Document 7
Asset Category – 11kV Switchgear
EPN

Asset Stewardship Report 2014

Brian Matthews

Approved by Richard Wakelen / Barry Hatton

Document date 04/03/2014

Document History

Version	Date	Details	Originator	Revision Class	Section Update
1.0	19/02/2014	Original document	Brian Matthews		
1.1	19/02/2014	Costs and volumes updated. Appendices 8, 9 and 10 added	Brian Matthews	Major	1.1, 1.3, 2.1, 7.4, App5
1.2	20/02/2014	Appendix 9 modified	Brian Matthews	Minor	App 9
1.3	20/02/2014	Costs removed from Appendix 8	Brian Matthews	Major	1.1, App 8
1.4	24/02/2014	HI and risk profiles updated	Brian Matthews	Major	7.2, 7.8, App 2
1.5	24/02/2014	ASR Preface added and ref to unscaled in header removed	Brian Matthews	Minor	Preface
1.6	25/02/2014	Minor formatting and spelling corrections	Brian Matthews	Minor	3.6.2, 3.5, 7.4, App 2
1.7	26/02/2014	Align with gold checklist v11	Brian Matthews	Minor	Throughout document
1.8	03/03/2014	Address Clive Deadman comments	Brian Matthews	Minor	Preface, 1.4

Version	Date	Details	Originator	Revision Class	Section Update
2.0	04/03/2014	Final version	Brian Matthews	Minor	

Preface

UK Power Networks uses Asset Stewardship Reports ('ASR') to describe the optimum asset management strategy and proposals for different groups of assets. This optimised asset management strategy and plan details the levels of investment required and the targeted interventions and outputs needed. Separate ASRs define the most efficient maintenance and inspection regimes needed and all documents detail the new forms of innovation which are required to maximise value, service and safety for all customers and staff throughout the ED1 regulatory period. Outline proposals for the ED2 period are also included.

Each DNO has a suite of approximately 20 ASR's. Although asset policy and strategy is similar for the same assets in each DNO the detailed plans and investment proposals are different for each DNO. There are also local issues which must be taken into account. Accordingly each DNO has its own complete set of ASR documents.

A complete list of titles of the ASR's, a summary of capex and opex investment is included in '**Document 20: Asset Stewardship Report: Capex/Opex Overview'**. This document also defines how costs and outputs in the various ASR's build up UK Power Networks 'NAMP' (Network Asset Management Plan) and how the NAMP aligns with Ofgem's ED1 RIGs tables and row numbers.

Where 'HI' or asset 'Health Index' information is included please note predicted ED1 profiles are before any benefits from 'Load driven investment.'

This ASR has also been updated to reflect the feedback from Ofgem on our July 2013 ED1 business plan submission. Accordingly to aid the reader three additional appendices have been added. They are;

1. **Appendix 8 - Output NAMP/ED1 RIGS reconciliation:** This section explains the 'line of sight' between the UKPN Network Asset Management Plan (NAMP) and the replacement volumes contained in the Ofgem RIGS tables. The NAMP is the UKPN ten year rolling asset management investment plan. It is used as the overarching plan to drive both direct and indirect Capex and Opex interventions volumes and costs. The volume and cost data used in this ASR to explain our investment plan is taken from the UK Power Networks NAMP. Appendix 8 explains how the NAMP outputs are translated into the Ofgem RIGS tables. The translation of costs from the NAMP to the ED1 RIGS tables is more complex and it is not possible to explain this in a simple table. This is because the costs of a project in the 'NAMP' are allocated to a wide variety of tables and rows in the RIGS. For example the costs of a typical switchgear replacement project will be allocated to a range of different Ofgem ED1 RIGs tables and rows such as CV3 (Replacement), CV5 (Refurbishment) CV6 (Civil works) and CV105 (Operational IT Technology and Telecoms). However guidance

notes of the destination RIGs tables for NAMP expenditure are included in the table in the Section 1.1 of the Executive Summary of each ASR.

2. **Appendix 9 – Efficiency benchmarking with other DNO's:** This helps to inform readers how UK Power Networks is positioned from a benchmarking position with other DNO's. It aims to show why we believe our investment plans in terms of both volume and money is the right answer when compared to the industry, and why we believe our asset replacement and refurbishment investment proposals are efficient and effective and in the best interest for our customers.

