UK Power Networks' Environment Report 2017/18

UK Power Networks
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Contents

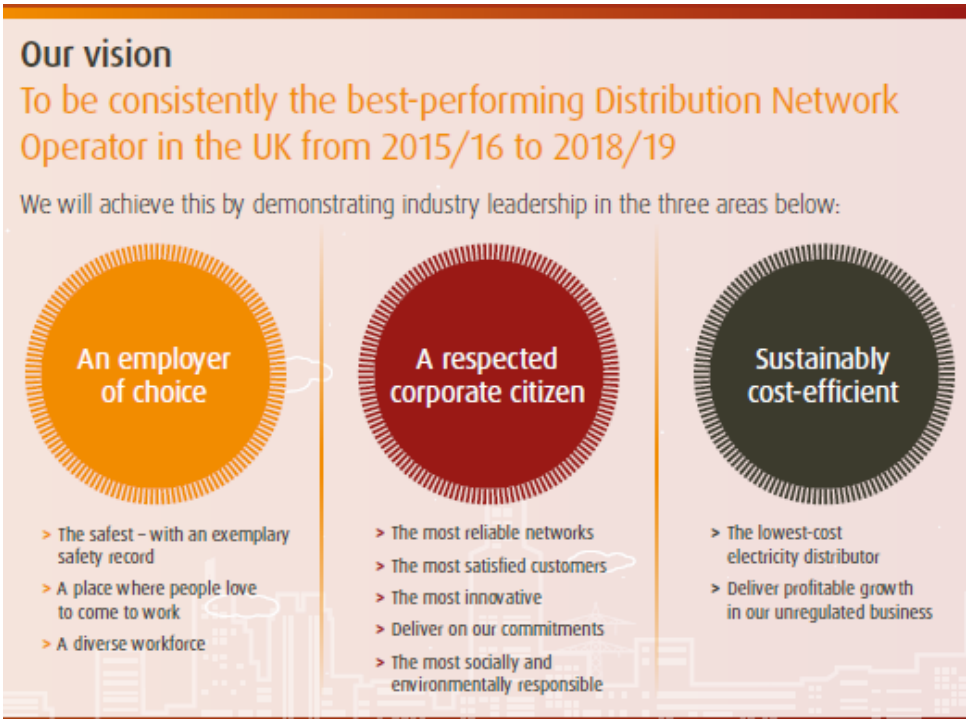
1 Introduction

1.1 Executive Summary

This document constitutes UK Power Networks' Environment Report for the regulatory year 2017/18 and is an annual requirement under standard condition 47 (Environment Reporting) of the Electricity Distribution Licence. It has been prepared on behalf of our three licensed distribution companies: Eastern Power Networks plc (EPN), London Power Networks plc (LPN), and South Eastern Power Networks plc (SPN). We are pleased to update our stakeholders on our performance across the key environmental measures and our work to deliver environmental benefits for our customers and the wider communities in the regions we serve.

We strive to make our operations as sustainable as possible and to reduce their impact on the environment. It is part of our vision to be a Respected Corporate Citizen and we work closely with communities and their representatives to identify areas where we can play an active, beneficial role. We have adapted our vision (see Figure 1) to refer explicitly to our social and environmental commitments.

Figure 1: Our Vision



The environmental commitments in our RIIO-ED1 Business Plan remain an important focus area for UK Power Networks. Key achievements in 2017/18 and anticipated future challenges are set out below:

- Three years into the RIIO-ED1 price control period we have reduced our business carbon footprint (BCF) by 16.7%; this exceeds the 6% target that we set ourselves (2% for each year of the period) and also represents a 6.1% reduction on the previous year's figure
- We diverted 83.4% of office and depot waste from landfill and recycled 99.3% of street works spoil – exceeding our RIIO-ED1 targets of 70% and 98% respectively
- We continued to lay the foundations for a successful transition to a low carbon economy. Our strategy of transforming UK Power Networks into a Distribution System Operator (DSO) is central to our approach and we are well underway with our plans. 2017/18 was particularly significant as it marked the launch of our business change strategic project, Innovation Refresh. This project aims to review our end-to-end lifecycle of innovation, from problem identification through to benefits realisation, to improve the process and ease with which our whole business is able to innovate
- We replaced 1,400 distribution transformers and 39 primary and grid transformers with EcoDesign specification equivalents, reducing losses from these assets by almost 7,000MWh per annum and almost 4,250MWh per annum respectively. This saves the equivalent electrical energy consumed by approximately 3,000 homes. We also continued to explore the likely impact on network losses of our transition from a Distribution Network Operator (DNO) to a DSO, and how mechanisms such as Active Network Management (ANM), Demand Side Response (DSR), Distributed Generation (DG), energy storage and a range of low carbon technologies can be used to manage them
- We successfully flood protected 12 substations with a combined total of more than 250,000 customer connections – moving us closer to our RIIO-ED1 target of protecting 78 substations from the effects of flooding during the RIIO-ED1 period. Successful projects included the protection of over 20,000 customers at Crawley Town Primary Substation from river flooding risk
- Our programme of work to tackle theft in conveyance led to 189 cases being resolved across our three regions in 2017/18. We worked closely with other distributors and suppliers to promote more effective electricity theft reduction efforts across the industry, drafting and sponsoring a formal change to industry processes
- We worked closely with the Environment Agency crime team in support of their efforts to secure prosecutions relating to criminal waste activities. We also installed pioneering noise reduction technology at a substation in our LPN region
- We continued to focus efforts on reducing leakage from fluid filled cables, targeting the poorest performing circuits on our network. In addition, we worked with key stakeholders to develop and test new techniques which are expected to have a positive impact on cable fluid loss
- In our LPN and SPN regions we comfortably met our RIIO-ED1 target (reduce cable fluid leakage of 207,000 litres by 2% per annum) during the year. The target was missed for 2017/18 in our EPN region, however, plans laid in that year will address this in 2018/19 and we are confident that all three licensees will achieve their targets
- In our EPN region we removed a total of 2.15km of high voltage (HV) overhead line from natural landscapes under two undergrounding schemes and worked closely with stakeholders to identify other areas that would benefit from the undergrounding of overhead lines

Links to the Business Plan are provided throughout this report and our RIIO-ED1 targets are listed in section 1.3.

We very much hope that this report will be of interest to our stakeholders and look forward to providing an update on our performance in 2018/19.

1.2 Our Business/Who We Are

At UK Power Networks, we manage the distribution of electricity from the National Grid to 8.3 million homes and businesses via our networks in London, the East of England and South East England. Our licensed companies EPN, LPN and SPN are responsible for operating and maintaining these networks; ensuring we provide safe, reliable and efficient electricity supplies to existing customers and timely, cost-effective connections to new ones.

Our operating area (see Figure 2) covers more than 29,250km^2 and includes most of London as well as large areas of rural and agricultural land and over 500 miles of coastline around the south east of England. It has many environmental landscape features that are of great importance – Areas of Outstanding Natural Beauty (AONB), National Parks, Sites of Special Scientific Interest, unique waterways such as The Norfolk Broads, and Central London which is rich in archaeological significance.

Figure 2: Our operating area

We have an important role to play in safeguarding the environment in which we operate, both by reducing our BCF and by taking action to protect and enhance the natural environment so that it can be enjoyed by current and future generations.

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

We are also firmly focused on the transition to a low carbon economy – developing our future capabilities as a DSO to deliver 'a smart grid for all', so that customers and communities will benefit from a decentralised, decarbonised and digitised energy system. To learn more about our plans, please see section 3.

1.3 Purpose of the Report

This report documents UK Power Networks' activities in relation to environmental matters during the 2017/18 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 present progress against the following targets in our RIIO-ED1 Business Plan:

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

2 Managing Our Environmental Impact

2.1 Introduction

Protecting the environment is part of our vision to be a Respected Corporate Citizen. We are acutely aware that our activities can have an effect on the surrounding area and have robust policies and procedures in place to ensure we comply with all relevant environmental legislation.

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. Through training and compliance monitoring, high levels of compliance with our environmental permits are maintained.

When working in protected habitats such as Sites of Special Scientific Interest or where protected species may be impacted, we consult with Natural England and, where appropriate, apply for relevant licences. Suitably qualified ecologists are engaged to help us with these activities. We also consult English Heritage if our work might have an impact on scheduled monuments or other protected historic sites.

Environmental governance is provided by our Health, Safety and Environment Committee, which is chaired by our 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. DNV-GL have advised us that our Environmental Management System meets the revised ISO 14001:2015 standard requirements. This 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 UK Power Networks has been a member of an Undergrounding of Overhead Lines Project Steering Group which facilitates the completion of approved network underground projects within its licensed areas. Established in 2005, the group consists of landscape experts (members of AONB and National Park organisations) acting as stakeholder representatives, and is chaired and facilitated by Natural England who has a national remit to advise on the management of designated landscapes. The group meets every three months.

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 (those that have completed Stage 2) 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 the relocation of a substation.

Projects 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 supporting evidence are recorded on an Overhead Lines Assessment Form. Throughout the scoring process the Steering Group members debate whether all relevant factors have been taken into account and any related issues resolved. A related issue could be whether or not the removal of the overhead line 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 2017/18 regulatory year.

Table 1: Undergrounding schemes completed in our operating area

Licensee	Landscape	Scheme Name	Distance (km)	Current position
EPN	Norfolk & Suffolk Broads	Share Marshes	1.40	Completed
EPN	Norfolk Coast	Cley	0.75	Completed

Table 2 shows a further 26 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 afforded to as many stakeholders as possible.

Table 2: Undergrounding schemes in progress in our operating area

Licensee	Protected Landscape	Scheme Name
EPN	Norfolk Coast	Bayfield
EPN	Suffolk Coast & Heaths	Shingle Street
EPN	Norfolk & Suffolk Broads	Cantley
EPN	Norfolk & Suffolk Broads	Ludham Marshes
EPN	Norfolk & Suffolk Broads	South Walsham Marshes
EPN	Norfolk & Suffolk Broads	Potter Heigham
EPN	Norfolk Coast	Burnham Overy
EPN	Suffolk Coast & Heaths	Shotley North
EPN	Suffolk Coast & Heaths	Shotley South
EPN	Suffolk Coast & Heaths	Blyth
EPN	Dedham Vale	Stoke by Nayland
EPN	Suffolk Coast & Heaths	Felixstowe
EPN	Norfolk Coast	Blakeney/Morston
EPN	Chilterns	Dunstable Downs
SPN	Kent Downs	Elham Valley
SPN	High Weald	Bedgebury Pinetum
SPN	South Downs	Charleston
SPN	South Downs	Firle Beacon
SPN	Surrey Hills	Hurtwood
SPN	Kent Downs	Preston Hill
SPN	South Downs	Malling Hill
SPN	Surrey Hills	Raikes Farm
SPN	Surrey Hills	Abinger Hammer Phase 2
SPN	South Downs	Alciston
SPN	High Weald	Ashdown Forest
SPN	High Weald	Moat Farm

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

Achievements in the 2017/18 regulatory year are shown in the RIGs worksheet E1 – Visual Amenity (please see the Annexes and Appendices). In the EPN region a total of 2.15km of overhead line were removed at Share Marshes in the Norfolk and Suffolk Broads and in Cley in the Norfolk Coast AONB. In the SPN region no overhead lines were removed due to there being no schemes ready for delivery.

Last year we reported that UK Power Networks had introduced a searchable map facility to provide stakeholders with a visual representation of completed schemes and enable them to identify other areas that would benefit from the undergrounding of overhead lines. The map has had 1,849 views since it went live in April 2017 and we have received one scheme nomination that is outside a Designated Area. The map is available to view on our website.

2.3 Oil Leakage

Fluid filled cables (FFCs) account for 35% of all cables running at 33kV, 66kV and 132kV in our three regions. In our RIIO-ED1 Business Plan we committed to reduce oil leakage from these assets by 2% per annum for the duration of the RIIO-ED1 price control period (April 2015-March 2023). In this section you will find information about our strategy for reducing oil leakage from FFCs on our network, a summary of 2017/18 performance and details of the work we have undertaken both independently and with key stakeholders.

Key reasons to reduce 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 the network operates as efficiently as possible by reducing the cost to customers of cleaning up oil leakages

Our strategy is to reduce cable fluid loss by investing in the network to refurbish and replace poor condition circuits. Where circuits develop new leaks, we ensure we are at the forefront of new technology and best practice to identify and repair damage as swiftly as possible.

2.3.1 2017/18 Performance

Cable fluid loss is measured by the total amount of fluid used to top up cables less any fluid recovered. A summary of 2017/18 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.

Table 3: Comparison of cable fluid lost in 2017/18 to historical performance in DPCR5

Licensee	Average annual cable fluid losses – DPCR5[1]	Cable fluid losses – 2017/18[2]	Difference (volume)	Difference (%)
EPN	48,435 litres	47,914 litres	521	-1%
LPN	122,384 litres	93,066 litres	29,318	-24%
SPN	52,729 litres	70,088 litres	17,359	+33%
Total	**223,548 litres**	**211,068 litres**	**12,480**	**-6%**

[1] The data in this column represents the average amount of cable fluid lost and not captured in each year of DPCR5, the price control period from April 2010 to March 2015.
[2] Cable fluid losses are measured by the total fluid used to top up cables less the total fluid recovered for all three of UK Power Networks' regions.

In 2017/18 a total of 211,068 litres of oil were lost in our three regions – a 6% reduction compared to average performance in the DPCR5 period but more than was reported last year (197,145 litres). Contributing factors were:

- A significant leak (approximately 9,865 litres) from the Dartford Ruxley circuit in SPN which was very difficult to locate and repair
- Significant leaks (approximately 9,245 litres) from the Back Hill Fisher Street circuits in LPN (UK Power Networks' worst leaker). The Back Hill Fisher Street circuits were decommissioned in March 2018 as part of planned works
- A significant leak (approximately 8,119 litres) from the Wymondley main circuit in EPN where access was restricted and difficult to locate and repair

We are working to ensure that going forward, cable fluid losses reduce in line with the commitment made in our RIIO-ED1 Business Plan. We have reviewed the projects described in that document in order to prioritise where circuit performance is known to be poorest. The highest priority projects have been authorised internally, at both a senior and executive management level. Some are currently at the execution stage and others are at the design stage with construction planned for 2018/19.

2.3.2 Initiation of Network Innovation Allowance (NIA) projects

In our previous Environment Reports we have provided updates on particular innovation projects which if successful will directly contribute to a reduction in cable fluid loss. An update for 2017/18 is provided below.

- **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.

  In 2017/18 the chemistry behind the development of the oil additive was transferred to a major cable fluid supplier for large-scale production. The cable fluid supplier has undertaken a procurement exercise to globally source commercial volumes of key formulation components; these have been obtained and self-healing fluid (SHF) will be manufactured shortly to produce mid-scale volumes of the formulation for both ageing studies and laboratory cable test rig trials. This will provide the cable fluid supplier with additional experience in the production and handling of the SHF blend in advance of higher volume field trials in cable circuits and eventually in routine production for subsequent transition to business as usual.

  The construction of test rigs has been completed and signed off by UK Power Networks and commissioning is now complete. The commissioned rigs will then be used to trial an industrially produced SHF formulation under a range of cable and fluid operating conditions for fluid cable taken from UK Power Networks' and Northern Powergrid's networks.

  Both DNO groups have nominated circuits and sourced cable samples at lengths required for cable rig testing. Samples of unused FFC were obtained from one of UK Power Networks' stores and fewer sections extracted from recently decommissioned circuits.

The selection of circuits for field trials is progressing. A particularly suitable one has been located in a substation in our SPN region. It is contained entirely within the grounds of the site and so can be used as a more highly controlled test site and one that will allow voltage testing. This also avoids the need for approvals to be sought from local authorities for road closures or landowners for site access. It is possible to carry out voltage testing on the cable which will demonstrate the safety of the SHF prior to its introduction into an energised circuit. Methods to deploy the SHF are also being considered in regard to using existing cable servicing assets with additional fluid delivery control.

