RIIO-ED1
Investment Justification
EPN Non-load Related Expenditure

Version 1.0

Contents

1 Executive summary

1.1 Expenditure forecast summary

UK Power Network's non-load related expenditures are organised into two principal categories:

- non-load network investment, including other costs; and
- network operating costs.

Non-load network investment expenditures include costs associated with:

- electrical safety, quality, and continuity regulations compliance (ESQCR);
- asset refurbishment;
- asset replacement;
- legal and safety;
- quality of supply (QoS);
- rising and lateral mains (RLM);
- flood defences;
- BT 21st century (BT21CN)
- technical losses and other environmental;
- civil works;
- high impact low probability (HILP) events;
- security of critical national infrastructure (CNI);
- black start;
- operational information technology and telecommunications (IT&T); and
- smart metering.

Network operating cost expenditures include costs associated with:

- inspection and maintenance;
- fault investigation and repair;
- tree cutting; and
- other network operating costs.

Table 1 below summarises our proposed non-load related expenditures for EPN. The cost numbers displayed in Table 1 reflect on-going efficiency improvements before the application of real-price effects. The cost numbers map directly to the RIG tables, but will not map directly to the Asset Stewardship Reports (ASRs), which exclude ongoing efficiencies, or our "What's changed and why?" summary document, which include real-price effects.

In addition to the average annual expenditure in the ED1 period, Table 1 presents the average annual expenditure over the full DPCR5 period taking into account three years of actual values and two years of forecast values. Average expenditure information for ED1 and DPCR5 is presented in all similar tables in this report.

On an aggregate level, EPN non-load related average annual expenditures for ED1 is lower (6% decrease) when compared to the full DPCR5 period.

	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Non-load network investment	98.9	95.7	97.8	99.7	97.7	88.6	83.4	76.4	**738.1**	92.3	84.4
Network operating costs	74.6	73.5	73.1	72.4	71.3	71.6	71.6	71.5	**579.7**	72.5	90.0
TOTAL (£m)	173.5	169.2	170.9	172.1	169.0	160.2	155.0	147.9	**1317.7**	164.7	174.3

Table 1: Summary of non-load related expenditure for EPN[1]

A summary of our proposed non-load network investment expenditure is provided in Table 2 below. The majority of the expenditure (~63%) over the ED1 period is for asset refurbishment/replacement.

	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
ESQCR	6.2	6.0	5.8	5.7	5.5	5.4	5.2	5.1	**45.0**	5.6	13.8
Asset replacement	48.0	50.9	57.8	62.6	59.6	54.3	53.1	47.2	**433.5**	54.2	46.7
Asset refurbishment	4.7	3.6	3.3	3.4	3.7	3.7	4.0	4.2	**30.7**	3.8	5.7
Legal and safety	7.9	8.2	5.5	5.4	5.7	5.5	5.2	4.8	**48.2**	6.0	5.0
Quality of supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
Rising mains and laterals	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	**9.8**	1.2	0.3
Flooding	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**7.5**	0.9	0.9
BT21CN	7.8	5.9	4.0	1.4	1.5	1.4	1.5	1.6	**25.1**	3.1	0.3
Technical losses and env.	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	**9.9**	1.2	2.0
Civil works	8.6	9.0	11.9	11.7	12.8	11.4	9.9	9.1	**84.4**	10.5	8.5
HILP events	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
Security of CNI	10.0	4.0	0.5	0.0	0.0	0.0	0.0	0.0	**14.5**	1.8	0.5
Black start	1.0	1.0	1.0	0.9	0.6	0.0	0.0	0.0	**4.5**	0.6	0.3
Operational IT&T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
Smart meters	2.0	3.6	4.5	4.9	4.8	3.4	0.8	0.8	**24.9**	3.1	0.2
TOTAL (£m)	98.9	95.7	97.8	99.7	97.7	88.6	83.4	76.4	**738.1**	92.3	84.4

Table 2: Summary of non-load network investment expenditure for EPN

A summary of our proposed network operating cost expenditures is provided in Table 3 below. Forecast average annual expenditures for inspection and maintenance are lower by 28% between the full DPCR5 period and ED1, whereas forecast annual expenditures for fault investigation and repair are lower by approximately 25%.

[1] In this and the tables that follow, differences between the total and the sum of individual rows or columns are due to rounding.

	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Inspection and maintenance	15.6	14.8	14.7	14.5	14.2	14.3	14.1	13.9	**116.1**	14.5	20.1
Fault investigation and repair	38.6	38.3	37.8	37.4	36.5	37.0	37.4	37.7	**300.8**	37.6	50.2
Tree clearing	15.8	15.9	16.0	16.0	16.0	15.8	15.6	15.4	**126.6**	15.8	15.8
Other NOCs	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	**36.2**	4.5	3.8
TOTAL (£m)	74.6	73.5	73.1	72.4	71.3	71.6	71.6	71.5	**579.7**	72.5	90.0

Table 3: Summary of network operating cost expenditure for EPN

A breakdown of total non-load network investment and network operating costs over the ED1 period is provided in Figure 1.

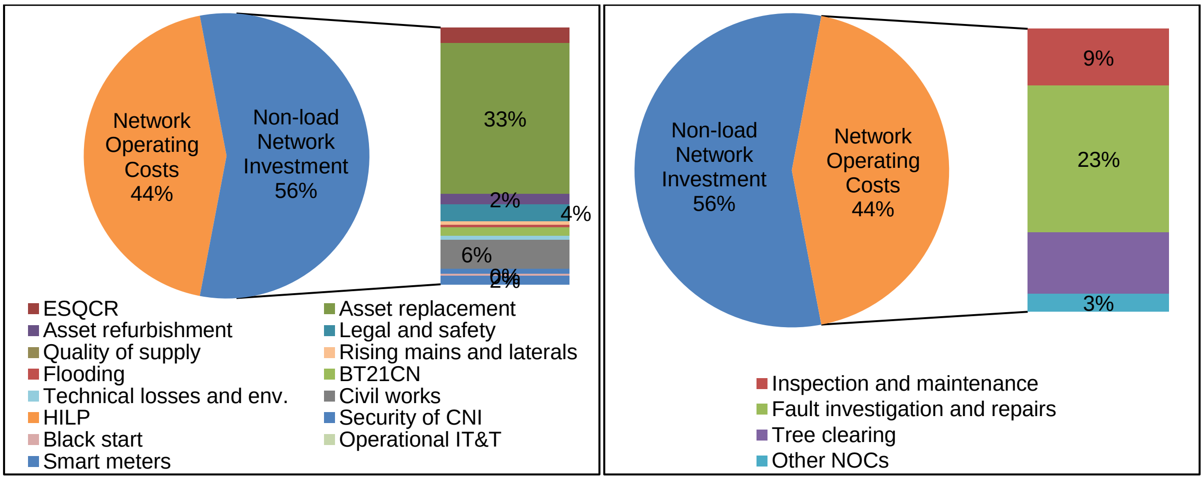

Figure 1: Breakdown of non-load network investment and network operating cost expenditure for EPN

1.2 Efficiency of volumes and expenditures

UK Power Networks uses an innovative approach to asset management that imposes tight controls on assets which are close to the end of their lives as determined through stringent condition, criticality, and defect health index assessments and definitions. Sophisticated proprietary tools, such as the asset risk and prioritisation (ARP) model that improves the accuracy of our determination and prediction of asset health, are an essential element of our asset management strategy. As we operate a complex network in the most densely populated regions in the UK, this innovative asset management strategy allows us to maintain the highest safety and reliability of our network whilst minimizing the number of interventions and maximising the utilisation and life of our existing assets.

Our ED1 forecast total expenditures build upon our proven track-record of improving network performance and asset efficiency. We are proposing to maintain the same distribution of Health Index 4 and 5 assets at the beginning and end of the ED1 period. This is the same asset health target that we set for the DPCR5 period.

We have carried out extensive cost-benefit analysis of our proposed ED1 non-load related investment volumes (covering approximately 65% of the ED1 non-load investment programme) relative to our equivalent DPCR5 volumes. The analysis shows that customers will benefit by more than £6 million of efficiency savings in ED1 given our proposed ED1 volumes compared to DPCR5 volumes. Extrapolating the findings from this analysis to our entire ED1 non-load investment programme suggests that our customers will benefit by more than £10 million in efficiency savings in ED1.

Reliability on our networks is among the best in the UK. However, we generally intervene on a smaller percentage of our assets and leave our assets in place for longer relative to other DNOs (see Figure 2). As a result, the average life of our assets is estimated to be 12% longer than other DNOs and we are able to provide very reliable service at a lower cost.

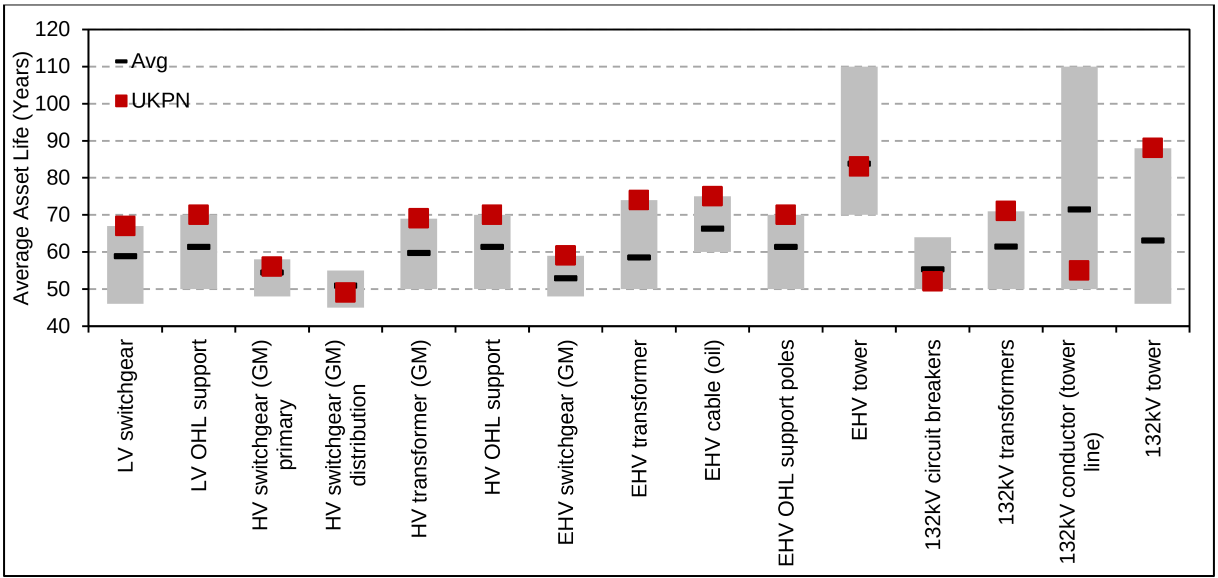

Figure 2: Comparison of average asset lives across major asset groups[2]