3. **Appendix 10 – Material changes since the July 2013 ED1 submission:** This section shows the differences between the ASR submitted in July 2013 and the ASR submitted for the re-submission in March 2014. It aims to inform the reader the changes made to volumes and costs as a result of reviewing the plans submitted in July 2013. Generally the number of changes made is very small, as we believe the original plan submitted in July 2013 meets the requirements of a well justified plan. However there are areas where we have identified further efficiencies and improvements or recent events have driven us to amend our plans to protect customer safety and service.

We have sought to avoid duplication in other ED1 documents, such as 'Scheme Justification Papers', by referring the reader to key issues of asset policy and asset engineering which are included in the appropriate ASR documents.

Contents

1.0 Executive Summary EPN 11kV Grid and Primary Switchgear

1.1 Scope

This document details UK Power Networks' non-load related expenditure (NLRE) replacement and refurbishment proposals for 11kV grid and primary switchgear for the RIIO-ED1 period. Indicative proposals for the ED2 period are also included.

There are 5,146 items of 11kV grid and primary switchgear in EPN, with an estimated MEAV of £525m. The proposed investment including civils is £8.0m per annum; this equates to an average annual 1.5% of the MEAV for this asset category.

Replacement costs for these assets are held in the Networks Asset Management Plan (NAMP) and in sections of the RIGs tables identified in Table 1. Note that the work associated with the replacement of 11kV Primary circuit breakers is mapped to several different RIGS tables and rows. Appendix 8 provides more information of the NAMP to RIGS mapping.

A full list of abbreviations is included in Section 6.0 of *Document 20: Capex Opex overview*.

INVESTMENT TYPE	ED1 COSTS	NAMP LINE	RIGS REFERENCE*
Asset Replacement	£19.1m	1.50.01	Additions CV3 Row 33 – 6.6/11kV CB (GM) Primary Removals CV3 Row 161 – 6.6/11kV CB (GM) Primary
Asset Refurbishment	£2.1m	1.50.01	CV5 Row 19 – 6.6/11kV CB (GM) Primary
Asset Replacement	£3.2m	1.50.01	CV8
Asset Replacement	£2.4m	1.50.01	CV105

Table 1 – Investment summary

Source: 19th February 2014 NAMP Table J Less Indirect

* Expenditure on this asset type is also included in CV6 civils and CV3 6.6/11kV UG cable

1.2 Investment Strategy

The investment strategy for RIIO-ED1 is detailed in *EDP 00-0012 Asset Lifecycle Strategy – Major Substations* and is based on achieving an optimal balance between maintenance, refurbishment and replacement by:

- Maintaining a constant risk level throughout the period by replacing or refurbishing assets when they reach HI4 or HI5
- Ensuring that the circuit breaker operating mechanism performance remains satisfactory by identifying deteriorating trends in circuit breaker trip times and refurbishing or replacing the assets as necessary
- Managing the deteriorating circuit breaker partial discharge performance of GEC type VMX by replacing assets as necessary.

1.3 Innovation

We have developed and deployed a new retrofit CB truck employing the minimum number of moving parts. During ED1, 90 switchpanels will be retrofitted with new trucks, which will save approximately £5.4m compared with traditional replacement strategies. In addition, the installation of online PD monitoring at 10 sites will enable the replacement of approximately 100 switchpanels to be deferred, saving around £10m.

1.4 Risks and Opportunities

	Description of similarly likely opportunities or risks arising in ED1 period	**Uncertainties (£m)**
Opportunity	Use refurbishment options 10% more often than planned	(0.7)
Risk	Cannot undertake refurbishment options for 10% of the time	0.7
Risk	Cost of refurbishment rises by 20% for 20% of planned refurbishment interventions in ED1 period	0.1

Table 2 – Risks and opportunities

2.0 Description of 11kV Grid and Primary Switchgear Population

2.1 11kV Grid and Primary Switchgear

There are 5,146 circuit breakers installed in 475 grid and primary substations operating at 6.6kV or 11kV. Switchboards in EPN range in size from single-panel rural sites to 33 panels in major cities, all of which are installed indoors. Table 4 shows the breakdown of types.