Next year, subject to successful completion of the rig tests, the cable fluid supplier will be engaged to produce a sufficient volume of oil for field trials on selected circuits. Circuit trials will be carried out according to plans developed by the DNOs and designed to ensure that their management and operations teams are satisfied with the performance of the SHF as a cable dielectric and self-healing fluid. Following completion of these trials, if successful, it is anticipated that this technology will be appropriately deployed in a controlled manner to suitable oil-filled circuits.

If the 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 NIA-UKPN-0012 and started in September 2015.

  Last year we reported that the first active pressure control unit (APCU) prototype and test rig had been designed and developed. The initial APCU 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 the FFC and uses this data to operate a variable pressure valve, thereby reducing leakage.

  This year significant testing was carried out at Elmeridge Cable Services' (ECS) Laindon offices where the system underwent an extensive and rigorous safety-testing programme. The APCU has been proven to work and is an effective method of controlling the cable pressure. A safety failsafe mechanism has been built into the system to ensure safe operation of the trial and avoid environmental impacts. If the devices fail to operate during the trial stage the system is designed to return to its normal operating condition (as it was without the trial device) to avoid any damage to the network.

  Since last year the testing and implementation of five units on to live network circuits has been successfully completed and the APCU is operating exactly as required. Trials on live network circuits are still in progress. The five units on the network are currently operating well and are maintaining a constant cable pressure. In order to gather sufficient data, these need to be observed under various weather and load conditions on the network.

  Having carried out significant development to date, we are confident that the APCU operates as required. The next stage in development is to assess the operation of the APCU on FFC cable systems with more than one tank position. Laboratory testing has proved this is possible and, more importantly, safe and effective. Two more units are planned for construction next year and a suitable circuit has been identified for the live trials. Given that there are significantly more circuits with multiple feed points, this is an important progression in development.

  If the 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.

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 the 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.

2.3.3 Stakeholder Engagement

It is imperative that the environmental impacts of cable fluid loss are managed effectively and we have a partnership agreement with the Environment Agency outlining how we should report, notify and manage cable leaks across the network. Our Environment team has worked with colleagues in our Asset Management and Network Operations Directorates to provide proactive knowledge sharing sessions at Environment Agency local offices. This ensures improved knowledge and understanding for both organisations on the management of cable leaks.

During 2017/18 we continued to work with key stakeholders to share best practice and work to target the poorest performing circuits on our network. 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, during a presentation of the Advanced Management of Fluid Filled Cables at the ENA innovation conference, UK Power Networks demonstrated the use of new innovative technology to reduce fluid loss from the cables
- Network trials and workshops to demonstrate the new technology being developed under Self-Healing Cables and Pressure Cable Active Control & Monitoring (see section 2.3.2)
- Discussions about 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

In summary, UK Power Networks has successfully reduced cable fluid losses by 6% in the third year of RIIO-ED1 (2017/18) when compared to average loss during DPCR5. It is anticipated that by 2019/20 the plans outlined above will reduce cable fluid loss in line with the 2% year on year commitment made in our RIIO-ED1 Business Plan.

2.4 Carbon Impact and Climate Change

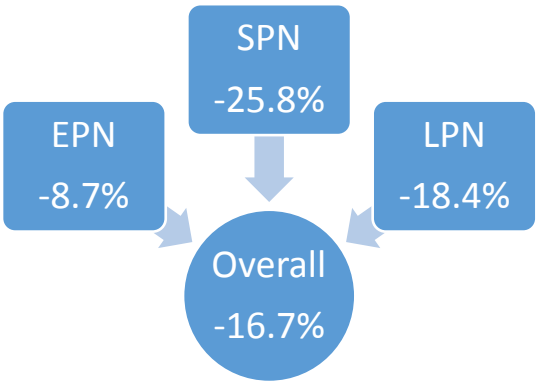
2.4.1 Business Carbon Footprint

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.

In our RIIO-ED1 Business Plan we set ourselves an overall target to reduce our BCF by 2% for each year of the RIIO-ED1 price control period. Three years in, our target was a 6% reduction against our baseline year of 2014/15 and we are pleased to report a reduction of 16.7% (see Figure 3), significantly ahead of this target. This also represents a 6.1% reduction on the previous year's figures.

Over the last three years we have reduced our BCF by 16.7%

Figure 3: 2017/18 BCF reduction by DNO



The processes described in this section are used to calculate the BCF for EPN, LPN and SPN. Where data is collected centrally, this is apportioned between the three DNOs based on headcount as of March 2018.

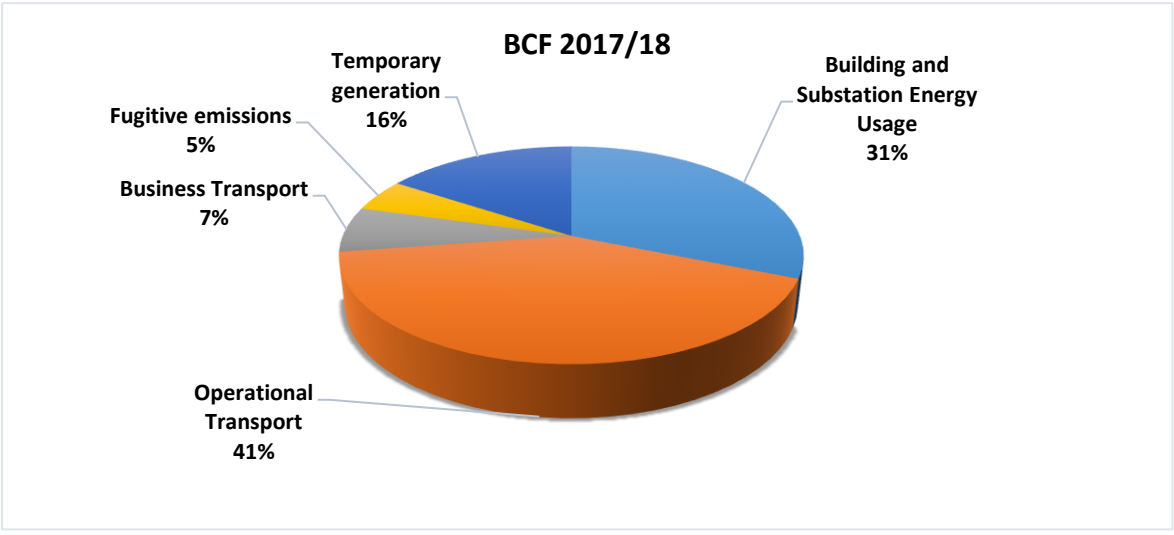
Bringing contracts in-house in EPN has increased EPN's share of the headcount from 37% in 2014/15 to 44% this year, and has proportionally decreased the share of the other two DNOs. EPN's much smaller reduction (shown in Figure 3) is due to the methodology used. If we apportioned based on geographical area, as opposed to headcount, LPN would only be allocated 2% of the shared footprint, creating an anomaly.

Our results for the 2017/18 regulatory year are shown in our RIGs worksheet E3 – Business Carbon Footprint (please see the Annexes and Appendices). In all calculations of our BCF we have used the government-issued carbon conversion factors published on 4 August 2017, which were in effect in March 2018.

2.4.1.1. Our BCF Reporting Process

Distribution losses account for more than 97% of our total BCF and are the focus of a separate strategy (please see section 2.4.3). Focusing on our BCF without losses highlights the potential for sustainability improvements in other areas. Excluding distribution losses, in 2017/18 the largest elements of our BCF were operational transport (41%) and building and substation energy usage (31%), followed by temporary generation (16%), business transport (7%) and fugitive emissions (5%). Figure 4 illustrates this breakdown.

Figure 4: 2017/18 BCF breakdown excluding distribution losses



We publish an annual report of our BCF which details the carbon emissions from our three DNOs within the above categories and presents our BCF with and without distribution losses (please see our website). These elements are illustrated in Figure 5.

Figure 5: Greenhouse Gas protocol scopes

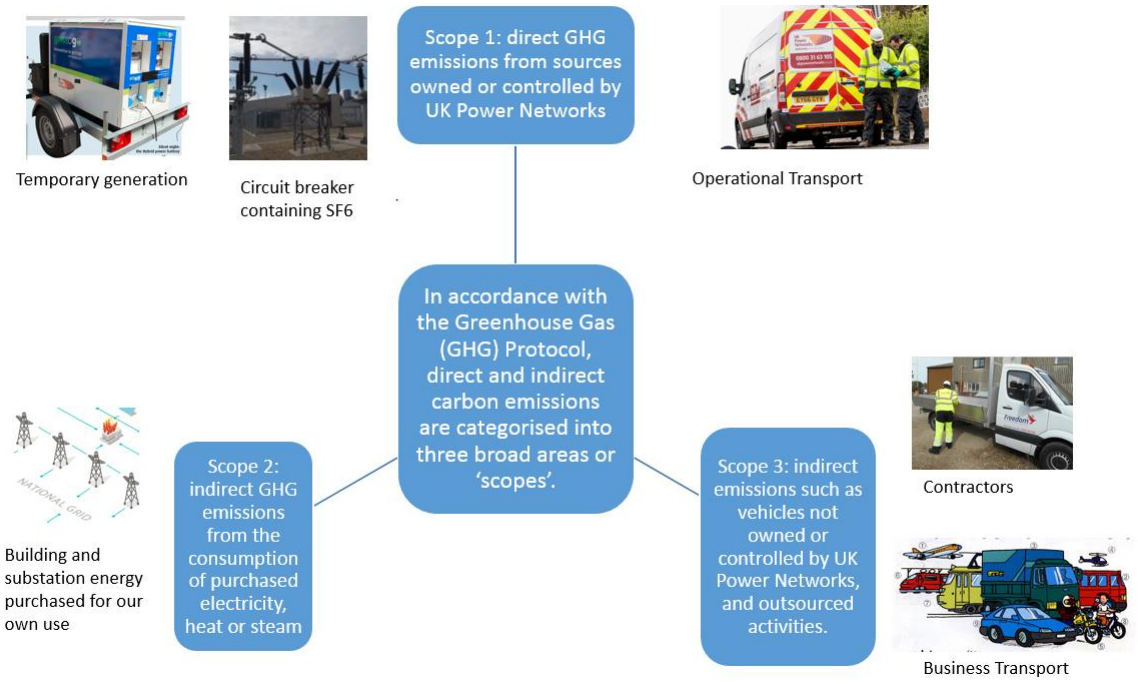


Table 4 shows our overall BCF excluding distribution losses for the regulatory years 2014/15 (our baseline measurement year as set by Ofgem) and 2017/18. Details of the individual components of our BCF excluding losses are also reported below.

Table 4: Our 2014/15 and 2017/18 BCF excluding losses

Licensee	2014/15 (tCO_2e)	2017/18 (tCO_2e)	% change
EPN	32,539.49	29,721.06	-8.7%
LPN	19,776.50	16,136.55	-18.4%
SPN	25,025.12	18,569.40	-25.8%
Total	**77,341.11**	**64,427.01**	**-16.7%**

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

Monthly reports are received from various sources 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 reports of modes of transport booked via 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 DNOs wherever possible. The use of common systems in all three of our regions means that some data is captured centrally. Where this is the case we apportion the data between the DNOs on a headcount basis. This approach is favoured over geographical apportionment, as the LPN region only accounts for around 2% of the total land area, which would result in an unrealistically small value.

Our entire BCF reporting process continues to be audited by our Internal Assurance team. Aspects of our BCF are also 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

There has been a shift in the relative proportions of the elements of our BCF since 2014/15, with the most significant change being the proportional decrease of 7% (i.e. 38% to 31%) 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 UK electricity network have led to a marked decrease in the carbon factor.

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 2017/18, 99.35% of fuel purchased was diesel, 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 later in this section as part of our Temporary Generation carbon footprint.

Table 5 shows the levels of tCO_{2e} emitted by UK Power Networks' operational fleet and contractors when working on our networks. As previously mentioned, we apportion fuel usage on a headcount basis, as we believe this is a more accurate method than geographical apportionment, which is based on square kilometres.

Overall, Operational Transport emissions have reduced from 30,948.23 tCO_2e in 2014/15 to 26,718.82 tCO_2e in 2017/18. This represents a 13.7% decrease and is due to the modernisation of our operational fleet and the roll-out of more sophisticated communications technology enabling staff to access cable plans and other documents in the field.

Table 5: Levels of tCO_2e emitted by our operational fleet and contractors working on our networks

Licensee	Direct operational staff	% of staff	2014/15 – total (tCO_2e)	2017/18 – our fleet (tCO_2e)	2017/18 – contractor (tCO_2e)	2017/18 – combined (tCO_2e)	% change
EPN	1,168	44%	11,450.84	7,172.35	4,489.68	11,662.03	+2%
LPN	798	30%	9,284.47	4,900.29	3,067.43	7,967.72	-14%
SPN	710	27%	10,212.92	4,359.90	2,729.17	7,089.07	-31%
Total	**2,676**	**100%**	**30,948.23**	**16,432.54**	**10,286.28**	**26,718.82**	-14%

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 our sites

Licensee	2014/15 – total (tCO_2e)	2017/18 – total (tCO_2e)	% change
EPN	13,574.67	9,574.34	-29%
LPN	6,942.63	6,093.71	-12%
SPN	6,648.78	4,420.07	-34%
Total	**27,166.08**	**20,088.12**	**-26%**

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
- 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. This element of our BCF is highly weather dependent, as we restore power through temporary generation whilst repairing any storm damage. This was particularly evident in 2017/18 in EPN when June, July and the initial part of August saw very wet and windy weather combined with heavy lightning storms and very strong winds due to Storm David in January.

Table 7: Levels of tCO_2e emitted from temporary generators and plant and equipment used on our networks

Licensee	2014/15 – total (tCO_2e)	2017/18 – UK Power Networks (tCO_2e)	2017/18 – contractor (tCO_2e)	2017/18 – combined (tCO_2e)	% change
EPN	4,321.55	4,382.62	226.46	4,609.08	+7%
LPN	1,717.71	582.97	154.72	737.69	-57%
SPN	6,328.58	4,691.45	137.66	4,829.11	-24%
Total	**12,367.84**	**9,657.04**	**518.83**	**10,175.87**	**-18%**

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 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

Business travel data is recorded by mode of transport used (e.g. air, rail and road). Only the usage of company car fuel cards is recorded by licensee and so the remaining total business mileage is apportioned based on the number of indirect staff employed in each region. Business kilometres are based on actual kilometres claimed. Fuel card usage is based on actual litres used.

For vehicles that are owned by UK Power Networks or purchased through our self-purchase company car 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 and have introduced Skype for Business this year. As Table 8 demonstrates, although EPN is showing an increase, partly due to a rise in its apportionment, our overall business mileage figures are slightly lower than our 2014/15 baseline.

Table 8: Business mileage summary showing levels of tCO_2e emitted by our staff and contractors when travelling on company business

Licensee	Indirect staff	% of staff	2014/15 – total (tCO_2e)	2017/18 – UK Power Networks (tCO_2e)	2017/18 – contractor (tCO_2e)	2017/18 – combined (tCO_2e)	% change
EPN	1,189	39%	1,651.60	1,591.96	156.87	1,748.83	+6%
LPN	903	29%	1,339.13	1,062.67	107.18	1,169.85	-13%
SPN	984	32%	1,473.05	1,321.83	95.36	1,417.19	-4%
Total	**3,076**	**100%**	**4,463.78**	**3,976.46**	**359.41**	**4,335.87**	**-3%**

2.4.1.7. Fugitive Emissions

Sulphur hexafluoride (SF_6) is an electrical insulating gas commonly found in modern electrical switchgear and can leak following faults or from old equipment. It is a hazardous material which can have a significant impact on the environment, being 22,800 times more harmful to global warming than CO_2.

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 2017/18. One kilogram of SF_6 is judged to have the equivalent greenhouse gas impact of 22.8 tonnes of CO_2; so the failure of one piece of switchgear in SPN, which released 32.6 kilograms, accounted for more than 90% of SPN's losses.

