reference source not found. shows one of the electric vehicles in the UPS fleet.

Figure 11 – A UPS electric vehicle

A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.18. Innovation Bunding (benefit: improves environmental impact)

This Innovative Solution uses polymer-based bunding equipment (Omnibund or Bundsep), which replaces the traditional concrete and sump pump systems. It bunds large transformers more cost-effectively and causes fewer CO_2 emissions during construction than the base case. These have been assessed and are included in our RIGs worksheet E6 – Innovative Solutions (please see the Annexes and Appendices).

We estimate that for every 1,000kg of excavation avoided by this solution we will be able to save 2kg of CO_2e. The estimated CO_2e savings have been calculated using Defra guidelines.

It has been conservatively estimated that the excavation depth required with a traditional concrete bund is 50 cm: with this solution no digging is required.

The cost of avoiding an outage for a transformer at every site where the Omnibund or Bundsep was installed has been estimated as follows:

- The cost of a senior authorised person per day
- The cost of a planner to arrange the outage and the average time to complete an outage (0.5 hours for a primary site and 2 hours for a grid site)

A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.2.19. Perfluorocarbon tracer (PFT) fluid-filled cable leak tracer (benefit: improving environmental impact)

Leaks from fluid-filled cables (FFCs) can be difficult and costly to locate. This Innovative Solution uses a PFT fluid-filled cable leak location method which allows cable leaks to be found quicker and at a lower cost than other methodologies. This technique introduces a small amount of PFT into cable fluid, which is detectable by a mobile unit. PFTs are made from a non-toxic, non-flammable, non-corrosive, chemically stable material which has been proven to cause no environmental or health issues. In addition it has been demonstrated that PFTs do not lead to degradation or premature ageing of our assets.

A link to the detailed CBA for 2016-17 solution performance can be found in the Annexes and Appendices.

3.3.3 Our customer connections focused solutions

Table 22 overleaf summarises the quantified performance of these solutions in 2016-17, including the connection cost reductions of approximately £6.8m that we have delivered to our customers through our innovative FDG and Point of Connection Mast 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 22 – Summary of 2016-17 Innovative Solutions

	Solution	Financial impact (net £m, 2016-17)	Ofgem output category	Additional benefits	2016-17 volumes deployed	Indicative 2017-18 forecast volume range
Increase Network Capacity/ Optimise Utilisation						
1	Power Transformer Real Time Thermal Rating	4.0	Reliability & Availability	-	0MVA	4- 10 transformers
2	LPN Interconnection	0.5	Reliability & Availability		18 projects	10- 20 projects
3	Energy Storage	2.2	Reliability & Availability	-	0MVA released	0 substations
4	FUN-LV	0.3	Reliability & Availability	2.05 MVA released	13 sites	13 sites
5	Demand Side Response	0.5	Reliability & Availability	-	0 MVA released	0-2 substations
Improve Asset Life Cycle Management						
6	CNAIM Modelling	17.5	Reliability & Availability		52 assets modelled	50 assets modelled
7	Joint Shell	0.3	Reliability & Availability		108 deployments	100 deployments
8	Oil Regeneration	0	Reliability & Availability		0 sites	0 sites
Improve Network Performance						
9	LV Re-energising Devices	-0.1	Reliability & Availability	-0.8 CI -1.5 CML	1,108 devices	100 devices
10	Automated Power Restoration System	-0.1	Reliability & Availability	-16.0 CI -0.6 CML	6,733 schemes	1,500 schemes
Improve Safety						
11	Public Safety	-0.2	Reliability & Availability		Impact on serious injury and fatality	Continue 2016 level
Improve Vegetation Management						
12	LIDAR Vegetation Management	1.6	Reliability & Availability		32,579km	15,000
Improve Connection Performance						
13	Flexible DG (FDG)	6.4	Connections		2 customers connected	2-8 customers connected
14	Load Blinding Relays	0	Connections		0 schemes deployed	0-2 schemes deployed
15	Distribution Network Visibility (DNV) Application	0.016	Connections		0 volumes	0 volumes
16	Point of Connection (POC) Mast	0.5	Connections		2 customers connected	0-2 customers connected
17	Timed Connections	0	Connections		1 offer made	2-8 offers made
Improve Environmental Impact						
18	Innovation Bunding	0.012	Reliability & Availability		1 site deployed	2-8 sites deployed
19	Perfluorocarbon tracer (PFT) fluid-filled cable leak location	1.0	Reliability & Availability		55 interventions	50 interventions
	Total	34.4				