Arc interruption medium	Withdrawable	Fixed pattern
Oil	1,663	6
SF_6	500	118
Vacuum	1,172	1,687
Total	**3,335**	**1,811**

Table 3 – Breakdown of 11kV grid and primary switchgear by type

Source: ARP model Ph 1 11kV GP Sgr 25 July 2012

The age profile for 11kV grid and primary switchgear is shown in Figure 1. The switchgear in EPN is the youngest in the UK Power Networks area, with an average age at the start of ED1 of 26 years. The oldest 10% of the population has an average age of 52 years at the start of ED1.

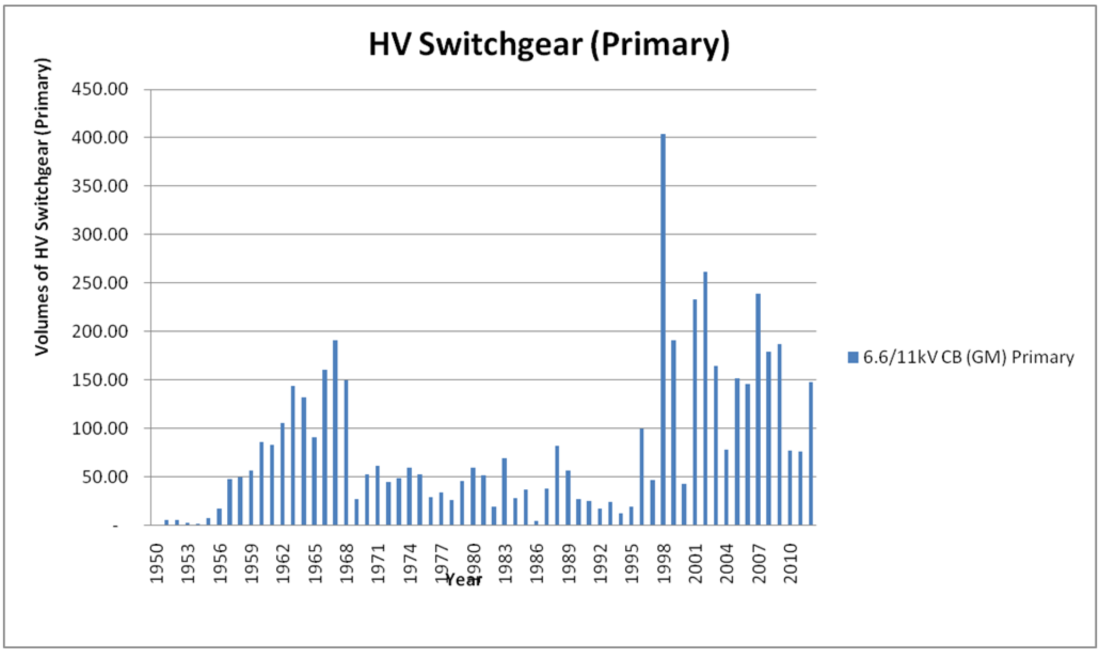


Figure 1 – 11kV grid and primary switchgear age profile

Source: 2012 RIGs submission V5

If the proposed retrofit and replacement interventions are carried out, the average age at the end of ED1 will drop to 25 years, with the oldest 10% rising to 59 years.

Note: For withdrawable equipment, the profile is based on the age of the circuit breaker truck rather than the housing. There were 970 withdrawable vacuum circuit breakers manufactured between 1998 and 2005, installed as retrofits into 1950s and 1960s oil CB housings.

EPN has a diverse range of 11kV switchgear types, with virtually every type ever manufactured being installed somewhere on the network. However, of the oil equipment, South Wales type 'C4X' and Reyrolle 'LMT' are the most common.

EPN was an early adopter of vacuum technology and so has a large population of older units, such as AEI 'BVAC' and Brush 'FV'.

Figure 2 – Metropolitan Vickers type 'V1R' switchboard at West Green Primary

Figure 2 shows a Metropolitan Vickers type 'V1R' switchboard at West Green Primary in North London. This was installed in 1956, but one of the panels was retrofitted with a GEC 'VMX' CB truck in 2000. The switchboard suffers partial discharge problems from the original and retrofit CBs, and is scheduled for replacement in 2017.