Table 9: Levels of tCO_2e emitted from leakage of SF_6 from our switchgear

Licensee	2014/15 – total (tCO_2e)	2017/18 – total (tCO_2e)	% change
EPN	1,540.83	2,126.78	+38%
LPN	492.56	167.58	-66%
SPN	361.80	813.96	+125%
Total	**2,395.19**	**3,108.32**	**+30%**

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

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 2017/18 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)	2017/18 – total (tCO_2e)	% change
EPN	1,178,315.84	838,822.16	-29%
LPN	913,866.74	644,057.92	-30%
SPN	663,791.18	489,723.08	-26%
Total	**2,755,973.76**	**1,972,603.16**	**-28%**

Table 11: Our overall BCF including distribution losses in tCO_2e

Licensee	2014/15 (tCO_2e)	2017/18 (tCO_2e)	% change
EPN	1,210,855.33	868,543.22	-28%
LPN	933,663.24	660,194.47	-29%
SPN	688,816.30	508,292.48	-26%
Total	**2,833,334.87**	**2,037,030.17**	**-28%**

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

2.4.2 Sulphur Hexafluoride Emissions (SF_6 emitted)

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% 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 6.6kV up to 132kV. SF_6 leakage is measured in kilograms 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 under 109,000 kilograms 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	41,022
LPN	46,089
SPN	21,603
Total	**108,714**

It should be noted that the new installed SF_6 capacity value is a significant increase from the 100,350 kilograms reported in our 2016/17 Environment Report. This is due to a change in the way that the SF_6 bank is calculated, which now includes equipment that may be temporarily unavailable or under test as well as in-service equipment.

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 method for circuit breakers. It is also the most viable insulation medium for switchgear of all voltages in the LPN area (which is subject to space constraints), 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 5,000 kilograms[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 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 and have failed to do so again in 2017/18 – though by a much smaller margin than the year before. Strenuous efforts are being made to bring this situation under control. These include but are not limited to prioritisation of SF_6 reduction projects and the implementation of emergency measures to expedite the delivery of leak mitigation where leak rates are significant and could adversely affect our leak rate target. We are focusing our efforts in this area so that we meet the target in all three of our regions going forward.

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 continue to be 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 mal-operation or failure – improving network performance
- Minimise the risk of exposure to SF_6 for our operational staff when working on the network or handling this substance

Where SF_6 leaks occur, our 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 is 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 of Switchgear Containing SF_6, which offers guidance on switchgear containing SF_6 from voltages of 6.6kV up to 132kV. 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 2017/18, in our EPN region, we successfully completed an expedited programme of works to replace two 132kV Brush DB145 SF_6 filled circuit breakers at Colchester Grid which were leaking heavily and substantially contributed to the poor EPN performance alluded to earlier. (21.85 kilograms of SF_6 were emitted, accounting for 30% of SF_6 leaks in EPN during the 2017 calendar year.)

Our 2018/19 plans include investment targeted at the most significant contributors to SF_6 leaks on our 33kV and 132kV switchgear.

[3] This is an estimate based on the average kilograms 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.

2.4.2.2. Our Stakeholders

Key stakeholders in this area are the parties 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 primary switchgear and above, a refurbishment will be sought. For secondary 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

Our future strategy is focused on two key areas:

- Improving SF_6 leakage recording performance in the system by providing tools and education to enable field personnel to accurately record all instances of leaks to enhance prioritisation and remedial action
- Exploring the use of SF_6 alternatives such as Green Gas for Grid (g^3) and commissioning these assets on our network when safe and economically viable to do so. This will be accomplished by maintaining contact with manufacturers, academic institutions and electricity distribution industry participants who are considering or conducting trials in order to be well positioned to take advantage of any cost-effective breakthrough product that results from such efforts

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 g^3 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 2017/18 regulatory year are shown in our RIGs worksheet E2 – Environmental Reporting (please see the Annexes and Appendices).

2.4.3 Distribution Losses

2.4.3.1. Technical Distribution Losses

Distribution losses are either 'technical' or 'non-technical' in nature. Technical distribution losses are the difference between the electrical energy entering the network and the energy delivered to the end customer and are a consequence of transferring electricity across the distribution system. Non-technical losses result from the under-recording or non-recording of electricity consumption – for example, 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 1/27 of the overall losses[4].

The remainder of this section examines technical distribution losses. For information about non-technical losses, please see section 2.4.3.2.

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

There 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% of technical losses will be due to fixed losses and around 70% will be due to variable losses, although there will be regional variations in this ratio.

- **Our Losses Strategy**

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

  Our Losses Strategy follows a three-step approach of:

  - Understanding losses
  - Plan & Design
  - Build & Operate

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

- **Current Assessment of Distribution Losses**

  In order to further our understanding and develop methods for mitigating losses we have, through the Losses Discretionary Reward (LDR), commissioned Imperial College London, Princeton University and others to undertake a variety of holistic and specific studies. This process started in early 2016, through our LDR tranche 1 activities, and continues through the current LDR tranche 2 period, from early 2018 to early 2020. We continue to publish reports and other material of interest that our research produces on our losses website[5], which also contains interactive explanations for the various losses types and causes.

[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)

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

We have taken the findings from LDR tranche 1 and, where appropriate and supported by CBAs, these have been embedded into our business as usual activities. We accept that understanding losses, modelling, analysis of data and mitigation methods is an ongoing process and while some areas of losses are well understood, others pose considerable challenges. For example, historically low voltage (LV) networks contained relatively few measurement points per circuit and where they did exist the measurement may have reported such basic information as a single maximum demand value for the total substation load. To be effective for losses mitigation, the measurement needs to be per LV phase of each LV feeder, highly accurate and reported in real time and where data gaps exist these need to be filled using assumed load profiles. With losses typically representing only 4% on LV networks, the more assumptions that are made the less effective the modelling becomes at a site specific or component level. So while our journey to increase the volume of measurement points, real-time reporting and modelling capability continues, the challenges are significant.

Table 13 shows a summary of total losses on our networks from data that has 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

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Total Losses (tCO_2e)[6]						
EPN	1,152,525	1,112,211	1,178,316	1,034,381	1,016,939	983,151
LPN	843,139	839,961	913,887	880,009	779,598	754,876
SPN	675,935	611,716	663,791	559,249	541,021	573,986
Total Losses (GWh)						
EPN	2,797	2,699	2,860	2,238	2,468	2,386
LPN	2,046	2,038	2,218	1,904	1,892	1,832
SPN	1,640	1,485	1,611	1,210	1,313	1,393
Total units distributed (GWh)						
EPN	35,108	33,794	32,882	32,721	33,295	33,106
LPN	28,722	28,006	27,632	27,442	27,266	27,021
SPN	20,994	20,508	19,713	19,413	19,468	19,373
Total losses (%)						
EPN	7.97	7.99	8.70	6.84	7.41	7.21
LPN	7.12	7.28	8.03	6.94	6.94	6.78
SPN	7.81	7.24	8.17	6.23	6.74	7.19

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

Table 14 shows the losses performance reported through our RIGs worksheet E4 – Losses Snapshot for the regulatory year 2017/18 (please see the Annexes and Appendices). The values in this table should be read in conjunction with the notes below.

Table 14: Summary of losses performance

Asset	EPN	LPN	SPN
	Saving (MWh)	Saving (MWh)	Saving (MWh)
LV Cables	1,091.0	322.7	606.2
HV Cables	0	0	0
Distribution Ground Mounted Transformers	321.7	931.3	138.0
Distribution Pole Mounted Transformers	15.8	0	5.5
Primary Transformers	0	0	0
Grid Transformers	0	0	0
Total	**1,428.5**	**1,254.0**	**749.7**

Based on the realised benefits reported in our 2017/18 RIGs worksheet E4 – Losses Snapshot (please see the Annexes and Appendices), a total of 3,432.2MWh of CBA justified improvements were made over the 12-month period. This equates to 1,414.2 tCO_2e in the year.

It should be noted that we undertake a significant number of activities that substantially reduce losses which are not CBA justified. An example would include replacing an aged distribution transformer with a current specification EcoDesign transformer of the same kVA rating. EcoDesign transformers comply with EU Regulations setting compulsory maximum losses levels for distribution transformers and are substantially more efficient than older specification transformers. Replacement in this example therefore reduces losses, but as the transformer specification is a mandatory requirement, the losses benefits are not included in the above RIGs E4 worksheet. We estimate that losses on our networks reduced by more than 13,260.1MWh per annum as a result of all the work undertaken, of which only 3,432.2MWh per annum is CBA justified.

- **Activities undertaken in the Regulatory Reporting Year**

Current Programmes to manage Distribution Losses

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

- **LV cables**

  We are installing larger cross-section conductors to reduce resistance and hence variable I^2R losses. Through changes in our LV Network Design policy, there has been a significant shift in the cable sizes being installed, with a sizeable reduction of $95mm^2$ in LV cable and a corresponding increase in $185mm^2$ and $300mm^2$ cable. In total, more than 2,019.8MWh per annum were saved by installing less $95mm^2$ cable than in the previous year and this is reported in the E4 worksheets. This year $95mm^2$ cable represented 26.5% of total LV cable installed – down from 30.6% in 2016/17 and 44.6% in 2015/16 when this policy change was implemented.

- **Use of larger distribution transformers**

  We are replacing existing distribution transformers with larger units where the saving in copper losses (variable) outweighs the increases in iron losses (fixed). Over the last 12 months we have increased the transformer size at 157 sites where the CBA demonstrated a positive NPV, yielding improvements of approximately 1,412.3MWh per annum. This is reported in the E4 worksheets.

- **Use of amorphous steel transformers**

  During LDR tranche 1 we collaborated with a transformer manufacturer to develop a pole mounted amorphous steel transformer, recognising that fixed losses in distribution transformers account for a significant percentage of overall technical losses. Our work with the manufacturer developed a single phase 50kVA pole mounted transformer; we have commenced installation of an initial consignment of 54 of these on our networks and will continue to review their performance.

- **Detection of contact voltage losses**

  Also during LDR tranche 1, through our work with Princeton University, we discovered what we believe is a new category of losses that does not fit into the standard definition of either technical or non-technical losses. We have invested in a Mobile Asset Assessment Vehicle (MAAV) and developed a programme to assess contact voltage losses (please see section 3.3.2.22). Unlike any other category of technical losses, these are entirely avoidable with sufficient investment and in LDR tranche 2 we will seek to validate the findings of the Princeton University report and further our understanding in this area.

The following activities are not CBA justified but are undertaken as part of our business as usual activities and have had a positive impact on loss reduction:

- **Replacement of distribution and power transformers**

  We continue to replace existing transformers with EcoDesign specification equivalents which will reduce the fixed iron losses that are constantly present on the network, irrespective of the current passing through it. This year we replaced a total of 1,400 distribution transformers, which reduced losses by 6,999.3MWh per annum, and 39 primary and grid transformers, reducing losses by 4,241.5MWh per annum.

- **11kV cables**

  As with our LV cables, we are installing larger cross-section 11kV conductors than in the past, following changes in our 11kV Network Design policy. This will have a long-term reduction in losses, as installing larger cross-section cables reduces the resistance and therefore the losses over the total life of the asset.

- **Ongoing review of design standards**

  We continue to review and amend Engineering Design Standards to ensure that our practices are implemented proactively in future designs where the long-term benefits outweigh the upfront capital costs. This will ensure that losses are minimised and these benefits remain with the assets throughout their life.

- **Forthcoming Programmes to manage Distribution Losses**

  During the next regulatory year we will continue to broaden our understanding of losses, developing our tools and processes and embedding these into our business as usual activities. For example, we propose to develop further sizes of pole mounted amorphous steel transformers, continuing our collaboration with manufacturers, and to disseminate our findings to other DNOs who may benefit from this activity.

- **Our Future Focus**

  We will continue to consider the impact that our transition from DNO to DSO is likely to have on network losses and also how we can utilise aggregated smart metering data for the identification of technical and non-technical losses. We seek to identify how mechanisms such as ANM, DSR, DG, energy storage and a range of low carbon technologies can be used to manage network losses. Generally these technologies are being developed to maximise network utilisation, which has network and societal benefits but may inadvertently increase technical losses. However, these mechanisms may be used infrequently for their primary purpose and we are therefore exploring whether they can be used to minimise network losses for the remainder of the time.

  We also intend to 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.

- **Summary of Losses Activities and Benefits during this Regulatory Reporting Year**

  Table 15 shows a summary of the costs and benefits from our CBA justified losses activities (technical losses) and has been developed from our RIGs worksheet E4 – Losses Snapshot (please see the Annexes and Appendices). From this extract we are able to understand the cumulative effect of our CBA justified losses activities during the whole of the RIIO-ED1 period to date. The annual reduction in losses is due to installing larger cross-sectional area LV cables and also the replacement of existing distribution transformers with larger lower loss units (see above). This figure is subject to replacement programmes and new connections projects and, as such, we anticipate that these results will remain relatively consistent over the RIIO-ED1 period.

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

Programme/ project title	Regulatory Reporting Year (2017/18)			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	0.437	2,019.8	832.3	5,704.7
HV Cable	0	0	0	0
Distribution Transformers	0.233	1,412.3	581.9	1,763.7
Primary & Grid Transformers	0	0	0	0

Table 16 shows a summary of the volumes of CBA justified losses activities during this regulatory reporting year and has been developed from our RIGs worksheet E4 – Losses Snapshot (please see the Annexes and Appendices).

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 (2017/18)	Forecast volumes for Following Regulatory Year (2018/19)
LV Cable	km	102.8	100-120
HV Cable	km	0	N/A
Distribution Transformers	ea	157	100-200
Primary & Grid Transformers	ea	0	N/A

2.4.3.2. Non-technical Distribution Losses

Non-technical losses result from the under-recording or non-recording of electricity consumption. Responsibility lies primarily with electricity suppliers who must ensure that consumption is correctly recorded within industry settlement systems. In particular, they must accurately read meters, set the appropriate energisation status against each metering point and detect, investigate and resolve situations where customers tamper with or bypass their electricity meter. Separately, there is that element of electricity theft committed by persons who make unauthorised connections to the distribution system and do not register with a supplier. This is known as theft in conveyance and we estimate it accounts for around 10% of total electricity theft on our networks.

Tackling theft in conveyance 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 such instances. Ceasing ongoing theft is clearly important, but our operations also identify and remedy the dangerous situations often associated with unauthorised connections. Our investigators will frequently encounter overloaded connections, substandard wiring and exposed conductors presenting both fire and electrocution risks. UK Power Networks is helping to protect the occupiers of such premises, their families, neighbours and the wider general public.

Our programme of work led to 189 cases of theft in conveyance being resolved across our three regions in 2017/18, while a further 113 cases investigated during the year remained in progress. In the latter case UK Power Networks worked with property owners to facilitate appropriate connection arrangements (including the delivery of service upgrades where necessary) or was otherwise waiting for the customer's chosen supplier to carry out metering point 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 accordance with normal industry processes. Nevertheless, in a small number of cases it may become necessary for UK Power Networks to disconnect the unauthorised supply. In the absence of safety concerns we seek to avoid enforced disconnections; however, our policy makes such provision and we will take this step as a last resort to avoid the indefinite continuation of instances of theft.

In 2017/18 UK Power Networks made strident efforts to improve industry processes and to work with other distributors and suppliers to promote more effective electricity theft reduction efforts across the industry. We welcomed an invitation to present at the 2018 UK Revenue Protection Association Conference and have been active in a new pan-industry initiative which brings together suppliers and distributors to share ideas and best practice. We drafted and sponsored a formal change to industry processes to help with theft mitigation activities. Distributors are now mandated to either aid Crimestoppers with premise identification, ensuring that theft leads are passed to the relevant supplier, or otherwise confirm that they will follow up an apparently unregistered site. Additionally, we developed modelling now in use by suppliers across GB which assists them in fulfilling their obligations to apportion identified losses via electricity theft within the industry's settlement systems.