To better understand the impact of the outputs from our innovative asset management strategy, compared with other DNOs, UK Power Networks developed two alternate cost benefit analysis scenarios:

- industry representative condition (IRC);[3] and
- WPD representative condition (WPDRC).[4]

These two scenarios are used to compare our proposed ED1 non-load investment programme expenditures to those of other DNOs. Additional information on our cost benefit analyses is available in *Annex 13c: Cost Benefit Analysis* of our submission. The IRC based replacement volume scenario for EPN shows that customers are benefitting by more than £82 million through UK Power Networks' innovative asset management strategy. If this benefit is representative of UK Power Networks' overall non-load investment programme, the total benefit to customers would be £137 million in ED1. The WPDRC scenario for EPN

2 Source: Sinclair Knight Merz. "Review of UKPN HI Classification and Asset Life Allocation". 5 March 2014.

3 In the IRC scenario, volume is determined based on an 'industry average' condition-based replacement strategy. Expenditure is calculated using a unit cost based on the EPN RIIO-ED1 plan. In order to establish an 'industry average' condition based replacement strategy, our asset engineers developed an age-based proxy, using industry average asset ages as a signal of when other DNOs condition-based strategies would result in asset replacement.

4 In the IRC scenario, volume is determined based on the asset replacement and refurbishment proportions used by WPD and assessed as efficient by Ofgem in their Fast Track decision. Expenditure is calculated using a unit cost based on our EPN RIIO-ED1 plan.

shows that customers are benefitting by more than £12 million through UK Power Networks' innovative asset management strategy. When this benefit is applied to UK Power Networks' overall non load investment programme, the total benefits to customers would be £35 million in ED1.

Our unit costs are optimal in relation to our planned volume and expenditure, given the relative constraints we face operating our networks. We focus on achieving the highest levels of efficiency in load-related and non-load related volumes to compensate for higher unit costs driven by locational and situational factors. This allows us to achieve an optimal balance between volume and total expenditure. Given the relatively fixed nature of distribution utility costs, a consequence of our focus on volume efficiency is that efficiencies in unit costs generally lag.

We believe that our unit costs are within the bounds Ofgem sets for efficiency when all variables are taken into consideration. UK Power Networks' average network unit costs will always be higher than the average benchmark network costs because of the skew created by the Greater London Area. Our historic focus on volume efficiency has delivered results, and we are now turning our attention to unit costs. Our ED1 plan commits us to deliver a reduction of approximately 10% in unit costs across our network as compared to our unit costs in DPCR5. While we have a solid track record of delivering improvements and continuing to improve, reducing unit costs faster than the current trajectory embedded in our ED1 plan will be extremely difficult. The easily identifiable, high-impact improvements in unit costs are being delivered in the last two years of DPCR5, and whilst reducing unit costs continue to be a relentless focus for us, opportunities for further reductions will be harder to identify and take longer to achieve, and will be further limited by our volume management efforts and unique regional constraints.

Our ED1 forecast volume and expenditure reflects our track-record of delivering efficiencies in our business, and are part of our ongoing commitment and journey of transformation. Since becoming UK Power Networks, we have delivered a number of improvements and implemented a number of programmes to achieve better long-term value for money for our customers. Highlights of these improvements and programmes include:

- reduced customer interruptions and customer minutes lost by 30.3 per cent and 42.5 per cent respectively;
- delivered our network health and load investment targets ahead of the plan;
- cut our costs, whilst still delivering our DPCR5 output commitments, so that we are on track to deliver £200 million of cost savings; and
- launched a shareholder funded £50 million business transformation programme to deliver best-in-class business processes and systems that will enable us to achieve our ED1 commitments.

2 Asset refurbishment / replacement volume forecasting

2.1 Overview

UK Power Networks, in collaboration with EA Technology, has enhanced and expanded its modelling techniques for establishing and managing asset health. These enhancements build upon our history of asset stewardship and incorporate sophisticated techniques to assess asset health, criticality and risk. To enable the enhancements, we developed a new modelling approach that builds upon the long-established methodology of condition based risk management (CBRM). This new decision-making support tool, the asset risk and prioritisation (ARP) model, is a bottom-up model that integrates asset health, criticality, environment and risk to identify targeted investment interventions across a broad range of asset groups.

The development of ARP started in May 2011, and is split into a number of phases. Phases 1 and 2, which are now complete, saw the development and implementation of the new base modelling capability, and enabled criticality, environment and risk to be modelled for a number of asset groups. Further phases will extend the criticality and risk modelling to most of the remaining asset groups, integrate load and non-load modelling capability, support the optimisation of total expenditures (totex) through consideration of trade-offs between operating and capital investment decisions, and facilitate analysis for the optimisation of investment to support a low-carbon SMART future. As referenced in *ASR - Document 15 - Asset Category - Modelling Overview*, "UKPN have continued to work with EA Technology and are taking a global lead in asset deterioration modelling".[5] This is an ongoing project due for completion by 2015.

ARP modelling is used to establish the ED1 plan for a significant portion of our expenditure. Going forward, we will continue to roll ARP modelling and analysis out to the vast majority of the remaining assets. For asset groups where it is not possible or would not provide good value for customers to develop an ARP model, UK Power Networks uses a statistical asset replacement model (SARM), a Markov model (Markov), informed by historical experience and engineering judgement as decision support tools to inform future investment interventions.

A more detailed discussion of our modelling tools, e.g., the ARP, SARM, and Markov models, is available in *ASR - Document 15 - Asset Category - Modelling Overview*.

2.2 Health indices and probability of failure

The first stage in the ARP process is to determine a numeric representation of the health of each asset. This health assessment combines information that relates to its age, environment, duty, specific condition and performance of an asset. This methodology gives us a comparable measure of health for individual assets in terms of proximity to end-of-life (EOL) and probability of failure (POF).

The ARP models use a rating of 1 to 10 to measure the current health of an asset. Low values (in the range 1 to 4) indicate some observable or detectable deterioration at an early

[5] Source: Robert Davis, Group CEO, EA Technology Ltd

stage. This may be considered as normal ageing, i.e. the difference between a new asset and one that has been in service for some time but is still in good condition. In such a condition, the POF remains very low and the condition and POF would not be expected to change significantly for some time.

Medium values (in the range 4 to 7), indicate significant deterioration, where the asset's degradation is starting to move from normal ageing to processes that potentially threaten failure. In this condition, the POF, although still low, is just starting to rise and the rate of further degradation is increasing.

High values (>7) indicate serious deterioration, where degradation processes are so advanced that they threaten failure. In this condition, the POF is significantly raised and the rate of further degradation will be relatively rapid.

In DPCR5, Ofgem introduced a system of health index (HI) classifications, which allows categorisation of assets into five bands of health from 'as-new' condition to 'requiring intervention'. The UK Power Networks scale is mapped to the Ofgem categories as follows in Table 4.

Ofgem HI	Ofgem Description	ARP Health Assessment
1	New or as new	0.50 to 1.00
2	Good or serviceable condition	1.01 to 4.00
3	Deterioration requires assessment and monitoring	4.01 to 6.00
4	Material deterioration, intervention requires consideration	6.01 to 7.00
5	End of serviceable life, intervention required	> 7.01

Table 4: ARP health assessment mapping to Ofgem Health Index categories

This mapping of UK Power Networks' ARP asset health scale to Ofgem's health index is similar to the classification used in DPCR5 to map the health assessment from our earlier condition based risk management (CBRM) model. As is discussed in *ASR - Document 15 - Asset Category - Modelling Overview*, the principal distinction in terms of health assessment and mapping between the ARP model and the earlier CBRM model, is the requirement that assets undergo a physical condition assessment prior to receiving a grade of 6.01 or higher (4 or 5 on the Ofgem scale) in ARP. This additional requirement ensures that we are not intervening on the basis of age alone, and that we are focusing our interventions on assets that are truly in need of replacement or refurbishment.

In comparison to the performance of other DNOs, this approach will result in us developing both an older asset base with a smaller group of assets identified with a higher probability of failure, and a lower volume of assets being replaced as a proportion of the total asset base. As a result, we are actively managing a smaller pool of assets with Health Index 4 and 5, which are closer to service failure than may be the case for other DNOs with different asset replacement methodologies where assets could potentially be retired too early. Our replacement modelling results in a realistic replacement profile for similarly aged blocks of assets.

The health assessment for an individual asset is built from available condition-related information and reflects an engineering assessment at a given point in time. Once the current health has been established for an asset or asset group, the ARP model predicts changes in health over time reflecting different degradation processes, and in response to different intervention strategies, both of which can vary by asset group.

The ARP deterioration modelling approach that UK Power Networks developed to drive targeted, asset condition-based, investment programmes makes use of high-quality asset data collected across the business. To control and measure the quality of the data feeding into the ARP models, we developed an innovative data quality and control process. This process results in a completeness, accuracy, and timeliness (CAT) score for each asset group. The CAT score provides a measure of data quality at a specific moment in time. CAT scores for each asset group are discussed in more detail in *ASR - Document 15 - Asset Category - Modelling Overview*.

2.3 Consequences of failure and criticality

In addition to asset health, the ARP model has the built-in capability to dynamically assess the criticality of a particular asset or group of assets. Asset criticality is a relative comparison of the consequences of failure. The ability of the ARP model to dynamically assess health and criticality is unique, and was the driving reason behind its development. Traditional CBRM models do not assess critically. Rather it is assessed through 'bolt-on' solutions, after the fact.

The consequences of failure of an asset take into account (i) whether it would cause an outage, (ii) whether it would pose a safety concern, (iii) whether it would pose an environmental concern, and (iv) the likely cost of repair. For each asset the overall consequence of failure is the sum across the four categories stated above, measured in 'modelled' £. The average consequence of failure is calculated for each asset group. Individual assets are classified based on their position relative to the average overall consequence of failure for the population.

Table 5 below summarised the criticality bands as defined by Ofgem.