All 11kV grid and primary switchgear NLRE replacements and retrofit projects proposed for ED1 are listed under NAMP Line 1.50.01 and detailed in Appendix 7. The principal RIGs lines are shown in Table 5 with a full list in Appendix 8.

RIGs Table	Row (additions)	Row (removals)	Description
CV3	29	157	6.6/11kV UG Cable
CV3	31		Building EHV
CV3	33	161	6.6/11kV CB (GM) Primary
CV5	19		6.6/11kV CB (GM) Primary

Table 4 – RIGs categories

3.0 Investment Drivers

The high-level investment drivers for 11kV grid and primary switchgear are detailed in EDP 00-0012, *Asset Lifecycle Strategy Major Switchgear*.

3.1 Defects

3.1.1 Defects used as investment drivers

As switchgear defects are found or cleared, they are recorded in the Ellipse asset register using the handheld device (HHD). Defects can be recorded either on an ad hoc basis or at each inspection and maintenance. Those used in the ARP model are shown in Table 6.

Measure	Inspection	Maintenance
Compound leak	Yes	Yes
Control cubicle	If present	If present
External connections	If present	If present
Gasket	Yes	Yes
Oil level	Yes	Yes
Oil sight glass	Yes	Yes
Partial discharge	Yes	Yes
SF_6 gas pressure	Yes	Yes
Shutter mechanism	No	Yes

Table 5 – Defects used in the ARP switchgear models

In calculating the overall Health Index, the ARP model counts the total number recorded against individual items of plant, not just those currently outstanding.

Each of these defects is described in more detail below.

- Compound leak – To provide an impulse voltage rating, bitumen compound was used as an insulation medium in busbars, CT chambers and cable termination boxes on most older metal-clad switchgear. If any compound leaks out, the impulse rating is reduced, with the risk of a disruptive failure if the equipment is subject to an overvoltage.
- Control cubicle – This records defects in the small wiring, auxiliary fuses and terminal blocks associated with the control of the circuit breaker. These defects can prevent the CB from operating correctly with a resultant impact on CIs and CMLs.
- External connection – For 11kV circuit breakers, this records defects with the primary isolating contacts. A problem here can result in overheating and eventual disruptive failure.

- Gasket – For oil-filled switchgear, this records a defective gasket, i.e. one that is allowing fluid to leak. No action is needed immediately, but, if left unchecked, the defect can result in a low oil level.
- Oil level – For oil-filled switchgear, this shows that the oil level is low and needs to be topped up. If left unchecked, this can result in a disruptive failure.
- Oil sight glass – For oil filled switchgear, this shows that the oil sight glass is unreadable, broken or missing. If left unchecked, it can result in a disruptive failure.
- Partial discharge – This shows that partial discharge has been detected using the UltraTEV device. If left unchecked, it could result in a disruptive failure. See section 3.6 for more detail.
- SF_6 gas pressure – SF_6 gas is used as an insulating medium. If the pressure falls below the rated value, the equipment could fail disruptively if left in service.
- Shutter mechanism – For withdrawable switchgear only, this records defects with the mechanism used to cover the busbar and circuit spouts when the breaker is withdrawn from its housing. Broken mechanisms represent a serious risk to operator safety.

3.1.2 Analysis of defects

An analysis of all 11kV grid and primary switchgear defects used in the ARP model is shown in Figures 3 and 4.

Figure 3 shows how old the asset was when the defect was recorded. Generally the number of defects increases as the plant ages with the majority occurring on plant between 30 and 55 years of age, which corresponds with the range of average asset life settings in the ARP model. Because of the large volumes installed in the last 15 years ago there are some defects on plant in this younger age band but further analysis shows that these are mainly associated with the original fixed portions on plant with retrofit CBs many of which are named replacement schemes in ED1.