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 theft in conveyance cases in RIIO-ED1

Programme/ project title	Regulatory Reporting Year (2017/18)			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	0.15	3,913	1,969	6,925

Table 18: Summary of theft in conveyance losses activities in the 2017/18 Regulatory Reporting Year

Programme/project title	Description of unit	Volumes in 2017/18 Reporting Year[7]
Countering Theft in Conveyance	Resolved Theft in Conveyance Cases	189
	'In Progress' Cases	113

2.5 Other Environment-related Activities

2.5.1 Waste/Landfill/Recycling

We have set ourselves challenging targets of diverting at least 70% of office and depot waste from landfill and recycling 98% of street works spoil (waste left over from street works). In 2017/18 83.4% of office and depot waste was diverted from landfill and 99.3% of street works spoil was recycled. We have a new waste contractor, Viridor, appointed for 2018/19 who is auditing all our waste streams to see where improvements can be made.

We manage our waste streams according to a 'waste hierarchy' – see Figure 6.

Figure 6: Our waste hierarchy

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

This approach is underpinned by a number of waste-prevention initiatives, some new, some established:

- A company-wide internal communications campaign focusing on recycling during National Recycling Week 2017
- The commencement of audits of our waste streams (by Viridor) to seek solutions for difficult to recycle items such as used resin buckets
- 'Follow-me' printing at all our main office sites to reduce paper waste – when one of our employees sends a job to a printer they have to confirm at the printer itself that they want it to print, eliminating accidental wastage
- 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
- The recycling, refurbishment and reuse wherever possible of waste metal from items such as electricity transformers and switchgear
- A process to ensure 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 to ensure that trees trimmed or felled as part of our maintenance programme around power lines are chipped, mulched, left in piles to provide habitats for wildlife 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.

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

2.5.2 Joint Partnership Agreements

We continue to support the nine Wildlife Trusts in our three regions, both financially and through providing a volunteer workforce; a mutually beneficial arrangement which provides a source of income for the Trusts and assists us with team building and developing staff skills.

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.

2.5.3 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 associated with our transformers, substations and generators. During the 2017/18 regulatory year UK Power Networks received 35 enquiries and complaints about noise. These mainly related to substations and transformers, with a small number relating to alarms or street noise. These were reported in our RIGs worksheet E2 – Environmental Reporting (please see the Annexes and Appendices). Mitigation measures were installed in five cases.

To determine if our equipment is causing a disturbance, and to 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 investigation and provide guidance on specialist mitigation measures.

Low frequency noise is transmitted through the air or ground. If the noise is emitted by a substation that is integral to a building, it is usually ground-borne and can be mitigated through the installation of anti-vibration pads. Integrated substations are quite common in the LPN 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 they also prevent heat escaping which effectively down rates the operating capability of the transformer. It is possible to install a forced ventilation system but this in turn introduces another noise source.

Mitigations to deliver noise reduction frequently include safety considerations such as maintaining safety clearances 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.

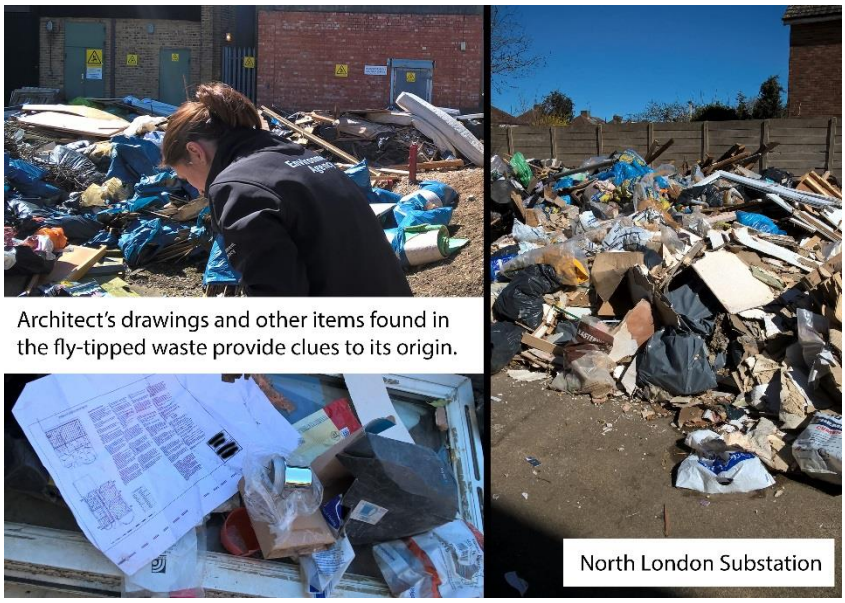
In 2017/18 world-first Noisetrap© panels were installed at a substation in the LPN region (see Figure 7). Designed by Sonobex Limited and manufactured and installed by Merford Noise Control, the screens are mounted as doors to the transformer bays and use coupled resonator elements to attenuate airborne noise whilst crucially allowing natural airflow to cool the electrical equipment inside the building. This solution reduced the noise levels outside the substation and helped to resolve the customer's complaint.

Figure 7: An innovative noise screen installation at a substation in our LPN region

2.5.4 Tackling Fly-tipping

We worked closely with the Environment Agency crime team in support of their efforts to secure prosecutions relating to criminal waste activities. Several of our North London substations were targeted by criminals who broke in and fly-tipped large quantities of building, household and commercial waste (see Figure 8). Before the affected sites were cleared and re-secured, UK Power Networks' Environment Advisers assisted with the search for evidence to identify the origin of the waste and those who had failed in their duty of care under the Waste (England and Wales) Regulations 2011.

Figure 8: Fly-tipped waste at our substations



2.5.5 Environmental Employee Training & Awareness

2.5.5.1. Environmental Awareness Course

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). The course is delivered by members of the company's Environment team and is available to all employees in relevant roles. Every new apprentice who joins the company completes this course to give them an understanding of environmental issues relating to our business and their role in preventing harm.

2.5.5.2. Environmental Awareness Day

In October 2017 our Environment team organised and delivered an Environmental Awareness Day in London. A range of staff attended including safety, health and environment professionals, operational managers, trade union representatives, together with contractors and suppliers.

This event aimed to raise the profile of the most significant environmental matters and to highlight our responsibilities both as a business and as individuals. Guest speakers presented on a range of topics including ecology, archaeology, low frequency noise, waste management, and legal duties. Delegates saw product demonstrations of pollution prevention equipment and had the opportunity to discuss and learn about new technologies.

The Environmental Awareness Day was well attended and very positive feedback was received. Comments included:

> "…it helped raise awareness of environmental issues from ecology to archaeology."
> "Great presentation on noise."
> "It was a very informative day…the activities and group work were great."

2.5.5.3. ISO 14001:2015

UK Power Networks' Environmental Management System is certified against the relevant international standard by DNV-GL. During 2017/18 key staff attended external training on the changes since the 2004 version and preparations were finalised for transition to ISO 14001: 2015.

2.5.5.4. External Engagement

We operate in 127 local authority areas and in the course of a year we will have many interactions with local Environmental Health Officers and on topics such as noise and fly-tipped waste. In May 2017 UK Power Networks' Environment Advisers attended a meeting of Environmental Health Officers from across Kent (in our SPN region). They gave a presentation on how the electricity network operates and discussed aspects where our respective roles interact. We used case histories to highlight the need for low frequency noise from existing substations to be considered when new developments are being planned, and for suitable mitigations to be included in the planning conditions. Other topics included fly-tipping and littering around our substations, electro-magnetic fields and the work of our Public Safety team in raising awareness about safety around the electricity network. We would be pleased to arrange similar events elsewhere in our operating area if required.

2.5.5.5. Flood Preparedness

In 2017/18 UK Power Networks continued to invest in ensuring that customer supplies are protected from flood risk and achieve its commitment of protecting 78 substations from the effects of flooding during the RIIO-ED1 period. This commitment typically takes the form of investing in physical asset protection at substations to ensure that customer supplies are not interrupted during an extreme flooding event.

In 2017/18 we successfully flood protected 12 substations with a total of more than 250,000 customer connections. Successful projects included the protection of over 20,000 customers at Crawley Town Primary Substation from river flooding risk. Protection was achieved by raising the height of surrounding transformer containment walls, installing specially designed flood resisting doors and installation of a waterproof membrane to protect the substation buildings from a low probability 1:1000 flood event, including factors for climate change.

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, many substations have been identified as being at risk of flooding from surface water or local failure of water infrastructure which can have a devastating effect in a congested city like London. Primary substations at Burlington Road and Wandsworth Central were protected from such flooding in 2017/18, resulting in the protection of over 49,000 supplies.

Investment has also taken the form of research, monitoring and ongoing risk analysis of flood risk across the UK Power Networks footprint. In 2017/18 we carried out 16 detailed flood risk assessments and have been working with multiple specialist companies to develop further capability in dynamic flood risk analysis across all three of our regions.

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

Our flood protection programme is supported by two key documents: our policy and design guidance document EDS 07-0106 – Substation Flood Protection, which is available for use by internal and external parties, and the industry best practice document ETR 138 – Resilience to Flooding of Grid and Primary Substations. UK Power Networks has been an active participant in the recently approved update of the latter document to ensure consistency in its approach and compliance to the best practice document. Where substation sites are developed and new buildings and plant are installed, these 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 1:1000 year flood level set by the Environment Agency, allowing for a climate change factor to ensure that mitigations are future-proof.

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 vulnerable equipment.

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.

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

3.1 Introduction

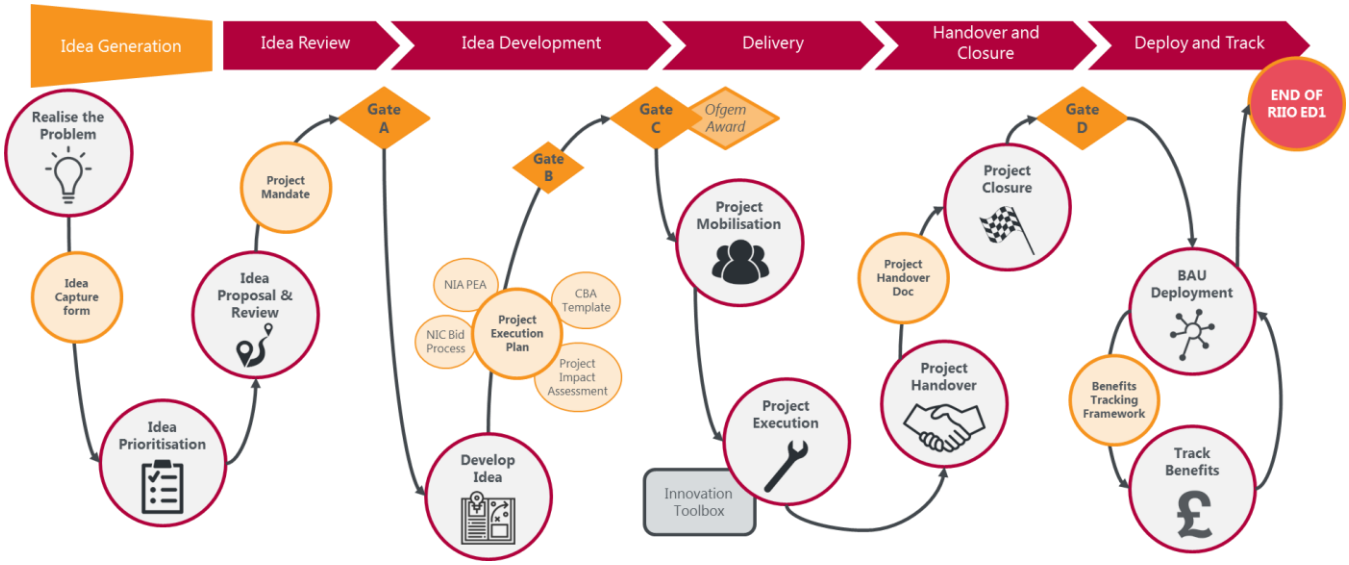
2017/18 has been a significant year for innovation at UK Power Networks. It marked the launch of our business change strategic project, Innovation Refresh, which aims to review our end-to-end lifecycle of innovation, from problem identification through to benefits realisation, to improve the process and ease with which the whole business is able to innovate.

The outcomes from this project are:

- Improved problem gathering from the business
- Increased volumes of ideas registered from external and internal sources, with greater granularity of source categories
- A higher transition rate from idea to project ratio, through a more robust idea filtering process
- An updated structured governance process to ensure innovation projects are managed to time, cost and outputs in accordance with our plans
- Clear benefits tracking from idea to realisation, linked to support our annual Regulatory Reporting Pack (RRP) submissions and more specifically the Environmental table E6
- Increased volumes of innovation projects delivered by business as usual owners

Our refreshed Innovation process is illustrated in Figure 9 below:

Figure 9: Our Innovation process



To achieve our vision of being the most innovative, we need to be able to measure our innovation performance. Table 19 demonstrates how we do this.

Table 19: How we measure our Innovation performance

Key Performance Indicator	Measure
Respected and recognised as leaders in our field by government and our regulator in the policy areas that are important to them	• Regular feedback from key stakeholders • We are regularly invited to provide input and expertise to their teams
We deliver the largest smart savings for our customers in ED1	• Largest savings listed in E6 smart savings in our annual RRP submission • Greatest number of reported innovative solutions over the period
On average top in the sector for innovation media coverage in the market over the four-year period	• Highest sentiment score in the Innovation category as independently measured by Alva Insight
Recognised as highly innovative by industry	• Prizes won in the key prestigious industry awards
Increasing collaboration	• Increased volumes of projects with other DNOs • Increased volumes of fast follow projects implementing other networks solutions to benefit our customers
Increasing innovation portfolio	• Increased innovation ideas progressing to projects • Year-on-year increase in innovation investment/funding • Year-on-year increase in project volumes across the business
Transition to business as usual	• Increased volumes of projects deployed into business as usual as reported in table *E6* in our annual RRP submission • Increased volumes of fast follow projects transitioned to business as usual

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. Renewable generation is ever more prevalent. In April 2018 there were three consecutive coal free generation days in the UK[8], highlighting the major changes occurring in the electricity system. Our three distribution networks boast 9GW of DG against a peak load of 16GW, accounting for one-third of all connected DG in the UK.

Wind generated more power than coal on 75% of days in 2017 and the cost is now cheaper than nuclear

The increased use of grid-scale storage, prompted by advancements in electricity storage technology. As at 11 July 2018, UK Power Networks alone had received just over 27.7GW of applications for battery storage, with over 1GW of connection offers accepted.

Carbon emissions in electricity are down 50% on 2012

A growing demand for electric vehicles (EVs). At the time of writing there are 164,000 plug-in vehicles in the UK, with over 55,000 in UK Power Networks' three regions.

[8] https://www.theguardian.com/business/2018/apr/24/uk-power-generation-coal-free-gas-renewables-nuclear

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

Innovation is 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 to 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
- **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

Effective engagement is key to our development as a business and to forging strong relationships with the many parties we interact with. 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 2017/18 Stakeholder Engagement and Consumer Vulnerability submission which is available here.

We recognise that the future is not planned alone. We focus heavily on sharing, educating on matters regarding networks, and most importantly listening and learning from actors across the value chain.