Ofgem CI	Ofgem Description	Criticality Values
1	Low criticality	Less than 75% of the average overall consequence of failure
2	Average criticality	Greater than, or equal to, 75% and less than 125% of the average overall consequence of failure
3	High criticality	Greater than, or equal to, 125% and less than 200% of the average overall consequence of failure
4	Very high criticality	Greater than, or equal to, 200% of average consequence of the average overall consequence of failure

Table 5: Criticality index categories

Risk is a function of probability of occurrence and severity of impact. The health index is a measure of the probability of failure and the criticality index is a measure of the severity of the impact of failure. Taken together the health and criticality indices provide a measure of risk.

2.4 Optimising planned activities and expenditures

UK Power Networks' network asset management plan (NAMP) defines the non-load related expenditures for the ED1 period. The NAMP assesses the need for investment by applying appropriate and proportionate approaches depending on the materiality of the investment stream.

The NAMP incorporates several optimising features:

- interventions only occur when there is clear evidence of a deteriorated condition; we generally do not intervene on the basis of age alone;
- consideration of engineering options, including refurbishment or replacement.
- optimisation of trade-offs between capital and maintenance expenditures;
- coordination of load and non-load interventions; and
- harmonisation of related interventions.

As a result of our transition to the ARP model, UK Power Network's network asset management plan is principally condition based, and interventions are seldom driven by age considerations alone. This results in an optimisation of intervention volumes across the network.

Engineering options are identified through a robust process that considers a wide range of potential solutions and results in a short-list of viable solutions. Further analysis is then undertaken to determine the "scheme" that delivers the greatest long-term value for customers while meeting our obligations. UK Power Networks is focused on finding the lowest-cost solutions, and as such refurbishment is generally the first consideration. However, the NAMP takes into account technical information, such as the nature of the deterioration and constraints (e.g. access to the asset) that ultimately may impact the final determination. Examples of the range of options that are considered within the NAMP are provided in the scheme papers included in this submission.

In some instances, incurring additional maintenance expenditures to defer the need for capital investment could be the optimal solution. In other instances, incurring capital expenditures to reduce or eliminate inefficient maintenance expenditures could be the optimal solution. Our NAMP takes the trade-offs between capital and maintenance expenditures into consideration.

Individual investment schemes are aggregated and put through an optimisation process that seeks to ensure that the interactions between schemes, in particular load and non-load related, are recognised and the objectives and outputs appropriately balanced. If beneficial, interventions will be accelerated or delayed to capture synergies available through the coordination of load and non-load schemes.

In addition, UK Power Networks will harmonise related interventions, and seek to make repairs or replacements in a manner that makes the most efficient use of our existing resources. For example, in the NAMP, we consider whether refurbishments or replacements are likely required for related assets or for multiple elements of a single asset. These interventions are coordinated within the NAMP to occur concurrently or sequentially in an efficient manner.

2.5 Demonstrating delivery of outputs

In preparation for DPCR5, DNOs determined:

- the health index profile of assets at the beginning of DPCR5;
- the health index profile of assets at the end of DPCR5 as a consequence of degradation absent any intervention; and
- the impact of proposed replacement and refurbishment programmes on the profile at the end of DPCR5.

This is illustrated in Figure 3 below.

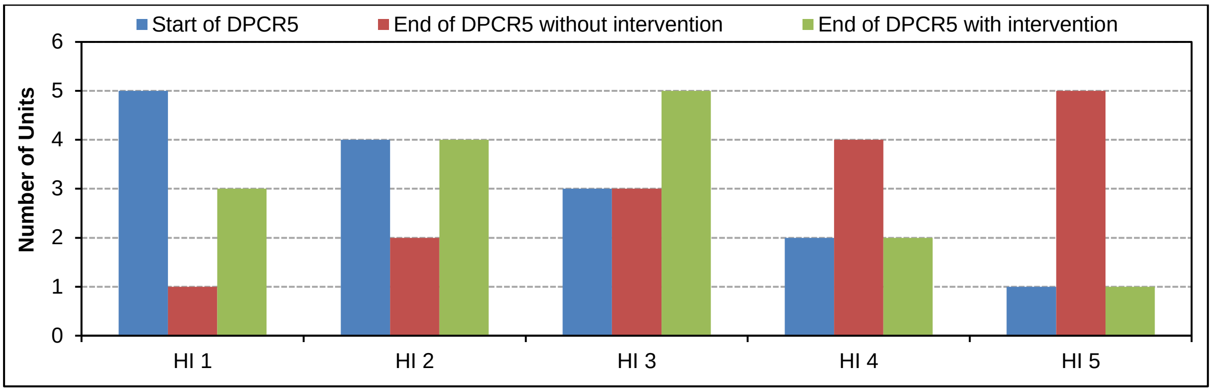

Figure 3: Illustrative distribution of health indices

This methodology was introduced to ensure that DNOs focused on delivering replacement programmes in line with their forecasts. For ED1, DNOs will determine:

- the health index profile of assets at the beginning of ED1;
- the health index profile of assets at the end of ED1 as a consequence of degradation absent any intervention; and
- the impact of proposed replacement and refurbishment programmes on the profile at the end of ED1.

For ED1, Ofgem also extended the concept to include criticality. Health index and criticality index data is presented in a matrix which shows the number of assets that fall into each band as illustrated in Figure 4 below. This matrix is determined for assets at the beginning of ED1 and at the end of ED1 taking into account the impact of proposed replacement and refurbishment programmes.

		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1					
	C2					
	C3					
	C4					

Figure 4: Health index and criticality matrix

UK Power Networks will maintain the profile of its asset risk for each network broadly consistent over the ED1 period. This will involve maintaining the number of assets in each index category across the entire network broadly consistent, and in particular not allowing the numbers of Health Index 4 and 5 assets to increase materially. UK Power Network's plans for the ED1 period will also maintain the health of the most critical assets (C3 and C4).

This output target is set for the network as a whole, and as such within individual asset groups or classes the number of Health Index 4 and 5 and Criticality 3 and 4 assets increase or decrease.

A summary of our health and criticality output targets is provided in *Annex 2: Forecast Outputs*.

2.6 Forecasting approach for each asset group

The approach used to determine the ED1 asset replacement programme for each asset category is shown in the Table 6 below.

Asset Group	Methodology	Net Asset Value (£m)	% of ED1 Expenditure
LV overhead lines poles	ARP	327.9	5%
LV overhead lines conductor (inc. services)	Historical	248.6	5%
LV underground cable (inc. services)	Historical	6,537.9	2%
LV switchgear	SARM	226.0	2%
Link boxes	Markov	155.8	5%
LV cut outs	Historical	696.3	1%
HV overhead lines poles	ARP	428.8	3%
HV overhead lines conductor	Historical	381.0	7%
HV underground cable (all)	Historical	1,763.2	6%
HV switchgear	ARP	475.6	14%
HV transformers	SARM	375.6	2%
EHV overhead lines poles	ARP	87.7	1%
EHV overhead lines towers and fittings	ARP / Cormon	51.8	0%
EHV overhead lines conductors	ARP / Cormon	131.7	4%
EHV underground cable (solid)	Historical	478.3	3%
EHV underground cable (oil)	ARP	161.0	1%
EHV underground cable (gas)	Policy	0.0	0%
EHV switchgear	ARP	106.2	4%
EHV transformers	ARP	247.4	4%
132kV overhead lines poles	ARP	0.7	0%
132kV overhead lines towers and fittings	ARP / Cormon	311.8	2%
132kV overhead lines conductor	ARP / Cormon	124.6	8%
132kV underground cable (solid)	Historical	56.8	6%
132kV underground cable (oil)	ARP	192.3	1%
132kV underground cable (gas)	Policy	0.0	0%
132kV switchgear	ARP	86.4	6%
132kV transformers	ARP	250.0	5%
Batteries	Age	6.4	2%
Other	Historical / Policy	274.3	1%

Methodology	% of ED1 Expenditure
Age	2%
ARP	44%
ARP / Cormon	14%
Historical	29%
Historical / Policy	1%
Markov	5%
Policy	0%
SARM	5%

Table 6: Summary of volume forecasting methodologies for EPN

3 Non-load network investments

The following sections review each category of non-load related expenditure in our plan.

3.1 Electricity safety, quality and continuity regulations

The Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR) regulate power quality and supply continuity requirements and specify safety standards. Compliance with ESQCR is a statutory requirement for DNOs. UK Power Networks has defined its company policies to adhere to ESQCR and minimise risks to members of the public and employees.

In EPN, the principal drivers of ESQCR expenditures are substation and overhead line signage, anti-climbing devices, clearance issues, climbable trees, stays and risk mitigations. The volume and expenditure forecast for the RIIO-ED1 period only includes additional work identified for the period, and does not include the backlog of activities from DPCR5.

Forecast interventions and total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	2742	2666	2589	2522	2450	2383	2318	2256	**19926**	2491	4587
Expenditure - TOTAL	£m	6.2	6.0	5.8	5.7	5.5	5.4	5.2	5.1	**45.0**	5.6	13.8

Table 7: Electricity safety, quality and continuity regulations ED1 forecast volume and expenditures for EPN

3.2 Asset replacement/refurbishment details

As assets age they deteriorate. Deterioration occurs at different rates for different assets and as a result of a range of environmental conditions. UK Power Networks replaces or refurbishes assets which are either at the end of their useful life due to their condition, or need to be replaced on safety or environmental grounds. UK Power Networks does not intervene on an asset on the basis of age alone.

Condition and defect information are used to develop work programmes targeted to replace poor condition assets and those with operational restrictions. The overall programme is a mix of cost effective solutions consisting of like-for-like replacement, refurbishment and opportunistic reinforcement.