3.3.4 Innovative Solutions in 2017-18

Across our portfolio of Innovative Solutions, looking ahead to 2017-18 we would expect that:

- Our Innovative Solutions for improving quality of supply (i.e. APRS and Bidoyngs) will see expanded deployment 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 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 have been smaller in 2016-17 than in 2015-16)
- Overall benefits delivered to customers, through reduced connection times and costs, 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) will continue to deliver benefits at a similar level
- The 19 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 2017-18

3.4 Smart Metering

3.4.1 Our strategy for maximising the net benefits of smart metering

Smart meters are the next generation of power meters that are being installed by energy suppliers in every home in Great Britain. Smart meters come with an in-home display screen that shows in almost real time exactly how much is being spent on energy. They will bring an end to estimated bills.

Our RIIO-ED1 Business Plan outlined the areas in which we will realise benefits from smart metering data. These are:

- Improved real-time data – fault management and customer service enhancements: Providing real-time data on faults via the 'last gasp' facility and remotely testing the meter energisation status can significantly improve fault management performance and customer service. It will be possible to identify and target faults more quickly and to provide the customer with significantly enhanced information and a faster response
- Improved asset and performance data – network condition and planning: Providing detailed usage information from meters across the network can significantly improve network planning. It will provide for better targeting of LV refurbishment and should avoid additional development – supporting some new connections and helping to 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

Since submitting our plan we have continued to explore and evaluate smart metering benefits and the best way to realise them within the context of Great Britain's smart meter roll-out. To inform our planning, we have consulted with colleagues across the Cheung Kong Group (CKG) with experience of smart meter roll-outs in other countries. We have also used our membership of the International Utilities Working Group to discuss the topic with major utilities outside the UK.

This approach has enabled us to develop a Smart Meter Benefits Realisation Strategy that has been approved by our Smart Meter Steering Group, which includes four members of our Executive Management Team and is sponsored by our CEO. It has also been reviewed and discussed with the Department for Business, Energy & Industrial Strategy (BEIS).

Our strategy is guided by three principles, which reflect our ambition to fully embed smart metering data into our business as an enabler of our wider RIIO-ED1 and RIIO-ED2 business plans. These are:

- We will continually take the learnings from other roll-outs to accelerate our ability to realise benefits
- We will ensure that we have the right levels of ownership and accountability across our business for realising smart metering benefits, and develop expertise and insight into our smart metering data from the earliest opportunity
- We will ensure that our investment in realising the benefits of smart metering aligns with our plans to transition to a DSO

Realising our strategy will require us to continually engage with our customers in order to gauge their needs, understanding and interest in smart metering. During the 2017-18 regulatory year we will finalise our stakeholder engagement plan for smart meters, including focused sessions on smart metering-related topics and the incorporation of smart metering into our wider engagement activities, so that our stakeholders are given an appropriate context of how smart metering enables our business plan.

To realise the benefits from smart metering, we also recognise that we must continually learn from the data that is provided from SMETS2 meters. Accordingly, we have agreed the scope, roles and responsibilities of a new business function: our Smart Operations team. This team will be the owner of the DCC adaptor that will allow us to connect to the Data Communications Company (DCC) infrastructure and will also be the key point of contact with DCC and other relevant industry players. Most importantly, our Smart Operations team manager will have responsibility for delivering our benefits realisation plan.

From our discussions and research into other smart meter roll-outs, it is clear that deriving benefits from smart metering data requires a mature business capability with expertise in the structure, quality and content of the smart metering data and also our analytics and Advanced Metering Infrastructure solutions. Our Smart Operations team is in place and will combine data expertise, technology capability and business knowledge. A key part of the team's role is to develop sufficient understanding and insight into smart metering data, so that they can coach other business functions on how best to embed smart metering data into their day-to-day activities.

3.4.2 Smart meter installations in our operating area

Table 23 shows the volumes of cumulative meter installations in our three regions during the 2016-17 regulatory year. The in-year installation volumes are broadly equivalent to the previous year. There were no SMETS2 installations during the 2016-17 regulatory year.

Table 23 – Smart meter installations

Licensee	2015-16 smart meter volumes	2016-17 smart meter volumes	Cumulative smart meter volumes	Percentage penetration of smart meters
EPN	117,821	209,735	327,556	9%
LPN	63,847	114,708	178,555	8%
SPN	80,252	167,932	248,184	11%
Total	261,920	492,375	754,295	9%

We expect to see some uplift in the rate of installations during 2017-18, with a greater upturn in installation rates in 2018-19. This forecast is based on planned roll-out data shared by energy suppliers and has been used to inform the timing of investment to utilise smart metering data.