3.1.2 The Role of Networks in a Changing World

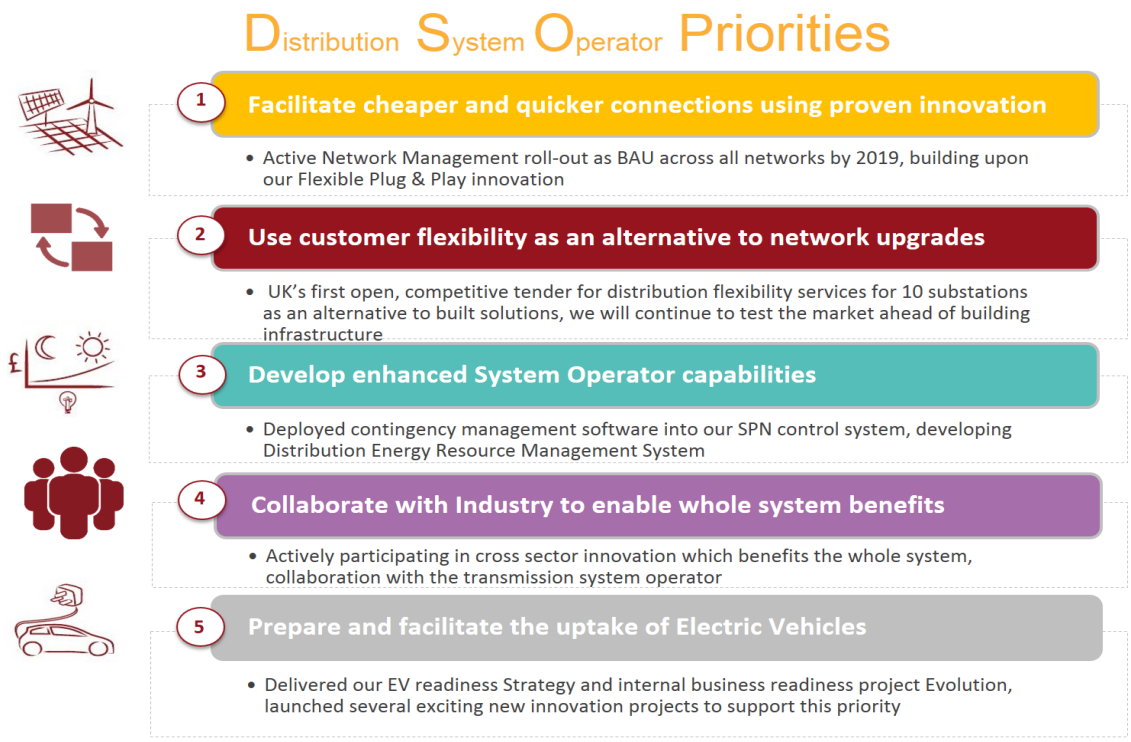
In recent years we have seen how our customers – motivated by efficiencies, new technologies and government policies – can drive radical changes such as the sudden and widespread connection of renewable generation, and more recently EVs, to our networks.

To support these changes and make the transition to a more flexible and agile energy system, we are transforming from a traditional DNO that simply manages network assets to a DSO that is transparent and proactive in enabling a smart flexible system that responds to customers' needs.

We remain focused on laying the foundations for a successful transition to a low carbon economy and continue to invest heavily in innovation. Our successful innovation projects are helping us develop key capabilities across our business whilst allowing our business as usual transition to build upon the initial concepts.

In order to deliver this transition, we have set ourselves a number of Future Smart DSO priorities (see Figure 10). We are pleased to have made significant progress against these priorities during the 2017/18 regulatory year.

Figure 10: Our Future Smart DSO priorities



3.1.3 The Low Carbon Challenge

The 2050 Climate Change Act targets require the UK to reduce carbon emissions by 80% 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% of generation should be low carbon. Technologies such as nuclear and carbon capture and storage would be included within this target
- The reduction of the carbon intensity of the transport sector from 125gCO_2/km to 102gCO_2/km by 2020 and 86gCO_2/km by 2030 implies that 9% of new car and van sales in 2020 and up to 60% 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% of homes and over half of business heat demand

As a DNO we believe that we have a crucial 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 EVs or to connect renewable generation. The following sections explain how UK Power Networks is preparing for a low carbon future.

3.1.4 The Generation Challenge

Over 9GW of generation is connected to our network

As at 31 March 2018 UK Power Networks had over 9GW of generation connected to its network in its three regions – with solar generation being the largest contributor. Our Flexible DG service, FDG, enables us to connect power sources such as wind or solar to constrained areas of network, delivering cheaper and faster connections and enabling schemes that previously would have been financially unviable to go ahead.

FDG has saved our connection customers more than £73.5 million in RIIO-ED1

FDG continues to deliver significant savings for connecting customers – in RIIO-ED1 alone it has saved our connection customers more than £73.5 million. Due to the success of this product offering, we have accelerated the roll-out of the solution across our network by the end of 2019 and have invested heavily in our back-office network management systems to facilitate this.

We have also developed an innovation project, known as Powerful-CB, to facilitate the decarbonisation of heat targets and maintain our assets within a safe fault-level operating range. Powerful-CB aims to demonstrate that greater quantities of DG can be connected to our 11kV distribution networks using Fault-Limiting Circuit Breakers (FLCBs). 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 UK Carbon Plan.

We are working with our technology partner, ABB, to develop the FLCB for use in a primary substation (Method 1) and in a customer's premises (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

Since 1990 the power sector has reduced its greenhouse gas emissions by 49%. DNOs have been instrumental in this progress by enabling the rapid connection of new renewable technologies.

UK Power Networks now has over 6GW of renewable DG connected to networks that were never envisaged to cater for distributed energy and two-way power flows. This is roughly equivalent to the capacity of two Hinkley Point C nuclear power stations. Despite the scale of this revolution we have delivered a step change in our performance, with reliability and service at consistently high levels and reduced distribution costs (roughly half the cost of an annual TV licence) for our customers.

However, it is clear that for the UK to meet its climate change targets by 2050 it needs a targeted approach for all sectors, not just electricity. This is now happening – with the spotlight firmly on transport to reduce both carbon emissions and dramatically improve air quality. These challenges have resulted in increased demand for EVs, with more than 80 new models expected to be available in the next two to three years.

Today, within our three regions, there are 51% more EVs on the roads than was forecast just three years ago. Clearly, with this scale of uptake it is imperative that we understand the implications for our networks and develop smart solutions to manage the change. We have been working hard to develop best in class EV uptake forecasts to ensure we deliver the correct solution, at the right time, for our customers.

We have identified five perceived barriers to the transition from an internal combustion engine vehicle into a plug-in electric vehicle:

1) **Cost** – Even with a grant subsidy from the government, customers see the initial purchase cost of an EV as a barrier. However, recent studies have shown that as much as 85% of vehicle sales are now via contract hire and when total cost of ownership calculations are conducted the transition becomes more favourable. Our EV team has seen this barrier lower considerably over the past 12 months
2) **Choice** – A key indicator of the strength of the UK market for EVs is the number of segments covered by the electric models currently available. More than 75 plug-in cars and vans available in 2018 now include superminis, large family cars, hatchbacks, estates, SUVs, executive models and medium-sized vans. Previous experience of introducing new technologies into the automotive market shows that having a broad range of both models and body styles is key to ensuring a strong uptake of new technologies. With the large numbers of brands and classes now available, the EV market has a strong base on which to continue to grow and, as such, this barrier is slowly lowering
3) **Range** – In 2017/18 the UK saw many new plug-in EV models launched. These new models offer greater range, with many battery EVs averaging between 150 miles on a single charge. Battery capacities now average 50 kWh and range has been extending year on year, lowering this barrier to transition
4) **Performance** – This is often only perceived as a barrier – when compared to the ICE equivalent the pure electric variants offer better performance
5) **Charging** – Today, limited availability of public charging stations is the biggest barrier to the adoption of EVs. This is where UK Power Networks aims to facilitate the transition to zero emission vehicles, and charging will be the focus of this section of the report

Despite these challenges, our core objectives remain the same: keep the lights on, deliver a great service and invest efficiently in the network. We have a very clear strategy to achieve these outcomes, which will enable the uptake of EVs at the lowest cost for our customers. In January 2017 we established an EV working group to create an EV Readiness Strategy and response plan (see Figure 11).

Figure 11: Our EV Readiness Strategy and response plan

Our EV Readiness Strategy comprises the following 'strategic pillars':

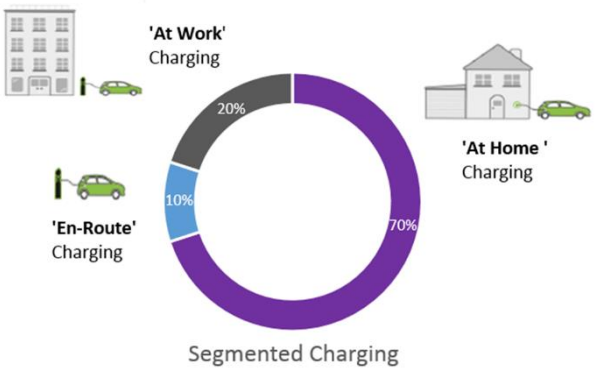
1) **Forecasting** – Given the challenge identifying where EVs could cluster on our network, and in the absence of smart meter data, we are collaborating with partner organisations and academic institutions to build a comprehensive EV data set and advanced analytics to pinpoint the neighbourhoods where targeted intervention could be required
2) **Deploy monitoring and control** – We are investing heavily in developing state of the art active control and monitoring systems for our LV network. Our EV analytics steer us to where we need to deploy network monitoring and should we discover that the network requires intervention, we are able to deploy controllable solutions in response

3) **Deploy Smart solutions** – We are investing in both commercial and technical innovations to enable our customers to connect faster and cheaper than ever before. For example, our work with UPS installing smart charging solutions coupled with energy storage has enabled a 270% increase in the number of electric freight vehicles that can operate out of one of its biggest central London depots whilst avoiding the costs and time for traditional upgrades to the network

EV charging segments

In 2017 UK Power Networks' EV Market Intelligence team devised three charging segments to quantify where most charging sessions would occur: home charging, at work (or destination) charging, and en-route charging. These are illustrated in Figure 12 below.

Figure 12: The three EV charging segments



Installing a 7kW EV charger has the potential to triple the load on an average domestic property that would typically consume 2kW and currently there is no requirement to notify network operators when one is installed. This is a significant challenge – the equivalent of being faced with the potential requirement to serve three times the number of customers we supply today without knowing where those extra customers live. For this reason we think it is key that DNOs see the notification of EV chargers in domestic properties become a mandatory requirement.

We are innovating to enable this revolution by working in collaboration with other organisations that bring complementary skills in technology, data and customer innovation. We are confident that through this work we will continue to facilitate the UK's successful transition to a low carbon future.

Meeting the EV challenge is a strategic priority for UK Power Networks. In 2017 we established a dedicated EV working group comprising staff from key departments across our business. This group developed Evolution – an EV readiness project consisting of nine workstreams – to ensure we are at the forefront of facilitating the electrification of transport. We have developed innovation projects to support our preparations for an increased uptake of EVs – see below for examples of the large demonstration innovation projects we have underway.

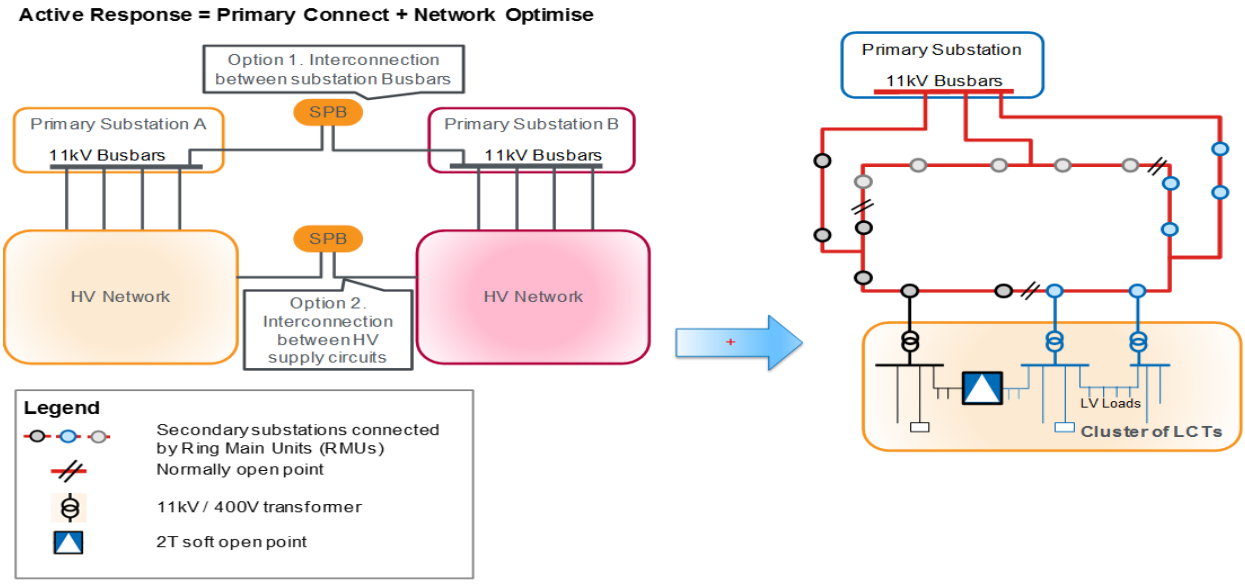
Active Response

For DNOs, the uptake of low carbon technologies has been more rapid than expected. Notably, the number of EVs registered in UK Power Networks' three regions has exceeded our RIIO-ED1 business planning forecasts by 51%. National Grid's 2017 Future Energy Scenarios expect this to materialise as 3.5GW of additional peak demand across GB by 2030.

In response to this uptake we propose to demonstrate two solutions (please see Figure 13):

1. **Network Optimise** – optimisation and automatic reconfiguration of HV and LV networks in combination using remote control switches and Soft Open Points (SOPs)
2. **Primary Connect** – controlled transfers between primary substations using a Soft Power Bridge (SPB) to share loads and optimise capacity

Figure 13: The Primary Connect and Network Optimise solutions



Automation, optimisation and power electronics to enable load sharing at HV and LV

We estimate that by 2030 Active Response solutions could save customers £271 million in reinforcement costs, which is roughly equivalent to £9.34 from every electricity customer's bill. The project methods will also enable carbon savings of 19,592tCO_2 eq. and capacity benefits of 4.2GW by 2030. For more information about this project, please visit our Innovation website:

http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/active-response/

3.1.6 The Heat Pump Challenge

We have seen a relatively small uptake of heat pumps in 2017/18; only 1,013 were connected to our networks during the year. In its 2017 Future Energy Scenarios, National Grid observed that decarbonisation of heat is where the biggest change needs to occur in order to achieve the 2050 carbon target documented by the Committee on Climate Change.

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 (e.g. solar) to use at night time. At UK Power Networks we work with two main categories of storage – fixed and moveable. An example of moveable storage is Vehicle to Grid (V2G).

Fixed grid-scale storage continues to be an area of major commercial interest for developers, manufacturers, construction partners, regulators and government. As of 11 July 2018 we had received 1,574 applications to connect battery storage for a total capacity of just over 27.7GW – see Figure 14 and Figure 15.