The table below summarises UK Power Network's planned expenditures for each type of asset for asset refurbishment and replacement, by voltage level (where appropriate), over the RIIO-ED1 period.[6]

[6] Voltages are grouped as follows: low voltage (LV) - 480/240V; high voltage (2/3/6.6/11kV); extra-high voltage (EHV) - 25/33/66kV

	LV	HV	EHV	132kV	TOTAL (£m)
Overhead tower lines	0.0	0.0	9.3	51.0	**60.3**
Overhead pole lines	41.9	47.5	17.0	0.0	**106.3**
Underground cables	9.2	27.6	16.8	31.1	**84.7**
Switchgear	35.3	67.0	18.6	27.8	**148.7**
Transformers	0.0	10.7	21.4	23.1	**55.1**
By Voltage - SUB-TOTAL (£m)	86.4	152.7	83.0	133.0	**455.1**
Protection and control	13.0				**13.0**
Batteries	7.3				**7.3**
Cost recoveries					**-11.3**
TOTAL (£m)					**464.2**

Table 8: Summary of RIIO-ED1 non-load asset refurbishment and replacement expenditure for EPN

3.2.1 Overhead tower lines

There are 3,038 circuit km of conductor in EPN, on 4,737 132kV towers and 1,196 33kV towers. The long-term investment proposal for the replacement of overhead tower lines has been informed using the age profile of the overhead tower lines. The intervention volume has been set to manage the network risks by maintaining the number of overhead tower line assets that have a Health Index of 4 or 5 to a reasonable level.

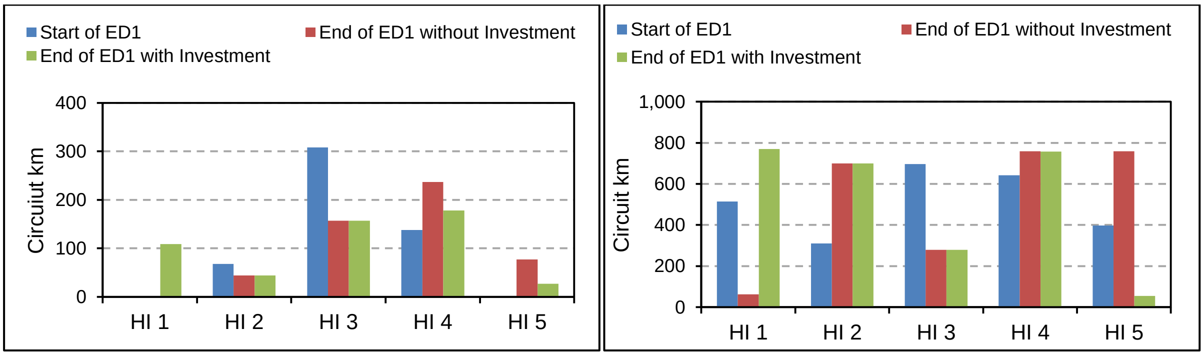

Figure 5: 132kV (left) and 33kV (right) overhead tower lines distribution of Health Index with non-load interventions

Forecast asset replacements/refurbishments and total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - conductor	km	46	86	134	79	189	71	114	96	**815**	102	27
Volume - towers and fittings	each	967	553	791	613	1268	617	734	722	**6262**	782.8	424.6
Expenditure - conductor	£m	3.0	4.9	6.5	6.6	5.4	4.2	5.3	3.9	**39.8**	5.0	1.7
Expenditure - towers and fittings	£m	2.7	2.2	2.6	3.2	2.6	2.4	2.5	2.2	**20.5**	2.6	2.4
Expenditure - TOTAL	£m	5.7	7.1	9.1	9.8	8	6.6	7.8	6.1	**60.3**	7.5	4.1

Table 9: Overhead tower lines ED1 forecast volume and expenditures for EPN

Forecast asset replacements/refurbishments and total expenditures, by voltage level, for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
132kV - conductor	km	46.0	78.0	127.0	79.0	95.0	71.0	114.0	96.0	706.0	88.3	25.8
EHV – conductor	km	0.0	8.0	7.0	0.0	94.0	0.0	0.0	0.0	109.0	13.6	0.8
HV – conductor	km	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LV – conductor	km	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Volumes – TOTAL	km	**46.0**	**86.0**	**134.0**	**79.0**	**189.0**	**71.0**	**114.0**	**96.0**	**815.0**	**101.9**	**26.6**
132kV – towers and fittings	Each	775	456	680	525	1151	522	657	603	**5366**	670.8	325.8
EHV – towers and fittings	Each	192	97	111	88	117	95	77	119	**896**	112.0	98.8
HV – towers and fittings	Each	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
LV – towers and fittings	Each	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
Volumes – TOTAL	Each	**967**	**553**	**791**	**613**	**1268**	**617**	**734**	**722**	**6262**	**782.8**	**424.6**
132kV	£m	4.4	6.3	8.0	6.9	6.4	6.1	7.3	5.7	**51.0**	6.4	3.5
EHV	£m	1.3	0.9	1.1	2.9	1.6	0.5	0.5	0.4	**9.3**	1.2	0.6
HV	£m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
LV	£m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
Expenditure - TOTAL	£m	**5.7**	**7.1**	**9.1**	**9.9**	**8.0**	**6.5**	**7.8**	**6.2**	**60.3**	**7.5**	**4.1**

Table 10: Overhead tower lines ED1 forecast volume and expenditures, by voltage, for EPN

Additional detail on the overhead tower lines interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 1 - Asset Category - Towers and Conductors*.

3.2.2 Overhead pole lines

There are 496,872 wood poles in EPN, and specifically 155 on the 132kV network, 35,031 on the 33kV network, 214,343 on the HV network, and 147,363 on the LV network. The long-term investment proposal for the replacement of poles has been informed using the asset health, criticality and consequence of failure data of the poles.

During the ED1 period, we are proposing to replace approximately five percent of our wood pole assets in SPN. Furthermore, each new pole installed in the network will have a “pole saver” fitted that will extend the life of the asset, and there will be installations of boron rods which can delay or defer a replacement on suitable poles during ED1.

There are no plans to refurbish or replace the 132kV poles in ED1 because the circuit is in relatively good condition. Any defects found at inspection will be dealt with as part of the defect management project.

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	1181	5421	350	326	270
	C2	4303	19734	1275	1189	982
	C3	0	0	0	0	0
	C4	0	0	0	0	0

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	1043	4922	1093	176	314
	C2	3795	17922	3979	640	1147
	C3	0	0	0	0	0
	C4	0	0	0	0	0

Figure 6: 33kV pole distribution of health and criticality indices with non-load interventions

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	12	103	14	2	4
	C2	30344	147825	6695	6814	4848
	C3	3370	13180	604	469	0
	C4	14	38	1	6	0

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	7	81	34	5	8
	C2	16643	117840	49495	7489	5059
	C3	1712	10577	4441	664	229
	C4	10	29	11	9	0

Figure 7: HV pole distribution of health and criticality indices with non-load interventions

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	0	0	0	0	0
	C2	44138	179341	6435	8501	7691
	C3	115	1016	14	62	48
	C4	1	0	0	0	1

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	0	0	0	0	0
	C2	37480	151153	47037	6192	4244
	C3	183	771	240	32	29
	C4	1	1	0	0	0

Figure 8: LV pole distribution of health and criticality indices with non-load interventions

Forecast asset replacements/refurbishments and total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - conductor	km	299	316	347	358	347	315	314	334	**2628**	328.5	64.6
Volume - poles and fittings	each	10106	8054	6866	6615	5866	5865	5865	5865	**55102**	6888	8482
Expenditure - conductor	£m	6.6	7.6	8.9	8.8	8.2	6.7	6.8	7.2	**60.7**	7.6	3.1
Expenditure - poles and fittings	£m	6.8	6.2	5.9	5.7	5.4	5.2	5.2	5.1	**45.6**	5.7	8.2
Expenditure - TOTAL	£m	13.4	13.8	14.8	14.5	13.6	11.9	12	12.3	**106.3**	13.3	11.4

Table 11: Overhead pole lines ED1 forecast volume and expenditures for EPN

Forecast asset replacements/refurbishments and total expenditures, by voltage level, for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
132kV - conductor	km	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EHV – conductor	km	0.0	17.0	48.0	59.0	48.0	16.0	15.0	35.0	**238**	29.8	19.3
HV – conductor	km	149	149	149	149	149	149	149	149	1190	148.7	40.7
LV – conductor	km	150	150	150	150	150	150	150	150	**1200**	150.0	4.6
Volumes – TOTAL	km	299	316	347	358	347	315	314	334	**2628**	328.5	64.6
132kV – poles and fittings	Each	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EHV - poles and fittings	Each	539	539	539	539	539	538	538	538	**4309**	539	460
HV - poles and fittings	Each	2752	1739	1520	1519	1520	1520	1520	1520	**13610**	1701	1614
LV - poles and fittings	Each	6815	5776	4807	4557	3807	3807	3807	3807	**37183**	4648	6409
Volumes – TOTAL	Each	10106	8054	6866	6615	5866	5865	5865	5865	**55102**	6888	8482
132kV	£m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
EHV	£m	0.8	1.9	3.4	3.3	2.8	1.3	1.5	2.0	**17.0**	2.1	1.8
HV	£m	6.5	6.1	6.0	5.9	5.9	5.7	5.7	5.6	**47.5**	5.9	4.9
LV	£m	6.1	5.7	5.4	5.3	5.0	4.9	4.8	4.7	**41.9**	5.2	4.7
Expenditure - TOTAL	£m	13.4	13.8	14.8	14.5	13.6	11.9	11.9	12.4	**106.3**	13.3	11.4

Table 12: Overhead pole lines ED1 forecast volume and expenditures, by voltage, for EPN

Additional detail on the overhead pole lines interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 2 - Asset Category – Wood Poles, Narrow Based Steel Towers and Conductors*.

3.2.3 Underground cable

There are 62,081 circuit kilometres of underground cable in EPN. The overall population includes fluid-filled cables (across the 132kV and 33kV network) and solid cables across the majority of voltage levels.

The investment strategy is designed to ensure the lifetime cost of the underground cable assets are kept to a minimum while optimising performance and ensuring safety and regulatory compliance.

The principal drivers for the replacement of underground cables are safety, network security, public safety, environment, condition and compliance with relevant legislation. There are two key investment drivers for underground cables.

- For fluid-filled cables, the business objective throughout the planning process for ED1 was to invest at a level that will maintain leakage rates at roughly the same level throughout the ED1 period, which is around the national average rate.
- For solid cables, the investment drivers are based primarily on a case-by-case condition assessment based on the number of faulted cable sections.