3.4.3 Current state of IT and communications investments

As of April 2017 we have completed the design and begun the final industry test phase (known as User Entry Process Testing or UEPT) of our DCC adaptor; this provides a landing point for smart metering data within our business. In the same period we began the final stages of realising a strong security framework around our smart metering systems (in accordance with the Smart Energy Code security obligations). This has been demonstrated by the excellent outcome from the Smart Energy Code Administrator's Security Audit, in which UK Power Networks had arguably the fewest observations in the industry. To minimise the risk to implementation, we have worked closely with Northern Power Grid and Scottish Power Energy

We have completed the design and begun the final industry test phase (UEPT) of our DCC adaptor.

Networks who share the same vendor of DCC adaptor. Through this forum we have been able to coordinate queries with DCC and also leverage each other's challenges and successes.

Based on the expected timelines for future releases shared by DCC, we are on track to receive the data of any enrolled SMETS2 meters by Q3 2017-18. Before then we will have completed our Competent Independent Organisation (CIO) audit and addressed any remediation activities and feedback.

We have recently undertaken a significant Business Transformation Programme which has delivered improved technology capabilities that enable better provision and coordination of data between our key applications. In delivering this programme we have improved our ability to share the scope of customers impacted by network faults and planned network outages between our business functions. The design of these changes factored in the requirements for smart metering and will enable us to share outage alerts with our control room engineers, dispatch coordinators and customer call agents without significant rework or IT development.

Whilst we are committed to delivering the required changes to our IT infrastructure to realise smart metering benefits early on, we have also aligned the timelines of our change initiatives to the smart meter roll-out plans. In doing so we avoid the risk of stranded investment due to changing requirements or programme delays outside our control. To ensure the design and solution options for future IT investments are well informed and balance cost and future optionality, we have engaged with our existing technology providers and technology service suppliers to understand their views on solution design options and outline costs. This information will be used throughout the 2017-18 regulatory year, as we ramp up our delivery of smart metering-related change.

3.4.4 Actions taken in 2016-17 to maximise the value of smart metering data

We continue to support the supplier-led roll-out of smart meters by addressing any required interventions identified with our network termination equipment that prevent a smart meter from being installed; we achieved full compliance in all five of the industry defined Smart Meter Intervention performance SLAs. Our dedicated Smart Operations team is focused on coordinating our engineers to support energy suppliers' installations. Within this team we have begun to establish a continuous improvement capability that will help to realise further outperformance of the industry defined metrics. Most importantly, it will provide an enhanced installation experience for our customers and for the energy suppliers who require our support at the point of meter installation.

To ensure we provide the service our customers expect, we have continued our quarterly supplier surveys that were introduced in 2016 with detailed telephone and online surveys. The detailed surveys cover eight principal categories to help us shape and monitor our performance and after two surveys we have achieved an average score of 7.35 out of 10.

We have continued to work with the Energy Networks Association (ENA), BEIS, Ofgem, the Information Commissioner's Office and Citizens Advice to develop a common Data Privacy Framework for DNOs. In parallel the ENA has commissioned surveys by Ipsos MORI to better understand the concerns of consumers. Our stance on personal data from smart meters is that such data will not be retrieved or accessed by us until we have completed our Privacy Impact Assessment and have implemented appropriate privacy controls.

3.4.5 Benefits realised to date

As the communications infrastructure and provision of data services via DCC have not yet gone live with R1.2 (which enables the relevant functionality required by DNOs), we have realised no benefits from smart metering so far. This is reflected in our RIGs worksheet E5 – Smart Metering (please see the Annexes and Appendices).

As energy suppliers increase their installation rates we believe that while SMETS2 meter numbers will increase in 2017-18, the relatively low volume will provide a valuable incubation period to develop an understanding of the realities of SMETS2 data and the functionality and performance of DCC and wider smart metering infrastructure. During this time we would expect to be able to use smart meter alert notifications within our contact centre should a SMETS2 customer experience a fault. We would also utilise the service request functionality of each SMETS2 meter to analyse the four quadrant (real, reactive, import and export registers) and voltage information that can be obtained. This will be used to further tailor our thinking as to how our management of losses and investment planning cycles best utilise smart metering data.