Figure 14: Formal storage applications

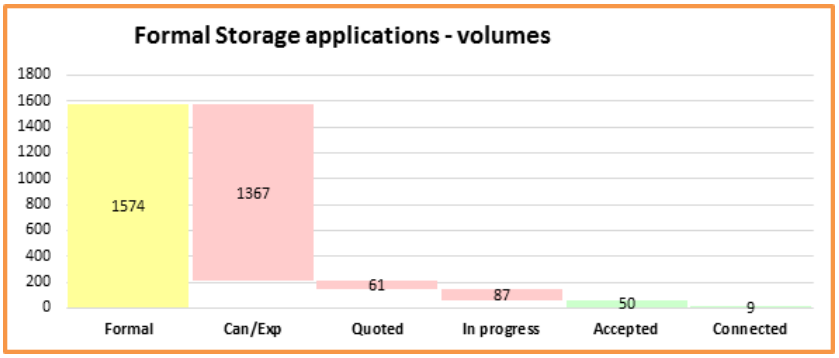
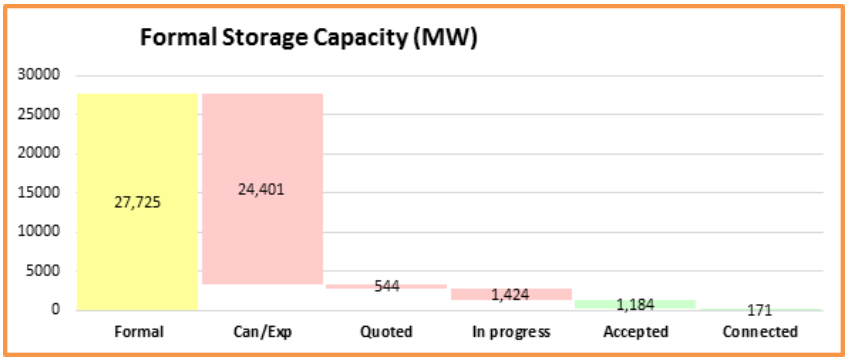


Figure 15: Formal capacity applications



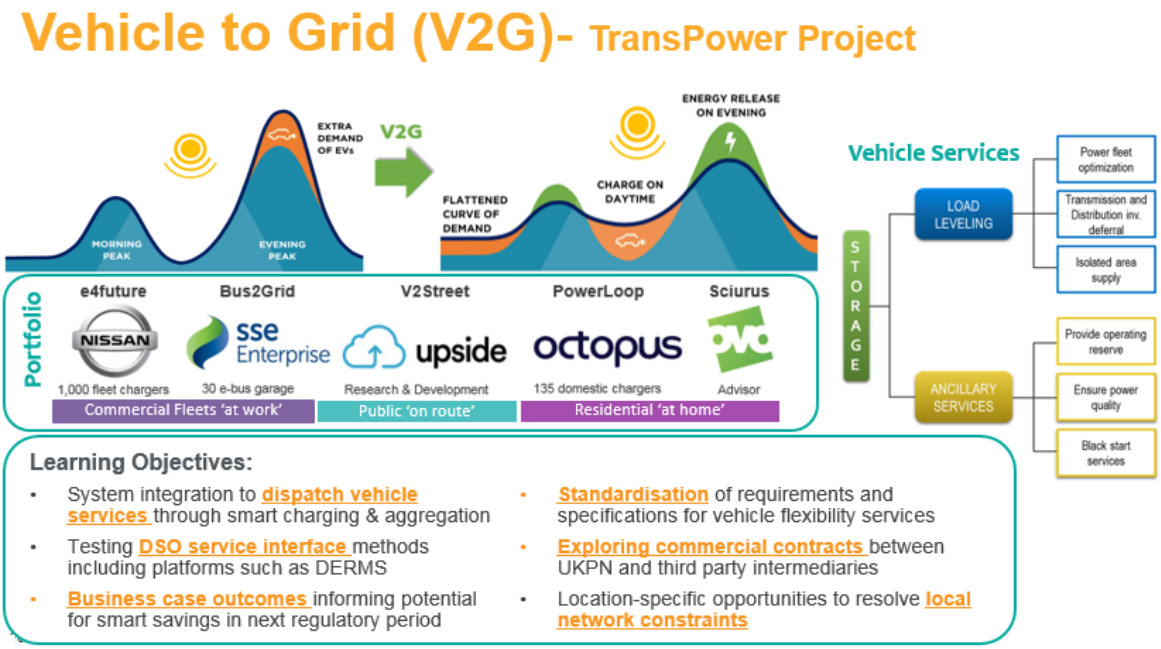
The rate of acceptance versus application remains at a low level. This is mainly attributable to the pre-requirements of a competitive grid connection when bidding in the capacity market. While volumes of applications do not follow a set annual trend, they do track the market incentives. On balance, overall volumes remain similar between the regulatory years, with different time profiles. The reduction in June and July 2018 is attributed to the inclusion of an assessment and design charge.

V2G technologies are expected to play an important part in making the UK's electricity supply network smarter and in encouraging take-up. Vehicles that can import electricity from the grid when demand is low and export it when demand is high could help to even out peaks and troughs and make the grid more efficient.

To support the development of this technology, £30 million was made available in January 2018 from the Department for Business, Energy & Industrial Strategy (BEIS) – working with the Office for Low Emission Vehicles (OLEV) and Innovate UK – to fund projects that investigate new business models, consumer awareness and technologies that support interaction between EVs and the grid.

We actively encourage the development of technologies which are able to support the grid at a local level. To this end, we have partnered on five successful V2G projects in support of the government's innovation initiative, investing over £1 million via a Network Innovation Allowance (NIA) project called TransPower (see Figure 16 below).

Figure 16: The TransPower V2G project



3.1.8 Key Emerging Opportunities

Future Smart – delivering 'a smart grid for all'

The UK's transition to a low carbon economy is revolutionising the way we generate, distribute and consume electricity. As you will see from our Future Smart Animation Video, an increasing number of people will have electric and driverless cars, use smart appliances in their homes and generate, store and sell their own electricity. New market players will be able to act as third-party intermediaries between customers and the energy market, helping them manage their household or building package – whether that be mobility, comfort or entertainment – to optimise experiences across their lifestyle and working day. As a DNO we recognise that we need to evolve to meet these changing needs and prepare for those yet to come.

Our Future Smart strategy of transforming UK Power Networks into a DSO is central to our low carbon approach and we are well underway with our plans. We are committed to delivering 'a smart grid for all' so that customers and communities benefit from a decentralised, decarbonised and digitised energy system.

A key part of our approach to developing our DSO capabilities is to embed successful innovations into the business. Innovation has already delivered £149 million of smart savings to customers and deployed 22 innovation solutions as business as usual over the first three years of our RIIO-ED1 Business Plan, helping us deliver decarbonisation at the lowest cost to customers. We continue to invest in innovation to develop our DSO capabilities.

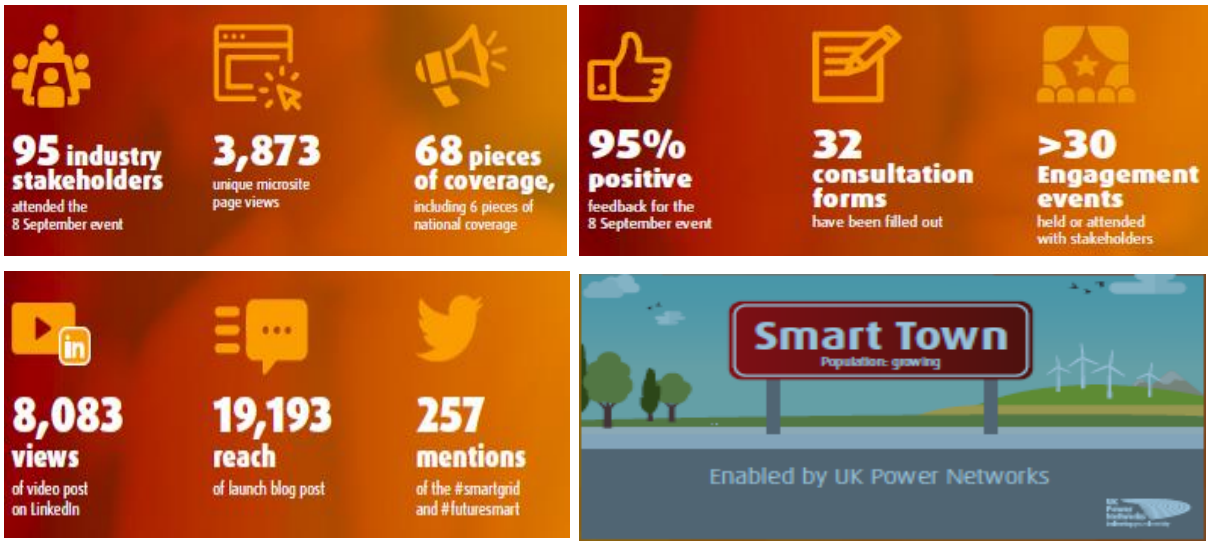
Customers helping to shape our plans to deliver 'a smart grid for all'

At a time of unprecedented change in our industry it is more important than ever that we listen, collaborate and share to deliver 'a smart grid for all'.

Customer collaboration is directly influencing UK Power Networks' plans to implement our vision of a smart future where networks are reliable, smart and flexible, to enable customers to benefit from exciting energy developments and keep costs down.

In 2017 we ran a consultation and a series of engagement events on our Future Smart strategy and DSO priorities with a wide range of stakeholders. An overwhelming majority (90%) of our stakeholders agreed with our definition of the DSO capabilities that will be required and the priorities that we proposed in our DSO plan. Figure 17 shows how we engaged with our stakeholders.

Figure 17: Our methods for engaging with stakeholders



You can read in detail what our stakeholders had to say in our What our stakeholders said report, including how we are responding to their feedback.

Listening to our stakeholders and delivering on our smart grid plans

Stakeholders' views have had a strong influence on our 2018/19 DSO plans and we are delivering on our commitments to make this future a reality. Our DSO strategy now identifies five priority areas (see Figure 18):

Figure 18: Our priority areas for 2018/19

To learn more about our smart grid plans, please click here.

DSO Priority 1 – Facilitating quicker and cheaper connections using proven innovation

Delivering cleaner, greener, cheaper electricity though flexible connections

Our innovative connection offer, Flexible Distributed Generation (FDG), uses ANM to enable more renewable energy to be connected to the electricity network in innovative, customer-friendly and cost-effective ways.

FDG has removed potential barriers to UK renewable generation developers. It uses innovative connection methods without major cabling and substation works, and lowers connection costs, which incentivises growth of wind and solar farms. We estimate it has saved our customers more than £73.5 million in connection costs, by reducing the need to build new electricity network infrastructure. In 2017/18 this connection method saved 20,394tCO_2e – roughly equivalent to 250,000 trees.

We offer this connection service in return for customers accepting a 'flexible' connection where the electricity output is curtailed for short periods when the network is highly utilised to keep power flows within safe and reliable limits. ANM technology is used to automatically manage the electricity generators' output.

Stakeholders asked us to implement the roll-out of ANM two years earlier than planned, to support earlier access to flexible connections. We have successfully responded by producing roll-out plans and bringing forward the roll-out of FDG connections in each of our three regions by the end of the 2019 calendar year. The plans outline when each Grid Supply Point (GSP) will be opened for FDG connections. Our flexible connections roll-out plans for the East of England, south east of England and London can be found here.

DSO Priority 2 – Using customer flexibility as an alternative to network upgrades

Maximising connected network resource to reduce network investment and drive lower costs in customer energy bills

Traditionally we would upgrade and reinforce our network assets through additional cabling and substations to accommodate growing peaks of demand on the network. The capability to reduce these peaks allows us to delay investment until it becomes clear that reinforcement is required. We can also use it to manage outages, to increase network security.

We are running market tenders for flexibility services such as DSR (solar farms, wind farms, storage etc.) so that we avoid expensive, inconvenient, environmentally impacting upgrades and deliver the low carbon transition at the lowest cost to our customers. UK Power Networks was the first electricity network operator to launch a public tender in 2017 for flexible services such as DSR to manage local energy and operate its network more efficiently. We have successfully awarded the first flexibility contract with the option to utilise batteries installed in nearly 40 homes across the London Borough of Barnet through the manufacturer and aggregator Powervault. This will enable local residents to save on their energy bills – and earn from their batteries, as they will receive payment when these discharge.

Stakeholders asked us to continue to run flexibility tenders for DER and provide a flexibility roadmap to help provide market certainty and visibility. This is exactly what we have done and the roadmap has been launched.

We have also partnered with the software company Open Utility to develop and trial a ground-breaking online marketplace for local flexibility, called Piclo Flex. This innovation will digitalise, streamline and optimise how flexibility providers bid in their flexibility services and help connect us to smarter alternatives to manage and operate our networks.

DSO Priority 3 – Developing enhanced System Operator capabilities

Collaboration with the System Operator (SO) to realise additional generation capacity in the highly utilised networks

We are working in collaboration with National Grid on two key initiatives to improve transmission and distribution coordination with each other, to ensure a beneficial whole-system approach to managing the local and national electricity networks.

- **Power Potential**

  Our innovation project Power Potential will help us make the best use of existing and new DER resources on our network. It will support the growth of low carbon technologies such as wind and solar power and help us to manage the operational challenges that the intermittent generation of renewable energy presents.

  By creating a reactive power market in the South East, we believe that Power Potential can deliver over 3.7GW of additional generation capacity in the area by 2050 and reduce the need to build additional electricity infrastructure. If the approach we are trialling could be introduced nationwide, it could save customers more than £400 million by 2050.

  We want to create new opportunities for our customers. By setting up a market, we can ensure that the Power Potential approach helps manage the whole electricity system whilst delivering the most cost-effective solution to the customer within the wider electricity system.

- **The Regional Development Programme**

  The South East electricity system is one of the most complex areas of network in Europe with several interconnections to continental Europe, a nuclear power station and a significant volume of renewable energy resources. The network supplies electricity over an area of approximately 8,200km^2, incorporating all of Kent, East Sussex and much of West Sussex and Surrey.

  The continuing evolution to a decentralised generation landscape and incentives to deliver clean energy have put a strain on an already heavily loaded part of the system. Currently there are over 1.8GW of embedded generation and 3.6GW of transmission connected generation in this area alone, with 2GW of HVDC interconnector contracted and coming online in the next three to four years. This requires both National Grid and UK Power Networks to consider a collaborative, whole-system approach to managing and optimising network capacity. Doing so will reduce the need to build costly transmission infrastructure, meaning customers will continue to benefit from cheaper and quicker connections.

DSO Priority 4 – Collaborate with industry and others to enable GB-wide benefits

Working with industry and forging partnerships to deliver a smart grid that is inclusive to all customers and leaves no one behind

We are working on a key industry project and are leading innovative partnerships to inform and educate customers about the exciting opportunities that lie ahead in the energy sector. As we transition to a DSO, we will strive to bring all of our customers and stakeholders along with us.

- **The Open Networks Project**

  The ENA Open Networks Project is laying the foundations of the smart grid in the UK and is helping to inform similar developments in Ireland. It is a key initiative to deliver government policy set out in the Ofgem and BEIS Smart Systems and Flexibility Plan, the government's Industrial Strategy and the Clean Growth Plan. UK Power Networks is actively contributing to the project in collaboration with Ofgem, BEIS, 10 of the UK and Ireland's electricity network operators, and other key stakeholders.

  The project works with stakeholders to develop arrangements to meet the smart energy future via a collaborative environment to share innovation and best practice, bringing together experts to develop potential arrangements that deliver new revenue opportunities for stakeholders and value for the end customer. As such it will support the enablement of a whole range of new energy technologies that generate, consume and manage electricity, delivering low carbon energy for the UK.

- **Supporting community and local energy growth**

  Our role is to inform, educate and enable stakeholders to connect more flexible and distributed forms of energy, avoid the need for costly reinforcement, enter the market to provide flexibility services and keep bills as low as possible.

  We have published a series of EV guides to provide awareness, information and guidance on key topics for target audiences. We continue to play an educational and informational role to ensure that all customers and stakeholders are aware of the opportunities the future holds.

  We recognise that community energy organisations and local authorities have an important role to play in the future of energy. This has been reinforced by feedback from our stakeholders, who have asked us to support local energy growth as well as inform and educate different customer groups. We are responding to this request by working with trusted stakeholder groups to help us understand their needs and develop useful guidance.

In support of community energy organisations, we have set up a strategic partnership with Community Energy England. We jointly launched a new dedicated community energy webpage on UK Power Networks' website to act as a knowledge centre, support community energy growth and help community energy organisations navigate their interface with UK Power Networks. We are also leading a consultation in partnership with Community Energy England to understand community energy needs and learn how community energy organisations want to be supported, and what improvements we can make to our services in response to their needs.

- **Understanding how vulnerability might change as a result of the changing energy landscape**

  The transformation in energy could significantly alter the way in which individuals and households engage and consume electricity and there is the risk (as arose with the advent of broadband) of some customers being left behind and/or placed in vulnerable circumstances. Stakeholders who recognised this asked us to explore our role in relation to those without the flexibility to change their energy use habits.

  We will commission research to understand the impact that future energy has on vulnerability. In particular we would like to understand how – alongside fuel poverty and Priority Services Register (PSR) needs – financial capability, digital skills and the implications of flexible time of use tariffs on customers whose energy use cannot be flexible will change the nature of vulnerability. As part of this exercise we will also look to understand the role that we and other organisations have in supporting customers in vulnerable circumstances.