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	0	23	3	1	3
	C2	1	49	8	2	8
	C3	1	30	5	2	5
	C4	1	34	6	2	6

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	0	16	8	1	5
	C2	1	34	18	0	12
	C3	1	20	12	0	4
	C4	1	24	13	0	9

Figure 9: 132kV fluid-filled cable distribution of health and criticality indices with non-load interventions

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	24	149	75	12	17
	C2	17	106	54	10	12
	C3	6	37	19	3	4
	C4	1	6	3	0	1

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	2	102	126	13	34
	C2	2	72	91	9	23
	C3	0	27	29	3	2
	C4	0	4	5	1	0

Figure 10: 33kV fluid-filled cable distribution of health and criticality indices with non-load interventions

Forecast asset replacements/refurbishments and total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - cable	km	44.2	37.7	40.8	37.7	37.7	43.1	37.7	45.7	**325**	40.6	48.5
Volume - other assets	each	759	759	759	759	759	759	759	759	**6072**	759	509
Expenditure - cable	£m	7.7	7.2	10.5	12.1	13.1	10.2	9.5	8.2	**78.6**	9.8	10.1
Expenditure - other assets	£m	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	**6.1**	0.8	1.6
Expenditure - TOTAL	£m	8.5	8.0	11.3	12.9	13.9	10.9	10.2	8.9	**84.7**	10.6	11.7

Table 13: Underground cable ED1 forecast volume and expenditures for EPN

Forecast asset replacements/refurbishments and total expenditures, by voltage level, for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
132kV – cable	km	0.3	0.3	0.3	0.3	0.3	3.7	0.3	8.2	**13.4**	1.7	2.7
EHV – cable	km	9.6	3.1	6.2	3.1	3.1	5.1	3.1	3.1	**36.3**	4.5	30.2
HV – cable	km	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4	**243**	30.4	9.4
LV – cable	km	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	**32.0**	4.0	6.1
Volumes – TOTAL	km	44.2	37.7	40.8	37.7	37.7	43.1	37.7	45.7	**325**	40.6	48.5
132kV – other assets	each	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.4
EHV – other assets	each	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	4.0
HV – other assets	each	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0
LV – other assets	each	759	759	759	759	759	759	759	759	**6072**	759	505
Volumes – TOTAL	each	759	759	759	759	759	759	759	759	**6072**	759	509
132kV	£m	1.4	1.6	3.7	6.4	6.6	4.0	4.4	3.0	**31.1**	3.9	3.2
EHV	£m	3.0	2.1	2.8	1.6	1.9	2.2	1.6	1.6	**16.8**	2.1	5.7
HV	£m	2.9	3.1	3.7	3.6	4.2	3.6	3.1	3.3	**27.6**	3.4	0.9
LV	£m	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	**9.2**	1.2	1.9
Expenditure - TOTAL	£m	8.5	8.0	11.3	12.9	13.9	11.0	10.2	9.0	**84.7**	10.6	11.7

Table 14: Underground cable ED1 forecast volume and expenditures, by voltage, for EPN

Additional detail on the underground cable interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 3 - Asset Category - Underground Cables*.

3.2.4 Switchgear

In total, in EPN, there are:

- 293 items of 132kV switchgear;
- 1,475 items of EHV switchgear;
- 5,359 items of 11kV grid and primary switchgear;
- approximately 32,724 HV switchgear assets; and
- approximately 30,040 LV switchgear assets and 47,632 link boxes.

The long-term investment proposal for the replacement or refurbishment of switchgear was informed by the health profile of the switchgear assets. The intervention volume has been set to manage the network risks by maintaining the same number of switchgear assets that have a Health Index of 4 or 5 at the beginning and end of the RIIO-ED1 period.

The EPN network includes a number of switchgear assets that were commissioned in the 1960s. Although age itself does not necessarily drive the failure of all types of assets, it can increase asset stress and makes assets more vulnerable to deterioration. The oldest 10% of secondary switchgear assets in this region has an average age of approximately 50 years. These assets form the majority of the interventions proposed for ED1.

The intervention volume for link boxes is 490 per year over ED1. This will allow us to target all of the assets with Health Index 4 and 5 by the end of the period and minimise public safety risks.

The figures below provide the health and criticality indices at the start of RIIO-ED1 and at the end of RIIO-ED1, with non-load interventions only.

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	70	62	25	18	13
	C2	26	13	9	2	1
	C3	47	5	2	0	0
	C4	0	0	0	0	0

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	89	58	26	9	18
	C2	33	8	3	7	0
	C3	24	27	1	2	0
	C4	0	0	0	0	0

Figure 11: 132kV switchgear distribution of health and criticality indices with non-load interventions

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	416	225	108	95	24
	C2	139	148	49	84	17
	C3	29	25	10	16	2
	C4	28	33	12	14	1

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	396	302	41	73	56
	C2	193	130	42	25	68
	C3	25	43	0	3	11
	C4	43	27	9	8	1

Figure 12: EHV switchgear distribution of health and criticality indices with non-load interventions

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	1055	1042	885	52	12
	C2	261	967	397	50	20
	C3	127	359	113	17	2
	C4	0	0	0	0	0

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	997	1158	785	91	21
	C2	398	626	583	74	17
	C3	153	189	266	12	0
	C4	0	0	0	0	0

Figure 13: 11kV grid and primary switchgear distribution of health and criticality indices with non-load interventions

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	7581	8348	596	426	0
	C2	1149	9824	4343	454	0
	C3	2	1	0	0	0
	C4	0	0	0	0	0

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	966	14318	1090	577	0
	C2	4853	4850	4656	1219	0
	C3	2	1	0	0	0
	C4	0	0	0	0	0

Figure 14: HV switchgear distribution of health and criticality indices with non-load interventions

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	8	25	31	0	0
	C2	3760	11129	14935	84	0
	C3	8	25	30	0	0
	C4	1	2	2	0	0

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	6	24	31	3	0
	C2	2486	11673	15551	198	0
	C3	40	23	0	0	0
	C4	3	2	0	0	0

Figure 15: LV switchgear distribution of health and criticality indices with non-load interventions

2015		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	4042	6510	3238	697	0
	C2	3011	5022	2412	520	0
	C3	3261	5253	2613	563	0
	C4	6	10	5	1	0

2023		Health Index				
		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	4656	4758	4861	212	0
	C2	3515	3715	3622	113	0
	C3	3790	3839	3922	139	0
	C4	7	8	7	0	0

Figure 16: LV link boxes distribution of health and criticality indices with non-load interventions

Forecast asset replacements/refurbishments and total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - refurbishment	Each	0.0	0.0	0.0	8.0	3.0	9.0	32.0	38.0	**90.0**	11.3	11.6
Volume - replacement	Each	5525	4177	2856	2798	2862	3115	3111	3179	**27623**	3453	7921
Volume - TOTAL[7]	Each	5525	4177	2856	2806	2865	3124	3143	3217	**27713**	3464	7932
Expenditure - refurbishment	£m	0.0	0.0	0.1	0.2	0.1	0.2	0.6	0.6	**1.9**	0.2	0.1
Expenditure - replacement	£m	17.0	16.4	22.2	22.0	20.7	18.3	15.7	14.3	**146.7**	18.3	18.0
Expenditure - TOTAL	£m	17.1	16.5	22.3	22.2	20.9	18.6	16.3	14.9	**148.7**	18.6	18.1

Table 15: Switchgear ED1 forecast volume and expenditures for EPN

Forecast asset replacements/refurbishments and total expenditures, by voltage level, for the RIIO-ED1 period are provided in the table below.

7 Includes circuit breakers, ring main units, switches, ground mounted cabinets, fuse cabinets, distribution boards, and link boxes

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
132kV - refurb./replace	each	11.0	6.0	3.0	2.0	26.0	15.0	11.0	5.0	**79.0**	9.9	24.4
EHV - refurb./replace	each	36.0	71.0	54.0	42.0	59.0	54.0	53.0	110.0	**479.0**	59.9	46.2
HV - refurb./replace	each	530	547	640	603	621	618	611	634	**4804**	600.5	549.8
LV - refurb./replace	each	4948	3553	2159	2159	2159	2437	2468	2468	**22351**	2793.9	7311.8
Volumes – TOTAL	each	5525	4177	2,856	2806	2865	3124	3143	3217	**27713**	3464.1	7932.2
132kV - refurb./replace	£m	1.1	2.5	6.4	7.0	6.0	3.2	1.5	0.1	**27.8**	3.5	4.0
EHV - refurb./replace	£m	3.8	1.6	2.4	1.8	1.3	2.6	2.7	2.3	**18.6**	2.3	3.8
HV - refurb./replace	£m	7.0	7.6	9.1	9.1	9.3	8.5	7.9	8.4	**67.0**	8.4	6.0
LV - refurb./replace	£m	5.1	4.7	4.3	4.3	4.2	4.2	4.2	4.1	**35.3**	4.4	4.4
Expenditure - TOTAL	£m	17.1	16.5	22.3	22.2	20.9	18.6	16.3	14.9	**148.7**	18.6	18.1

Table 16: Switchgear ED1 forecast volume and expenditures, by voltage, for EPN

Additional detail on the switchgear interventions, including a discussion of the types of interventions we have included in our plan, is available in four documents:

- *ASR - Document 5 - Asset Category - 132kV Switchgear*;
- *ASR - Document 6 - Asset Category - EHV Switchgear*;
- *ASR - Document 5 - Asset Category - 11kV Grid and Primary Switchgear*; and
- *ASR - Document 5 - Asset Category - HV Switchgear and LV Plant*.

3.2.5 Transformers

In total, in EPN, there are:

- 264 132kV transformers;
- 909 EHV transformers;
- approximately 32,223 HV distribution transformers.

Investment drivers for 132kV and EHV transformers can be split into two categories: internal condition and external condition. External condition factors include paint condition and corrosion of any part of the transformer, cooler or conservator and their pipe work. In addition, old gasket material can become compressed and brittle. These factors pose both an environmental risk, particularly on older transformers without oil bunds, and a network risk, as they can lead to severe oil leaks and unplanned outages. Internal condition factors are the degradation of solid insulation materials on the windings and the development of discharge and heating faults. Both of these internal condition factors are detected by non-intrusive oil sample testing. The intervention volume has been set to manage the network risks by maintaining the same number of transformer assets that have a Health Index of 4 or 5 at the beginning and end of the RIIO-ED1 period.

The long-term forecasts for lower voltage distribution transformer replacements have been set based on statistical model forecasts. The investment proposals have been validated by comparing the forecasts to historical fault rates and observed trends in condition data for the ageing distribution transformer population.

The figures below provide the health and criticality indices at the start of RIIO-ED1 and at the end of RIIO-ED1, with non-load interventions only.