3.4.6 Our plans for realising smart metering benefits in 2017-18 and in future years

During 2017-18 we will mobilise a number of projects that will enable smart meter outage data to be accessible and visible to our customer service and operational staff. We aim to have new functionality operational during the first half of 2018; this is in line with our Smart Metering Benefits Roadmap which describes the technology and business changes required to realise our smart meter strategy and also aligns with the SMETS2 roll-out plans released by energy suppliers The integration of our CRM solution with our DCC adaptor will also require a number of changes in our business processes; for example, our contact centre will need to deliver training to our contact agents that informs them on how smart metering customer journeys vary from traditional meters. These changes to our processes will be timed to complement the volume of SMETS2 meters within our three regions. The scope of change required is under final review with our Head of Customer Service and will be finalised during the early part of 2017-18.

We are also working with our customer service staff to ensure that the opportunities we have identified for the use of smart metering data are embedded into our digital investment plan. Our digital strategy is guiding our investment in developing our social media capabilities as well as our website, contact centre automation and Interactive Voice Response (IVR) capabilities. By ensuring that smart meters are part of our thinking in these areas, our customers will be able to realise the benefits of smart metering data, even if they are not directly aware of it. Examples of the changes planned during 2017-18 include: greater granularity of information on outage start and stop times within our online fault maps, the ability to confirm smart meters as SMETS1 or SMETS2 specification, and a review of how best to use smart metering data to support the customers on our Priority Services Register.

Our Smart Metering Benefits Roadmap spans the period 2017-2022. Specifically for 2017-18, it details a number of key investments that enable benefits to be realised from smart metering data once SMETS2 meters are installed in sizeable numbers. Over this period our focus will be on establishing our Smart Operations team as the business owners of our DCC adaptor and delivering the technology changes that will enable outage notifications to be utilised by our dispatch staff and customer contact agents. We will also ensure that smart metering data is made available to our reporting teams and that we have suitable tools and processes in place that utilise smart metering data to report on the duration of customer interruptions and network outages.

As we begin a refresh of our Network Modelling toolset we will support the testing phase of this programme with smart metering data. Our network modelling programme is scheduled for delivery in 2018-19, however we have identified an opportunity to explore how best to utilise smart metering data in the 2017-18 regulatory year.

The above examples highlight our immediate goals for the regulatory year 2017-18 – after which we will have established the capability to share smart metering data across our IT infrastructure, enhanced our regulatory reporting outputs based on smart metering data, and enabled smart metering specific customer journeys to be delivered through our customer contact centre.

While our realisation of smart metering benefits is dependent on the wider roll-out of SMETS2-compliant meters and establishing access to smart meter data, we have continued to support the industry roll-out of smart meters and are preparing our systems to receive their data. This expenditure, including our IT expenditure, is presented in **Table 24** for the 2016-17 regulatory year.

Table 24 – Summary of 2016-17 smart metering-related expenditure in £m

Source	Category	EPN	LPN	SPN	Total
C22/E5	Smart Meter Communication Licensee Costs	1.96	1.26	1.24	4.46
C22/E5	Smart Meter Information Technology Costs	1.13	0.80	0.81	2.74
CV34	Smart Meter Interventions - On-site/Physical Activities (including prior year restatement)	4.17	1.11	1.38	6.66
CV34	Smart Meter Interventions - Extra scheduling & call centre	0.02	0.01	0.01	0.04
CV34	Smart Meter Interventions - Smart Meter registration	-	-	-	-

4 Annexes and Appendices

4.1 EPN

Environment and Innovation pack - tabs E1-E8

4.2 LPN

Environment and Innovation pack - tabs E1-E8

4.3 SPN

Environment and Innovation pack - tabs E1-E8

4.4 UK Power Networks

Environment and Innovation Commentary
E4 Losses CBA GMT 315-500
E4 Losses CBA GMT 800-1000
E4 Losses CBA GMT generic
E4 Losses CBA LV cable 95-185mm
E4 Losses CBA LV cable 185-300mm
E4 Losses CBA LV cable generic
E4 Losses CBA PMT 50(1ph)-100(3ph)
E6 Innovative Solutions APRS
E6 Innovative Solutions CNAIM (ARP)
E6 Innovative Solutions DSR
E6 Innovative Solutions DNV
E6 Innovative Solutions Energy Storage
E6 Innovative Solutions Flexible DG Connections
E6 Innovative Solutions FUN-LV
E6 Innovative Solutions Innovative Bunding
E6 Innovative Solutions Joint Shell
E6 Innovative Solutions LIDAR
E6 Innovative Solutions LPN Interconnection
E6 Innovative Solutions LV Re-energising
E6 Innovative Solutions PFT
E6 Innovative Solutions POC
E6 Innovative Solutions PTRTTR

E6 Innovative Solutions Public Safety

E6 Innovative Solutions Timed Connections

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