DSO Priority 5 – Prepare and facilitate the uptake of EVs

Facilitating the electrification of transport and supporting customers' changing mobility habits

Please see section 3.1.5 where EVs are covered in detail.

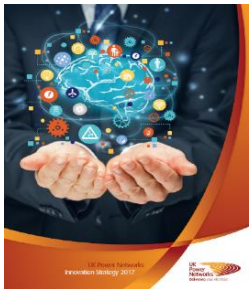
3.1.9 Volumes of Low Carbon Technologies deployed in 2017/18

Table 20 details, by licensee, the volumes of each low carbon technology deployed in 2017/18. 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 2017/18

Technology type	EPN	LPN	SPN	Total
Heat pumps	769	18	226	1,013
EV slow charge	638	445	427	1,510
EV fast charge	2,453	1,114	1,538	5,105
PVs (G83)	1,462	201	1,000	2,663
Other DG (G83)	-	-	-	-
DG (non G83)	80	17	51	148
Total	**5,402**	**1,795**	**3,242**	**10,439**

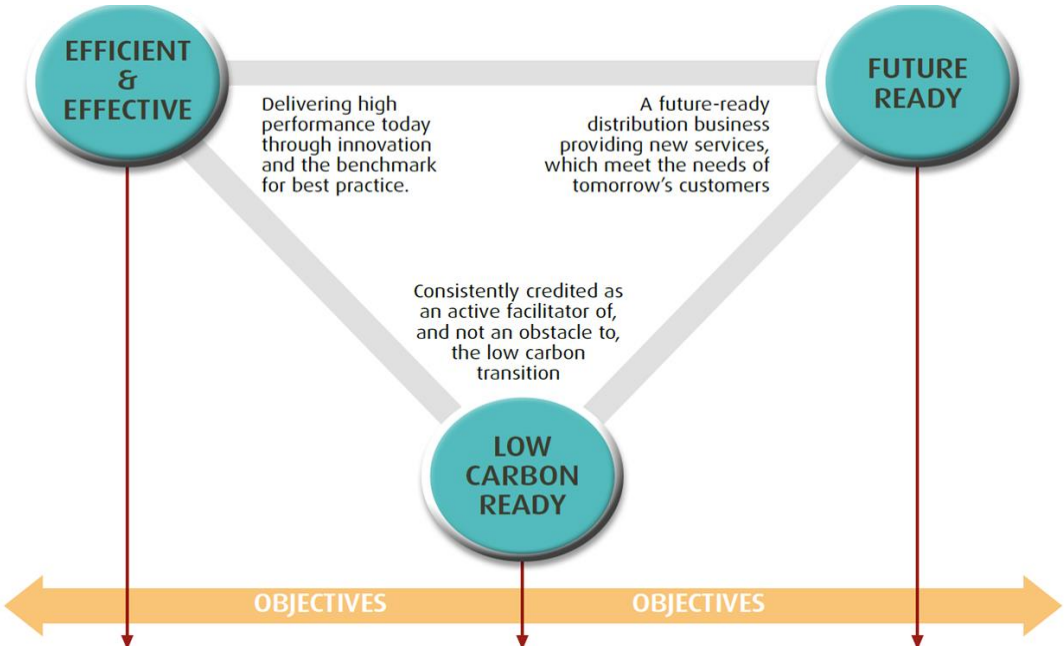
3.2 Progress of the Innovation Strategy



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 in March 2017 and is available here.

The key change we 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 19.

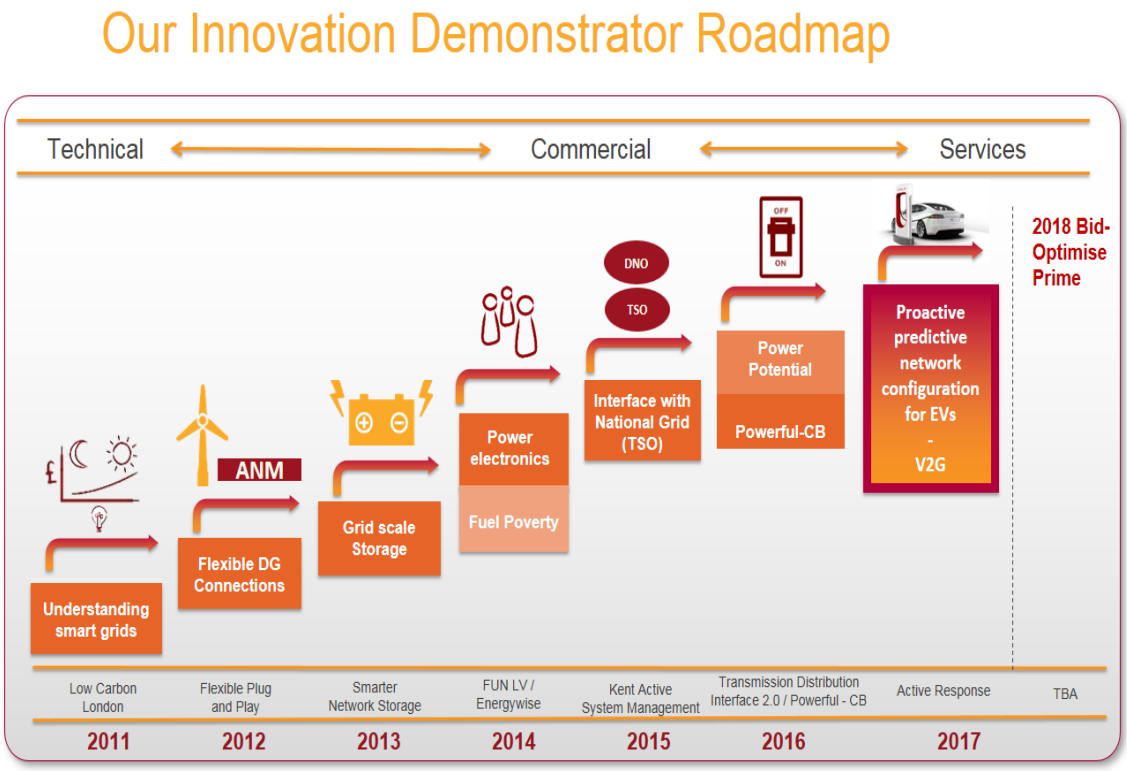
Figure 19: The focus areas of our strategy



- **Deliver good business value** – by maximising the smart savings delivered for customers
- **Deliver measurable social, environmental and safety benefits through our innovation projects** – including customer interruptions, customer minutes lost, 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

Our large innovation demonstrator projects are formulated in support of our Innovation Strategy through long-term horizon scanning – see Figure 20.

Figure 20: Innovation Demonstrator Roadmap



For further information about our Tier 2 and NIC projects, please visit our website.

Of the 46 ongoing innovation projects 39 have been funded under the NIA, four have been funded as Tier Two or NIC projects and three have received funding from other sources.

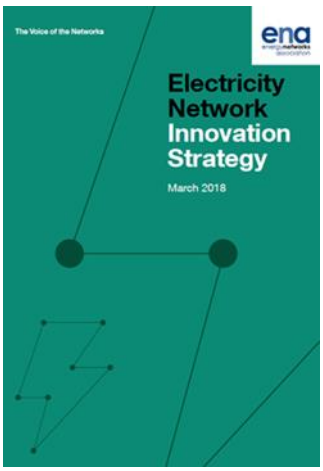
Our 2017/18 NIA Annual Summary can be found here. This lists all ongoing NIA funded projects, detailing how they align to our innovation themes and hence our overall strategy. Further information about UK Power Networks' expenditure under the NIA can be found on our website or on the Smarter Networks 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 2017/18 expenditure.

Table 21: A summary of our LCNF Tier 2 and NIC projects

Project	Licence area where trialled	Start date	Planned end date	Total budget	2017/18 expenditure	Funding Mechanism
Active Response	EPN and LPN	January 2018	November 2021	£17,023,824	£8,867	NIC
energywise	LPN	January 2014	August 2018	£4,246,417	£805,982	LCNF Tier 2
KASM	SPN	January 2015	December 2017	£3,852,501	£723,446	LCNF Tier 2
Powerful CB	LPN	January 2017	April 2020	£5,301,041	£1,193,667	NIC
TDI 2.0	SPN	January 2017	December 2019	NG led	NG led	NIC

In 2017 all DNOs joined forces to compile a single Electricity Network Innovation Strategy (ENIS). This sets out a jointly agreed approach to how innovation can best accommodate the future requirements of the energy system in its entirety and lead to the effective delivery of benefits in a collaborative and cost-effective way.



A rapidly changing environment requires new innovative strategies from all participants, including fundamentally different approaches to business and to serving customers and embracing a range of technical and commercial innovations to do so effectively.

Key drivers for the changing energy system in this context include:

- Shifting power generation sources
- Changes for customers in terms of choice and demand
- Policy drivers related to decarbonisation of heat and transport
- A greater focus on sustainability
- Regulatory trends to ensure a smart, flexible system with greater local system operation responsibilities for DNOs

These trends will give rise to the need for further innovation from DNOs (including UK Power Networks) and will simultaneously pose a number of challenges. We have synthesised these challenges into five themes which can be found here.

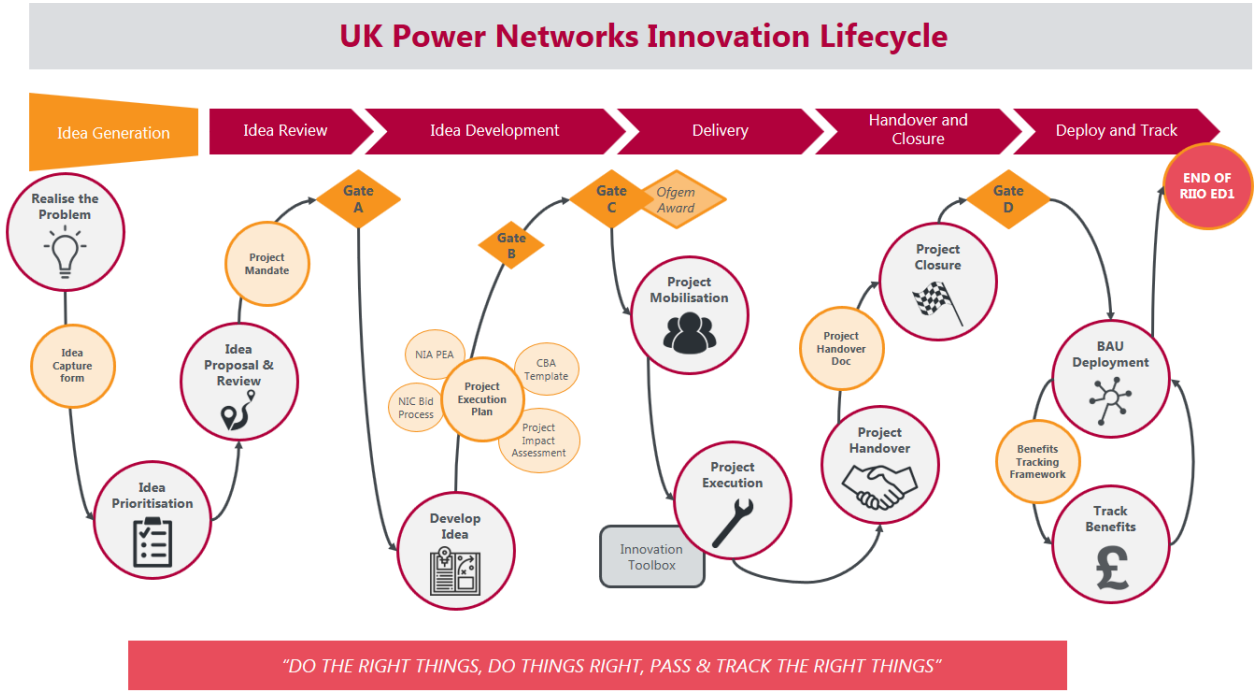
3.3 Roll-out of Smart Grids and Innovation into Business as Usual

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 22 Innovative Solutions since the start of RIIO-ED1 – 11 in 2015/16, eight in 2016/17 and a further three in 2017/18. These solutions are reported to Ofgem in our 2017/18 RIGs submission. Further information is provided in our RIGs worksheet E6 – Innovative Solutions (please see the Annexes and Appendices).

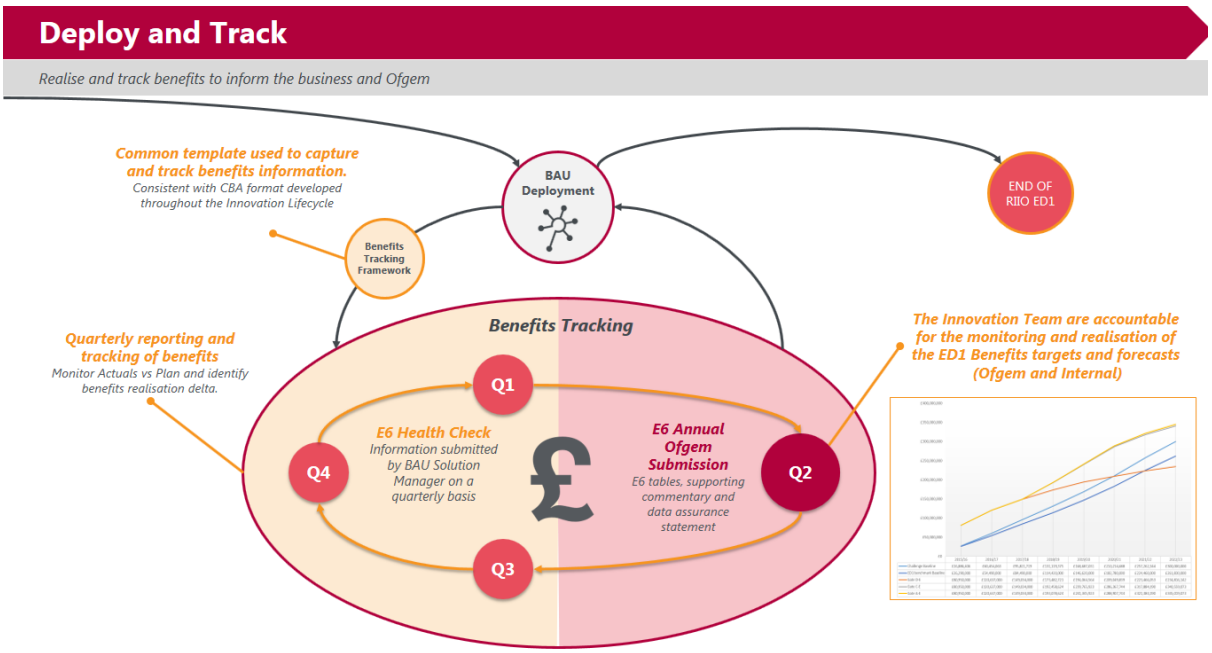
Our Innovative Solutions are at various stages of roll-out. Throughout their lifecycle they undergo a process of assessment, development and monitoring through to a completed roll-out to business as usual. This process is captured in our Innovation lifecycle process, as shown in Figure 21.

Figure 21: Our Innovation Lifecycle



If we extract the transition to business as usual (the 'deploy and track' element of the lifecycle), the process conducts a co-ownership period between the innovation team and the business solution owner, and at handover a full regulatory framework is completed to ensure business uptake and use of the solution is maximised. This is illustrated in Figure 22.

Figure 22: The deploy and track process



To ensure compliance with the RIGs for E6, UK Power Networks' benefits framework comprises the following activities:

- **Capture, assess and develop 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 2017/18 Innovative Solutions

The following pages provide an overview of each of the 22 Innovative Solutions delivered within one or more of UK Power Networks' regions during the 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

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% 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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.2. LPN Interconnection

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 whilst 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 (which are normally open). By designing the network with larger numbers of 11kV feeders connected in this way (i.e. as a feeder group), resilience can be maintained, with significant benefits in the percentage utilisation of each individual feeder.