2015		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	21	61	2	1	1
	C2	23	101	23	5	4
	C3	3	10	5	0	4
	C4	0	0	0	0	0

2023		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	11	42	32	1	0
	C2	26	68	54	6	1
	C3	1	9	7	1	4
	C4	0	0	0	0	0

Figure 17: 132kV transformer distribution of health and criticality indices with non-load interventions

2015		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	58	263	49	15	12
	C2	46	344	46	9	11
	C3	13	11	3	0	1
	C4	6	20	2	0	0

2023		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	39	199	137	12	9
	C2	29	205	198	18	6
	C3	9	16	3	0	0
	C4	0	19	9	0	0

Figure 18: EHV transformer distribution of health and criticality indices with non-load interventions

2015		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	2254	4991	8109	0	0
	C2	1472	4148	5296	0	0
	C3	644	1426	2317	0	0
	C4	230	509	827	0	0

2023		HI 1	HI 2	HI 3	HI 4	HI 5
Criticality	C1	581	6088	8685	0	0
	C2	531	4563	5822	0	0
	C3	164	1740	2483	0	0
	C4	60	621	885	0	0

Figure 19: HV transformer distribution of health and criticality indices with non-load interventions

Forecast asset replacements/refurbishments and total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/16	'16/17	'17/18	'18/19	'19/20	'20/21	'21/22	'22/23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - refurbishment	each	3.0	5.0	2.0	1.0	4.0	4.0	4.0	5.0	**28.0**	3.5	18.6
Volume - replacement	each	119	120	124	120	127	126	123	124	**983**	122.9	110.0
Volume - TOTAL	each	122	125	126	121	131	130	127	129	**1011**	126.4	128.6
Expenditure - refurbishment	£m	0.5	0.6	0.3	0.2	0.6	0.5	0.6	0.6	**3.9**	0.5	0.7
Expenditure - replacement	£m	5.0	7.0	5.5	6.7	7.3	7.3	7.3	5.2	**51.2**	6.4	4.3
Expenditure - TOTAL	£m	5.5	7.6	5.8	6.9	7.8	7.9	7.8	5.8	**55.1**	6.9	4.9

Table 17: Transformers ED1 forecast volume and expenditures for EPN

Forecast asset replacements/refurbishments and total expenditures, by voltage level, for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
132kV - refurb./replace	each	1.0	6.0	2.0	4.0	3.0	3.0	3.0	4.0	**26.0**	3.3	4.8
EHV - refurb./replace	each	6.0	4.0	9.0	2.0	13.0	12.0	9.0	10.0	**65.0**	8.1	19.8
HV - refurb./replace	each	115	115	115	115	115	115	115	115	**920**	115	104
Volumes – TOTAL	each	122	125	126	121	131	130	127	129	**1011**	126	129
132kV - refurb./replace	£m	2.2	4.2	1.6	3.5	2.8	2.6	4.1	2.0	**23.1**	2.9	1.3
EHV - refurb./replace	£m	2.0	2.0	2.8	2.0	3.7	3.9	2.5	2.5	**21.4**	2.7	2.2
HV - refurb./replace	£m	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.3	**10.7**	1.3	1.5
Expenditure - TOTAL	£m	5.5	7.6	5.8	6.9	7.8	7.9	7.8	5.8	**55.1**	6.9	4.9

Table 18: Transformers ED1 forecast volume and expenditures, by voltage, for EPN

Additional detail on the transformer interventions, including a discussion of the types of interventions we have included in our plan, is available in four documents:

- *ASR - Document 4 - Asset Category – Grid and Primary Transformers*;
- *ASR - Document 6 - Asset Category – Distribution Transformers*.

3.2.6 Protection and control

In total, in EPN, there are:

- 26,340 protection and control assets, excluding selector switches, ammeters, transducers and simple auxiliary displays; and
- 869 pilot cables.

Options for the refurbishment of protection and control assets are limited, and can only relate to the older electromechanical devices where component replacement or adjustment is possible. Modern protection devices are of a modular design, and do not lend themselves to any form of meaningful refurbishment. In the event of failure or unexpected operation, replacement is the only option.

This investment strategy for the replacement of protection assets is based on targeting devices with a known history of failure or poor performance, and an ongoing replacement plan for other protection assets based on age, criticality of failure (i.e. impact), probability of failure, and obsolescence. The plan for replacement of protection and control relays in ED1 allows for the replacement of approximately 2.1% of the known asset base population. While this is a low level of replacement and the total asset replacement would take approximately 380 years, this is a realistic level of work that can be delivered.

Forecast asset replacements and total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	56.1	62.5	71.3	71.1	70.3	71.9	72.9	76.9	**553**	69.1	51.6
Expenditure - TOTAL	£m	1.7	1.7	1.8	1.6	1.6	1.5	1.5	1.6	**13.0**	1.6	1.5

Table 19: Protection and control ED1 forecast volume and expenditures for EPN

Additional detail on protection and control asset interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 13 - Asset Category - Protection and Control*.

3.2.7 Batteries

In total, in EPN, there are 1,463 battery and charger installations and a further 6,981 assets containing batteries, principally Remote Terminal Units (RTUs).

The investment strategy for RIIO-ED1 is based on achieving an optimal balance between maintenance and replacement by adopting industry best practice testing techniques to maximize battery life.

Automatic battery discharge testing is now incorporated into the Grid & Primary battery charger specification which will optimise the timing of battery replacement. It is anticipated that battery life will be extended by one or two years by the use of this feature.

During the ED1 period 1,538 battery and charger installations at Grid and Primary substations will be visited as part of the Black Start resilience project and some will be replaced. These have been excluded from the ED1 asset refurbishment/replacement volumes and costs.

Forecast asset replacements/refurbishments and total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	162	136	152	118	127	150	292	292	**1429**	179	95
Expenditure - TOTAL	£m	0.8	0.7	0.8	0.6	0.6	0.8	1.5	1.5	**7.3**	0.9	0.7

Table 20: Batteries ED1 forecast volume and expenditures for EPN

Additional detail on batteries interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 21 - Asset Category - Batteries*.

3.3 Legal and safety

UK Power Networks has an obligation to operate its network in a safe and reliable manner. This includes ensuring that the general public is protected from the dangers of electricity and the reduction of risk of injury to staff and contractors.

3.3.1 Site security

Substations across our networks have a high concentration of valuable assets and pose a considerable risk to theft and public safety if not properly secured. Our volume and expenditure projections for RIIO-ED1 are driven by commitments to upgrade security features across our 132kV, EHV, and HV substations.

Forecast interventions and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	3681	4,081	170	158	172	170	159	164	**8755**	1094	439
Expenditure - TOTAL	£m	4.6	5.3	2.7	2.5	2.8	2.6	2.6	2.4	**25.4**	3.2	1.7

Table 21: Legal and safety, site security, ED1 forecast volume and expenditure for EPN

3.3.2 Other

The majority of this expenditure is driven by safety concerns at cable pits across the EPN service territory. There are approximately 3,500 cable pits in EPN with the following risk ratings:

- 149 very high risk pits,
- 228 high risk pits,
- 2,685 medium risk pits, and
- 438 low risk pits.

There have been 29 disruptive cable pit failures since May 2012 across UKPN. The incidents have resulted in the serious injury of four members of the public. We are investing £11.2M in DPCR5 in the inspection, maintenance, risk mitigation and research of our 52,801 cable pits. We are proposing to invest an additional £1.9M during the RIIO-ED1 period to complete this risk mitigation strategy in EPN.

Additional expenditures in this category include asbestos management, enhanced fire protection, and upgraded earthing.

Forecast interventions and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume – TOTAL '000	each	35.8	33.4	33.4	33.4	33.4	33.4	33.0	32.8	268.7	33.6	31.5
Expenditure - TOTAL	£m	3.4	2.9	2.8	2.9	2.9	2.8	2.6	2.4	**22.8**	2.8	3.3

Table 22: Legal and safety, other, ED1 forecast volume and expenditure for EPN

Additional detail on the cable pits interventions and those driven by other legal and safety considerations, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 16 - Asset Category - Cable Pits*.

3.4 Quality of supply

UK Power Networks has set an overall business objective to improve continuity of supply in so that Customer Interruptions (CI) and Customer Minutes Lost (CML) performance from 2013/14 is in the top third compared to other DNOs during ED1. The cost of this improvement in service to customers is nil, as it will be funded directly by shareholders.

3.5 Rising mains and laterals

Rising mains and laterals are cables or busbars that form part of the equipment installed within multi-occupancy premises to distribute electricity to more than one dwelling or unit.

In EPN, we own riser and lateral systems that are of an adoptable standard, or would have been at the time of construction, and were installed post 1972.

A programme of inspections has commenced to confirm ownership and the condition of RMLs in EPN. The type of cables installed will be used to determine the age and to confirm ownership of the RMLs.

UK Power Networks has adopted a new approach to inspect, maintain and replace risers and laterals located within multi-occupancy premises. A ten-year cycle of inspections is underway to confirm ownership and the condition of these risers and laterals.

Based on sample inspections and testing of RMLs carried out between 2011 and 2012, it was established that there are issues with the breakdown of insulation in vulcanised India rubber (VIR) cables and rods. For this reason a proactive program of replacements will be carried out for risers and laterals with VIR to reduce the risk to third-parties and UK Power Networks staff working on RMLs.

The main drivers for the replacement of RMLs are the following:

- Electricity Supply Quality and Continuity Regulations (ESQCR);
- condition of assets with known failure modes (e.g. VIR Cables);
- security and quality of supply to customers; and
- reduction in Customer Interruptions (CIs) and Customer Minutes Lost (CMLs).

Forecast interventions and total expenditure for the ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	200	420	420	420	420	420	420	420	**3,140**	392.5	28.8
Expenditure - TOTAL	£m	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	**9.8**	1.2	0.3

Table 23: Rising mains and laterals ED1 forecast volume and expenditure for SPN

Additional detail on Rising Mains and Laterals interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 11 – Services and Terminations*.

3.6 Other non-load network investments

3.6.1 Flood defences

UK Power Networks' flood mitigation strategy includes for protection against fluvial and tidal flood events as well as protection against surface and subsurface water flooding (pluvial). Main sources of guidance to the UK Power Networks' strategy are:

- ENA document ETR138;
- the Department of Energy and Climate Change (DECC);
- Environment Agency (EA);
- local authorities; and
- specialist consultants.

Flooding was a major concern from the Christmas 2013 storm. Over a 24 hour period, the highest recorded rainfall for the same period was experienced in Wych Cross (SPN – East Sussex), Goudhurst (SPN - Kent) and Frittenden (SPN - Kent) with between 30.8-38.6mm of rain. This resulted in saturated ground, and combined with the higher rainfall resulted in localised flooding across the south east with an Environment Agency spokesman stating it was the worst flooding to hit the South East region since the autumn of 2000.

In EPN, during RIIO-ED1, we are proposing to make additional investments to protect against surface and subsurface flooding as a result of disrupted water mains. We have mapped this risk across our network and performed detailed cost benefit analysis that clearly demonstrates the value of our proposed mitigation measures.

Forecast interventions, including mitigation schemes and site survey, as well as total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/16	'16/17	'17/18	'18/19	'19/20	'20/21	'21/22	'22/23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	9.0	8.0	10.0	10.0	9.0	10.0	10.0	5.0	71.0	8.9	7.4
Expenditure - TOTAL	£m	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**7.5**	0.9	0.9

Table 24: Flood defences ED1 forecast volume and expenditure for EPN

3.6.2 BT 21st century

In EPN there are 138 rented BT private wires in use for 132kV teleprotection. These circuits provide the communication paths for all 132kV intertripping schemes. As a consequence, EPN is currently dependent on the continued availability of leased services for the safe, secure and compliant operation of the distribution network.

With BT's migration to an IP-based communication protocol by 2018, the electricity network will be at risk due to the non-deterministic nature of IP networks. Malfunction of protection systems, due to teleprotection failure, may result in extended outages to an otherwise healthy network, increased damage at the point of fault, overstressing of other plant and equipment, risk to personnel and members of the public, and potential non-compliance with ESQCR.

The BT21CN programme installs a fibre communication platform to provide the Teleprotection paths currently serviced by BT private wires. A mixture of self-build and leased fibre has been identified as the most effective strategy on the 132kV network, delivering a technically compliant solution with the lowest whole life cost.

Forecast interventions, including mitigation schemes and site survey, as well as total expenditures for the RIIO-ED1 period are provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	102	116	124	124	125	125	126	127	**969**	12	21
Expenditure - TOTAL	£m	7.8	5.9	4.0	1.4	1.5	1.4	1.5	1.6	**25.1**	3.1	0.3

Table 25: BT 21st century ED1 forecast volume and expenditures for EPN

Additional detail on other BT 21st century interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 17 - Asset Category – BT21*.

3.6.3 Technical losses and other environmental

Losses represent the difference between the electrical energy metered entering the distribution system from National Grid and that billed to customers. These losses comprise a technical component which is the energy that turns to heat as electricity flows though the distribution system, a proportion that is a result of illegal consumption and inaccuracies in the process of reconciling the energy billed to customers with that entering the distribution system. Our plan to address losses include asset replacements, general reinforcements and loss management.

Other environmental reporting and mitigation schemes we are proposing for RIIO-ED1 include:

- oil pollution mitigation;
- noise abatement; and
- contaminated land clean up.

Forecast interventions and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	163	163	163	163	163	163	163	163	**1304**	163	116
Expenditure - TOTAL	£m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	**9.9**	1.2	2.0

Table 26: Technical losses and other environmental ED1 forecast volume and expenditure for EPN

3.6.4 Civil works

For the purpose of this plan the civil assets are divided into six subcategories:

- substation building components and surrounds;
- substation security;
- substation flood protection;
- oil containment;
- cable tunnels; and
- cable bridges

In total, in EPN, there are 37,176 distribution substations, 761 grid and primary sites, 13,800 secondary buildings, 703 primary building and 328 grid substation buildings.

There are two types of civil works in our plan:

- Condition driven civil works; and
- Asset replacement driven civil works.

Our condition driven civil works represent the investment in replacement of all substation building components and surrounds that have been assessed as 'poor condition'.

The failure of civil assets can lead to environmental and safety issues, affect quality of supply, compromise system security and in worst cases result in a large number of supply interruptions. Replacement of poor condition substation buildings and enclosures will also reduce the deterioration of substation equipment and the risk of trespassing.

Assets are forecast to be replaced once they reach Health Index 4. Due to most of the network civil works being constructed during the 1960s and the deteriorating conditions of the assets a large replacement programme will continue to be required throughout RIIO-ED1. We also anticipate that the ongoing inspection process will find new replacement works due to degradation.

Forecast interventions and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - interventions	each	1243	1242	1241	1240	1246	1241	1241	1231	**9925**	1241	1097
Expenditure - TOTAL	£m	4.5	4.1	4.3	4.1	4.5	4.1	4.1	4.1	**33.8**	4.2	4.0

Table 27: Civil works, condition driven, ED1 forecast volume and expenditures

Our asset replacement driven civil works forecast represents consequential volume and expenditure that arise as a result of the replacement of other assets. For example, this would occur when an existing building in good condition needs to be replaced to accommodate new transformers, switchgear, etc.

Forecast interventions volume and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume - TOTAL	each	316	340	399	344	431	410	361	425	**3026**	378	242
Expenditure - TOTAL	£m	4.1	4.9	7.6	7.6	8.2	7.3	5.8	5.0	**50.5**	6.3	4.5

Table 28: Civil works, asset replacement driven, ED1 forecast volume and expenditures for EPN

Additional detail on both condition and asset replacement driven civil works interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 10 - Asset Category - Civils*.

3.6.5 High impact, low probability events

High impact, low probability (HILP) events expenditure is designed to increase the security of supply to specific areas of the network that have a level of economic activity over and above a specified threshold.

There is no customer funded volume or expenditure forecast for EPN in RIIO-ED1.

3.6.6 Security of critical national infrastructure

UK Power Networks works with the security services and the Centre for the Protection of the National Infrastructure to take even more stringent security measures at sites which are key to the UK. The measures include the installation of enhanced security features, such as:

- electrified fences;
- alarm systems; and
- closed-circuit television.

Five sites will be benefited by the investment of £15m during RIIO-ED1.

Forecast interventions and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Expenditure - TOTAL	£m	10.0	4.0	0.5	0.0	0.0	0.0	0.0	0.0	**14.5**	1.8	0.5

Table 29: Security of critical national infrastructure RIIO-ED1 forecast expenditures for EPN

3.6.7 Black start

Black start is the procedure to recover from a total or partial shutdown of the distribution network system which has caused an extensive loss of supplies.

In the event that a large scale loss of local and national generation occurs, OFGEM and the Energy Emergencies Executive Committee (E3C) require each DNO to ensure SCADA control and tripping batteries (including intertripping systems, 50V and 60V) in all grid and primary substations are serviceable after a period of black start recovery.

Each DNO has approached this in a number of ways. UK Power Networks proposed to develop and install a black start controller unit to isolate/reduce the standing load on the grid and primary substation battery charger systems for both SCADA and tripping functions. Additionally, where a battery/charger installation has a single battery string, a second string will be added to facilitate the installation and functionality of the black start controller.

A company-wide standard has been written to detail the requirements for a black start controller and this has also been incorporated into a wider specification for grid and primary battery installations. Discussions have taken place with approved suppliers capable of providing the required equipment and this has helped to ensure the specification meets the needs of the network.

In order to meet the recommendation for 72 hour resilience, it is proposed that each grid and primary substation be equipped with dual string 110V tripping battery supplies, each string being rated for six hours use at rated output. In conjunction with the black start controller unit this will ensure that dc supplies to substation equipment during and after a period of black start outage is available. The SCADA monitoring battery supply will be sized for the full 72 hours, the maximum period a black start recovery is expected to last according to the report published by Ofgem in 2010.

It is estimated that this roll-out will take 8 years. Forecast volume and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	**TOTAL ED1**	AVG. ED1	AVG. DPCR5
Volume – TOTAL	each	205	205	203	196	126	0.0	0.0	0.0	**935**	117	71
Expenditure – TOTAL	£m	1.0	1.0	1.0	0.9	0.6	0.0	0.0	0.0	**4.5**	0.6	0.3

Table 30: Black start ED1 forecast volume and expenditures for EPN

Additional detail on Black Start interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 18 - Asset Category - Black Start*.

3.7 Other costs

3.7.1 Operational information technology and telecommunications

In total, in EPN, there are 7,565 RTUs (671 primary RTUs and 6,894 secondary RTUs). There are 1,342 primary Supervisory Control and Data Acquisition (SCADA) communications circuits (main and standby) and 6,894 secondary SCADA communications circuits.

To assist in the delivery of the government's carbon reduction targets and to minimise the overall cost to the UK as a whole, the use of smart technologies will become more widespread during ED1. These technologies will leverage greater capacity out of the power network and enable the connection of increased levels of low-carbon generation by providing more accurate data, extracting additional capacity from network elements, such as transformers and circuits, and using fast-acting algorithms to keep a potentially volatile network stable. All of this will require a larger volume of data to be transferred at greater speeds than is currently possible, both between equipment in the field and between that equipment and the control centre site.

Much of the SCADA equipment is now so old that it can no longer be supported. The network requires a significant upgrade to enable innovative technologies to be deployed to realise better asset information and enhance its management. This strategy proposes the replacement of a significant amount of SCADA equipment, including RTUs and communications systems over the RIIO-ED1 period.

The communications networks must also be able to operate during a power outage to swiftly and safely restore supplies. Secondary SCADA used the Vodafone PAKNET system to provide communications. The resilience of the PAKNET system is not sufficient for modern automation schemes due to the lack of battery back-up on the base station sites. This has resulted in many automation schemes not operating correctly, resulting in CIs and CMLs.

Our network management system (NMS) requires continual upgrading to enable reliable operation and to accommodate ever increasing demands. These include:

- increasing volume of RTUs installed on the network;
- increasing volume of automation;
- increasing sophistication of automation schemes;
- obsolescence of information and technology (IT) equipment; and
- increasing functionality.

Asset management and monitoring techniques will also become more widespread over the coming years, which will require a communications system with greater bandwidth to enable substation asset monitoring and management data to be transmitted effectively. This requires greater bandwidth, which cannot be provided with the existing SCADA systems.

Investment drivers for RTUs can be split into three main categories:

- availability of spares and components - due to the age of the RTU equipment and the relatively short lifespan of IT equipment, some of the components within the RTU and RTU plant cards are no longer manufactured and/or supported by the manufacture;
- suitability of technology - better technology is required to ensure the network can accommodate higher levels of volatile generation and unpredictable loads; and
- RTU availability - upgraded equipment is required to improve the availability of RTU assets during fault conditions and to enable accelerate restoration of supply to customers.