This arrangement allows for higher circuit utilisation levels, since each 11kV circuit (for a four-feeder group) can be loaded to 75% of its thermal capacity (or 80% for a five-feeder group), as opposed to 50% 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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.3. Energy Storage

This solution involves the deployment of utility-scale batteries to provide ancillary services (i.e. load following) as well as peak loping to reduce distribution reinforcement need. 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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.4. FUN-LV

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 DG 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.

This solution did not deliver any benefits in 2017/18. These are due to be delivered in RIIO-ED2.

3.3.2.5. Demand Side Response (DSR)

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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.6. Common Network Asset Indices Methodology (CNAIM)

The 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 assets with health indices 4 and 5 which are closer to ratings 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 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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.7. Joint Shell

LV lead cable 'T' joints which 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 make a cost-effective deferment of our asset replacement investment policy and reduce customer interruptions and customer minutes lost caused by joint failures.

During the regulatory year 2017/18 we installed 90 units on the 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.

A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.8. Oil Regeneration

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, and 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. We did not utilise this solution in 2017/18 due to the onset of new technology which has superseded it.

3.3.2.9. LV Re-energising Devices

During 2017/18 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 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 types of LV re-energising device are used at secondary substations across all three of UK Power Networks' regions in order to reduce customer interruptions and customer minutes lost. They are both installed on LV boards, directly replacing fuses. In 2017/18, 1,284 LV re-energising devices were deployed and are operating on UK Power Networks' distribution network, of which 117 are ALVIN Reclose devices and the rest are Bidoyngs.

Further details of this Innovative Solution are provided here. A link to the detailed CBA for 2017/18 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

The Automated Power Restoration System (APRS) virtual model of the electricity network is an algorithm triggered when an 'unexpected' trip is received via SCADA where it is deployed. The algorithm traces the circuit, polls SCADA on the circuit and identifies the fault from Fault Passage Indicators and/or Protection devices. It uses the current running conditions, isolates the identified fault and restores healthy network after checking loads. This 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 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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.11. 3.3.2.11: Public Safety

This Innovative Solution targets safety efforts in agricultural areas in our EPN and SPN regions, 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 our 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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.12. LiDAR Vegetation Management

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

The solution is being used to provide greater confidence in using the allocated budget in the most targeted and efficient manner, to minimise the impact of tree (growth)-related faults. It further helps to reduce the amount of cutting required to achieve better levels of fault prevention as in DPCR5.

UK Power Networks saves surveying costs by using LiDAR or similar techniques to produce an intelligent risk-based cutting programme, contributing towards cost-savings through targeted tree cutting.

Further details of this Innovative Solution are provided here. A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.13. Flexible Distributed Generation (FDG)

This solution was initially implemented through our LCNF Tier 2 funded project Flexible Plug and Play (FPP) and has since been deployed as a business as usual service known as Flexible Distributed Generation (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 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 distribution network at a lower connection cost, which allows 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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.14. Load Blinding Relays

This solution uses protection relays with 'load blinding' functionality to manage constraints and maximise network utilisation by connecting more DG. Load blinding relays allow 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 overhead 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.

Due to the reduction in volumes of DG connections, this application was not deployed in 2017/18.

A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.15. Distribution Network Visibility (DNV) application

DNV is a web-based application which 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. It is primarily used to inform network planning decisions and proactively manage UK Power Networks' distribution networks. DNV is used by our distribution planners to assess connection requests and is delivering benefits by 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)

The PoC mast and underslung ABSD are both 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 dressing 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. While they may not be used as the first option for all connections (in some cases wood pole solutions could offer better value), they offer a lower-cost alternative in cases where an expensive tower replacement would otherwise be required.

Due to the reduction in volumes of DG connections, this application was not deployed in 2017/18.

A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.17. Timed Connections

This solution is currently under development and is NIA registered and funded. It offers customers time-dependent connections which allow a higher MVA level to be taken in periods of reduced network demand.

For load generation connections, customers can be offered up to four time slots per 24-hour period and these time slots indicate the periods when they are allowed to consume/generate with additional capacity. Customers wishing to charge EVs over their connection require a large connection agreement; however, these are difficult and time-consuming to accommodate and come at a high cost to the customer. Two bus garages in London agreed to accept innovative time-restricted connections, allowing them to have a higher demand (as set out in their connection agreement) in the evening (23:00-07:00), and this arrangement allowed their connections to be made faster and cheaper. This alternative connection solution can also be offered to generation and storage customers.

A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.18. Innovation Bunding

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 1,000 kilograms of excavation avoided by this solution we will be able to save 2 kilograms 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 50cm: 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; and
- 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 two hours for a grid site).

A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.19. Perfluorocarbon tracer (PFT) fluid-filled cable leak tracer

Leaks from 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 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.20. 3D Laser Surveying

This solution uses a scanner with LiDAR (laser imaging, detection and ranging) technology. The information captured using 3D scanning can then easily be turned into traditional 2D diagrams.

A 3D laser scanning device is being used to take records of sites, instead of a traditional two dimensional (2D) topographical survey. 3D surveys were introduced in UK Power Networks in 2015 and have been extremely beneficial on a number of occasions. The benefits of using this type of technology are:

- The 3D scans enable detail to be captured which would be extremely complex in a traditional 2D survey
- It is more accurate than a topographical survey, with 0.5mm tolerance
- For a very complex site, it is much faster to collect data compared to a traditional survey
- For a high-risk site or confined spaces, the reduction in time required to complete the survey also results in improved safety

A 3D laser scan is more cost-effective than a traditional survey, due to the reduced labour required to conduct the survey using technology.

A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.21. Woodpecker Hole Filler

This solution repairs woodpecker damaged poles by using a filler. Used correctly it strengthens the damaged pole, avoids expensive replacements and reduces the chances of rot developing as a consequence of the holes. This solution can only be applied in certain scenarios based on the number, extent and distance between holes.

A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.2.22. Mobile Asset Assessment Vehicle (MAAV)

A MAAV surveys the carriageways of London, searching for contact voltage faults on our LV network. When a fault is detected the technicians will exit the vehicle and use handheld test equipment to pinpoint its location as well as an acceptable ground reference location. The data is recorded using a laptop computer installed in the truck and is stored in the Amazon EC2 storage environment.

The MAAV delivers benefits in three main areas:

- Reduced losses – Many of the events identified by the MAAV represent significant losses on the LV system. Through proactive identification and repair, losses at this voltage can be significantly reduced. There are also significant avoided emissions associated with reduced losses
- Avoided customer interruptions – Treating the detected contact voltage will prevent a possible LV fault, thus avoiding customer interruptions and customer minutes lost
- Improved safety – Some of the structures which are identified pose safety concerns to the public or our staff and contractors. The underlying faults may be the responsibility of customers, local councils or UK Power Networks; regardless of who is responsible for the underlying fault, proactive identification significantly reduces the safety risk for all

More information about this solution can be found here. A link to the detailed CBA for 2017/18 solution performance can be found in the Annexes and Appendices.

3.3.3 Innovative Solutions in 2018/19

Looking ahead to 2018/19, across our portfolio of deployed Innovative Solutions 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, DSR, 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 2017/18 than in previous years)
- 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 will continue to deliver benefits at a similar level, as noted in table E6 of our 2017/18 RRP submission

- The 22 solutions currently deployed by UK Power Networks will deliver similar financial benefits and several of our current Innovation projects will transition to business as usual and yield additional benefits in 2018/19

Table 22 indicates the forecast per solution for the current regulatory period.

Table 22: ED1 Solutions and forecast financial benefits[9]

ED1 Solutions	Benefits (£)				
Gate D-E Solutions	**2018/19**	**2019/20**	**2020/21**	**2021/22**	**2022/23**
Increase Network Capacity/Optimise Utilisation					
Power Transformer Real Time Thermal Rating	£14,030,000	£14,030,000	£14,030,000	-£370,000	-£370,000
Energy Storage	£540,000	£540,000	£540,000	£540,000	£490,000
DSR	-£20,000	-£20,000	-£20,000	-£20,000	-£1,000,000
FUN-LV	£0	£0	£0	£0	£0
LPN Interconnection	£450,000	£450,000	£450,000	£450,000	£450,000
Improve Asset Life Cycle Management					
Joint Shell	£300,000	£300,000	£400,000	£400,000	£100,000
Oil Regeneration	£0	£0	£0	£0	£0
CNAIM Modelling	£10,274,119	£6,577,241	£1,040,673	£601,612	-£974,513
Woodpecker Hole Filler	£89,602	£89,602	£89,602	£89,602	£89,602
Improve Vegetation Management					
LiDAR Vegetation Management	£710,000	£540,000	£380,000	£250,000	£90,000
Improve Safety					
3D Laser Surveying	£13,000	£13,000	£13,000	£13,000	£13,000
Public Safety	-£200,000	-£200,000	-£200,000	-£200,000	-£200,000
Improve Environmental Impact					
Innovation Bunding	£12,000	£12,000	£12,000	£12,000	£12,000
Perfluorocarbon tracer (PFT) fluid-filled cable leak location	£1,440,000	£1,440,000	£1,440,000	£1,440,000	£1,440,000
Improve Connection Performance					
Flexible DG Connections	£5,000,000	£5,000,000	£5,000,000	£5,000,000	£5,000,000
Load Blinding Relays	£0	£0	£0	£0	£0
POC Masts	£200,000	£200,000	£200,000	£200,000	£200,000
Distribution Network Visibility (DNV) Application	£20,000	£20,000	£20,000	£20,000	£20,000
Timed Connection	£250,000	£250,000	£250,000	£250,000	£250,000
Improve Network Performance (QoS)					
LV Re-energising Devices	£1,120,000	£1,120,000	£1,120,000	£1,120,000	£1,120,000
Automated Power Restoration System	£3,800,000	£3,800,000	£3,800,000	£3,800,000	£3,800,000
MAAV	£682,237	£682,237	£682,237	£682,237	£682,237

[9] The data in this table does not include non-financial benefits.

3.4 Smart Metering

3.4.1 Our Strategy for maximising the Net Benefits of Smart Metering

Smart meters are the next generation of meters that are being installed by energy suppliers in every home in GB. Equipped 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 set out three key areas in which benefits from smart metering data will be realised:

- 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 and time of use tariffs. It will be possible to undertake ANM and further avoid the need for network reinforcement/new investment

Since submitting our plan we have continued to explore and evaluate smart metering benefits and the best way to realise them in the context of GB'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 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

During the 2017/18 regulatory year a delay to implementation of the Data Communications Company's (DCC) infrastructure and suppliers' meter roll-out programme required us to revise our smart meter benefits strategy. During the 2018/19 regulatory year we will review and 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 have 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, mindful of the requirements of our Data Privacy Plan. Our Smart Operations team is the business owner of the DCC adaptor that allows us to connect to DCC's infrastructure. Combining data expertise, technological capability and business knowledge, the team has the following responsibilities:

- Acting as UK Power Networks' key point of contact with the DCC and other relevant industry partners
- Delivering UK Power Networks' benefits realisation plan
- Developing understanding and insight into smart metering data within the business, to coach other 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 2017/18 regulatory year. The in-year installation volumes have increased from the previous year's installation rate where the meter population is currently at 21% of UK Power Networks' customer base.

Table 23: Smart meter installations

Licensee	2016/17 smart meter volumes	2017/18 smart meter volumes	Cumulative smart meter volumes	Percentage penetration of smart meters
EPN	215,900	322,430	807,336	22%
LPN	117,666	164,911	436,878	18%
SPN	172,239	212,002	550,504	24%
Total	**505,805**[10]	**699,343**	**1,794,718**	**21%**

We expect to see a gradual increase in volumes of SMETS2 meter installations during 2018/19, with increasing installation rates during 2019/20. 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

Our DCC adaptor was commissioned during September 2017, providing a landing point for smart metering data within our business that includes a strong security framework for our smart metering systems (in accordance with the Smart Energy Code security obligations). To minimise the risk to implementation, we have continued to work closely with Northern Power Grid and Scottish Power Energy Networks (who share the same vendor of DCC adaptor) and through this forum we have been able to coordinate queries with the DCC, leveraging each other's challenges and successes.

Based on the expected timelines for releases shared by the DCC, we have recently started to receive data from enrolled SMETS2 meters where we have also completed our Competent Independent Organisation (CIO) audit, addressing any concerns raised. Through the implementation of a technical solution we have changed our processes, factoring in smart meter information to provide an ability to share the scope of customers affected by network faults and planned network outages between our business functions. This has enabled us to share outage alerts with our customer call agents, dispatch coordinators and control room engineers.

[10] The 2016/17 installation volumes show an increase from the figures published in last year's report, where the difference is due to a time lag in receiving installation data from suppliers.

Whilst we remain 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 so as to 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 continue to engage 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 2018/19 regulatory year, as we ramp up our delivery of smart metering-related change.

3.4.4 Actions taken in 2017/18 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; our approach complies with all five of the industry defined Smart Meter Intervention performance SLAs. Our Smart Operations team performs a coordinating role to help our engineers support energy suppliers' installations. Within this team we have established a continuous improvement capability, helping to realise further outperformance of the industry-defined metrics. It provides 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 covering eight principal categories, to help us shape and monitor our performance.

We continue to work with the ENA, BEIS, Ofgem, the Information Commissioner's Office and Citizens Advice to develop a common Data Privacy Framework for DNOs. Our stance on personal data from smart meters is that we will not retrieve or access this data until a Privacy Impact Assessment has been completed, with appropriate privacy controls implemented.

3.4.5 Benefits realised to Date

The communications infrastructure and provision of data services via the DCC has gone live, with R1.3 now implemented. However, we have not yet realised benefits from smart metering due to the very small volume of SMETS 2 meters installed so far.

We believe that while SMETS2 meter numbers will increase in 2018/19, the current relatively low volume will provide a valuable 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 2018/19 and in Future Years

The delay to the DCC national infrastructure and supplier-led roll-out has allowed us to review our programme timescales for the delivery of benefits. We have started a number of projects enabling 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 2019, 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 required a number of changes to our business processes; for example, our contact centre has delivered training to contact agents informing them on how smart metering customer journeys vary from traditional meters. Changes to our processes have included the use of SMETS1 meter information and are timed to complement the volume of SMETS2 meters within our three regions.

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. Examples of the changes planned during 2018/19 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 PSR.

Our Smart Metering Benefits Roadmap spans the period 2017-2022. Specifically for 2018/19, 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. 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 refresh 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 2019/20 where we have identified an opportunity to explore how best to utilise smart metering data from the 2018/19 regulatory year.

The above examples highlight our immediate goals for the regulatory year 2018/19, after which we will establish the capability to share smart metering data across our IT infrastructure, enhance our regulatory reporting outputs based on smart metering data and enable 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 metering 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 2017/18 regulatory year.

Table 24: Summary of 2017/18 smart metering-related expenditure in £m

Source	Category	EPN	LPN	SPN	Total
C22/E5	Smart Meter Communication Licensee Costs	2.19	1.38	1.38	4.95
C22/E5	Smart Meter Information Technology Costs	1.14	0.75	0.75	2.64
CV34	Smart Meter Interventions – On-site/Physical Activities (including prior year restatement)	3.76	1.15	1.32	6.24
CV34	Smart Meter Interventions – Extra Scheduling & Call Centre	0.29	0.4	0.26	0.95
CV34	Smart Meter Interventions – Smart Meter Registration	-	-	-	-

4 Annexes and Appendices

4.1 EPN

Environment and Innovation Pack – tabs E1-E8 – 2017/18

4.2 LPN

Environment and Innovation Pack – tabs E1-E8 – 2017/18

4.3 SPN

Environment and Innovation Pack – tabs E1-E8 – 2017/18

4.4 UK Power Networks

Environment and Innovation Commentary – 2017/18

RIGs E6 CBA – 2017/18

Generic CBA RIIO-ED1 – GMTs – 2017/18

Generic CBA RIIO-ED1 – LV Cable – 2017/18

Generic CBA RIIO-ED1 – PMTs – 2017/18

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UK Power Networks (Operations) Limited

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