Forecast operational information technology and telecommunications volume and total expenditure for the RIIO-ED1 period is nil for EPN.

Additional detail on RTU and SCADA interventions, including a discussion of the types of interventions we have included in our plan, is available in *ASR - Document 19 - Asset Category - RTU and SCADA*.

3.7.2 Smart metering

The Government has mandated the rollout of smart gas and electricity meters to all domestic and non-domestic customers by the end of 2020. This is a major national change programme that will involve visits to every premise in the UK and the installation of more than 100 million devices over a five year period.

The rollout of smart meters will play an important role in Great Britain's transition to a low-carbon economy, and help us meet our long-term challenges in ensuring an affordable, secure and sustainable energy supply. Smart meters will provide real-time information on energy usage and accurate billing, helping consumers to target their usage and save money; they will enable the introduction of more sophisticated energy management, with Time-of-Use Tariffs and load shifting and they will pave the way for the smart grid and the network of the future.

The rollout is Supplier-led to maximise the potential for consumer benefits, but has significant dependencies on and opportunities for, DNO. Specific dependencies include:

- interventions
- industry interface and income management
- security and privacy
- Data Communications Company (DCC) costs:

Opportunities include:

- improved real-time data - fault management and customer service enhancements;
- improved asset and performance data - network condition and planning; and
- improved real-time control.

We have assessed each area of cost for our networks and sought ways to optimise spend, consistent with delivering a quality consumer experience and the overall benefits. Forecast total expenditure for the RIIO-ED1 period is provided in the table below, and includes only those costs that are passed through to our customers. Cost categories include:

- interventions;
- indirect costs (including training);
- industry interface and income management;
- call centre;
- network condition and planning;
- DCC fixed and transaction charges; and
- IT costs.

Forecast interventions and total expenditure for the RIIO-ED1 period is provided in the table below (including variant costs).

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Expenditure - TOTAL	£m	2.0	3.6	4.5	4.9	4.8	3.4	0.8	0.8	**24.9**	3.1	0.2

Table 31: Smart metering RIIO-ED1 forecast expenditures for EPN

4 Network operating costs

4.1 Inspections and maintenance

UK Power Networks inspects and maintains its network to minimise the expected whole life cost of an asset. UK Power Networks has developed an inspection and maintenance policy based upon a combination of real time information and studies of asset condition. Inspection and maintenance is used to ensure that the life of an asset is maximised by identifying and fixing asset problems before they occur.

The strategy for inspection and maintenance is to continue to maintain, monitor and review the performance of the assets to achieve maximum life, while keeping the risks to the network and the general public, as well as whole-life costs, as low as reasonably practical. The overall strategy for ED1 is to manage a steady state position for the majority of the asset types, with Health Indices remaining consistent across the period. This approach is based on known condition data from historic inspection and maintenance reporting and operating performance of the assets, combined with local knowledge and experience. The proposed plan manages any change in risk due to an ageing asset population or from the deployment of increasing volume of lower maintenance equipment such as vacuum and SF6 switchgear.

UK Power Networks adopted reliability centred maintenance (RCM) assessments to optimise inspection and maintenance activities. This has recently driven changes to substation inspections and overhead plant maintenance, as well as the adoption of new inspection techniques that optimise maintenance requirements. New technology also provides the chance to reconsider how we carry out activities not only more efficiently, but in a safer manner. Inspection and maintenance innovations include:

- increased use of (remote) change of state operations to check mechanism operations and hence reduce routine inspections;
- continuous (fixed) partial discharge monitoring;
- tailoring post fault maintenance to the cumulative fault current rather than number of operations; and
- tailoring diverter maintenance to the specific transformer and tap changer types.

4.1.1 Inspections

An increase in the inspection period has been recently instigated for substation sites, driven by an opportunity to create efficiency improvements that will optimise expenditure in this area during ED1. For secondary substations, the period between dedicated inspections will be increased from two years to three years. For primary substations the period between inspections will be increased from every four months to once every six months. This change in strategy is enabled by the recognition that there are a number of ad-hoc visits to substations throughout the year into which some of the basic aspects of the period inspections can be incorporated.

Generally speaking, the routine inspection of a substation includes the inspection of all the assets within it. Hence, with the secondary substation inspections increased from two to three years, the interval for inspections of the distribution transformers, HV switchgear (circuit breakers, ring main units and switches) and LV assets (wall-mounted LV boards, air circuit breakers and feeder pillars) in the substation also increased. Similarly, with the grid and primary substation inspections increased from three to six months, the inspections of the grid and primary transformers, HV/EHV/132kV circuit breakers and other assets in the substation increased.

The volume and expenditure reductions forecast in ED1 are driven by the changes to inspection activities explained above, efficiency opportunities that have been identified and the reduction in unit costs.

Forecast volume and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume – TOTAL '000	each	204	204	205	203	204	205	203	204	**1632**	204	215
Expenditure - TOTAL	£m	6.0	5.6	5.5	5.4	5.3	5.3	5.2	5.1	**43.4**	5.4	7.3

Table 32: Inspections ED1 forecast volume and expenditures for EPN

4.1.2 Maintenance

Maintenance activities are driven by the desire to maintain the current level of CI and CML throughout the RIIO-ED1 period. Maintenance activities are carried out on assets in our network on a routine basis at intervals determined by the type and condition of an asset. Intervals for maintenance activities are set based on a combination of the outcome of RCM studies, manufacturers' recommendations and our experience in operating the assets.

Forecast volume and total expenditure for the RIIO-ED1 period is provided in the table below. The decrease in expenditure proposals in ED1 is primarily due to a reduction in unit costs and the mix of maintenance activities.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume – TOTAL '000	each	77.1	77.8	77.7	76.9	77.0	78.4	78.9	78.8	**622.5**	77.8	52.1
Expenditure - TOTAL	£m	9.6	9.3	9.2	9.1	8.9	9.0	8.9	8.8	**72.7**	9.1	12.8

Table 33: Maintenance ED1 forecast volume and expenditures for EPN

4.2 Fault investigations and repairs

Collectively, our investment and operational programmes seek to minimise the likelihood of faults on our network. However, inevitably, they will still occur. When faults occur, our priorities are goal is to respond to faults in an efficient, timely, and effective manner to restore service as quickly as possible and ensure the safety and security of our network, the public, our employees and contractors.

The volume and expenditure included in our plan are designed to keep the volume of incidents broadly consistent over the DPCR5 and RIIO-ED1 periods.

Under regulatory reporting, there are two main categories of trouble call activities: incidents covered by the Interruption Incentive Scheme (IIS) and Occurrences Not Incentivised

(ONIs.) The forecast volume of activities and expenditure in each of these two categories is provided in the following subsections.

4.2.1 Trouble call

Forecast volume and total expenditure for trouble calls covered by the IIS for the RIIO-ED1 period is provided in the table below.

	Units	'15/16	'16/17	'17/18	'18/19	'19/20	'20/21	'21/22	'22/23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume – TOTAL '000	each	20.0	20.1	20.1	20.1	20.0	20.2	20.2	20.2	**161**	20.1	20.6
Expenditure - TOTAL	£m	28.4	28.6	28.5	28.4	27.7	28.3	28.4	28.8	**227.2**	28.4	36.4

Table 34: Trouble call RIIO-ED1 forecast volume and expenditure for EPN

4.2.2 Occurrences not incentivised

Forecast volume and total expenditure for ONIs for the RIIO-ED1 period is provided in the table below.

	Units	'15/16	'16/17	'17/18	'18/19	'19/20	'20/21	'21/22	'22/23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume – TOTAL '000	each	40.8	37.1	34.7	32.3	30.5	30.5	32.0	32.0	**270**	33.8	47.0
Expenditure - TOTAL	£m	9.4	8.7	8.4	8.2	7.9	7.8	8.1	8.0	**66.6**	8.3	12.6

Table 35: Occurrences not incentivised RIIO-ED1 forecast volume and expenditure for EPN

4.2.3 Severe weather (SW120)

Each year, periods of poor weather and storms can result in network damage. In some very rare instances these storm events are classified as exceptional, or 1 in 20 year events. The network damage of these 1 in 20 year storms generally arise from gale force winds that disrupt trees and overhead lines.

Forecast total expenditure for severe weather for the RIIO-ED1 period is provided in the table below. The projected £7m is equivalent to approximately half of one event occurring in the RIIO-ED1 period.

	Units	'15/16	'16/17	'17/18	'18/19	'19/20	'20/21	'21/22	'22/23	TOTAL ED1	AVG. ED1	AVG. DPCR5
Volume – TOTAL '000	each	185.6	185.6	185.6	185.6	185.6	185.6	185.6	185.6	**1485.0**	185.6	325.6
Expenditure - TOTAL	£m	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	**7.0**	0.9	1.2

Table 36: Severe weather (SW120) RIIO-ED1 forecast volume and expenditure for EPN

4.3 Tree cutting

The strategy for tree cutting is to ensure vegetation around overhead lines is managed in order to keep the risks to the network and the general public, as well as overall costs, as low as reasonably practical.

Tree cutting is managed through the deployment of contractors and in-house staff to maintain cutting to ENA Technical Specification 43-8 (horizontal and vertical clearances) and to achieve a more resilient network as required by ENA Technical Recommendation ETR132 (Network Resilience) of the ESQCR 2006.

Forecast volume and total expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	**TOTAL ED1**	AVG. ED1	AVG. DPCR5
Volume – TOTAL '000	spans	209	209	209	209	209	209	209	209	**1671**	209	194
Expenditure - TOTAL	£m	15.8	15.9	16.0	16.0	16.0	15.8	15.6	15.4	**126.6**	15.8	15.8

Table 37: Tree cutting RIIO-ED1 forecast volume and expenditure for EPN

4.4 Other network operating costs

Other Network Operating Costs (NOCs) include:

- dismantlement costs;
- remote location generation operating costs, including fuel; and
- substation electricity

Forecast expenditure for the RIIO-ED1 period is provided in the table below.

	Units	'15/ 16	'16/ 17	'17/ 18	'18/ 19	'19/ 20	'20/ 21	'21/ 22	'22/ 23	**TOTAL ED1**	AVG. ED1	AVG. DPCR5
Expenditure - TOTAL	£m	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	**36.2**	4.5	3.8

Table 38: Other network operating costs RIIO-ED1 forecast expenditures for EPN