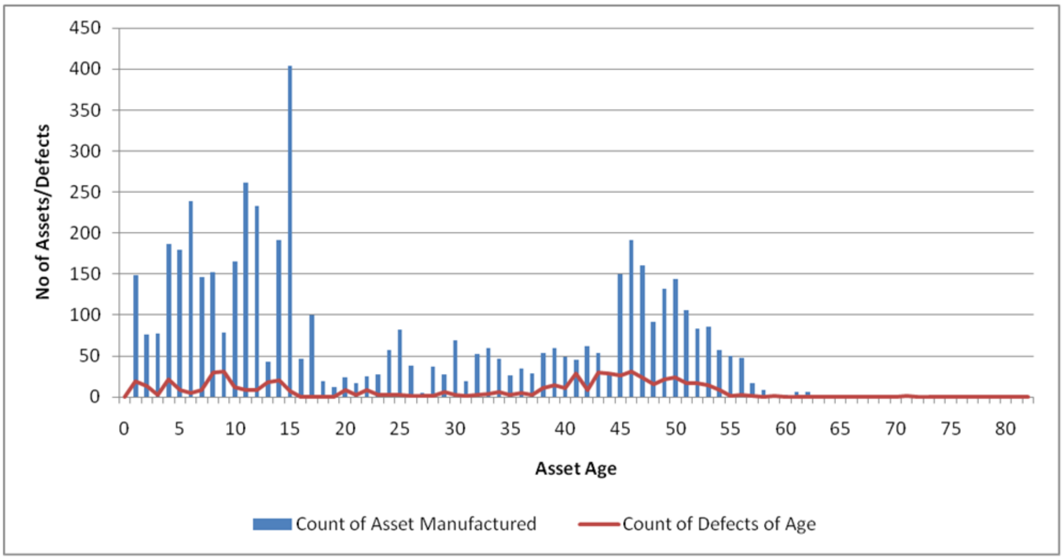


Figure 3 – Switchgear defects by age of asset

Source: Ellipse Defect extract 'EPN Defect Analysis v2' 19_02_2

Figure 4 shows the number of switchgear defects reported since 2007, when the Ellipse asset register was introduced. 2007 includes defects that may have existed for several years, while the numbers reported in subsequent years more accurately represent new defects found. From 2008 there is a rising trend.

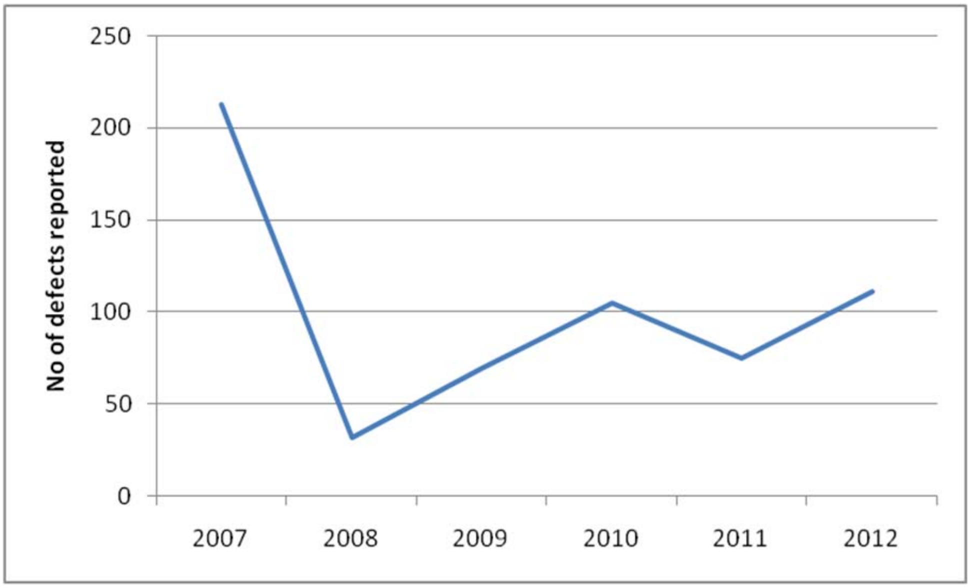


Figure 4 – Number of defects reported per year

Source: Ellipse Defect extract 'EPN Defect Analysis v2'

3.1.3 Examples of defects

Figure 5 – Defective test bushing

Figure 5 shows the result of partial discharge activity in the test orifice of an AEI 'BVAC' panel at High Street Primary, Brentwood. Parts are no longer available, so the bushing was removed from service. The switchboard continues to give discharge problems and is scheduled for replacement in 2017.

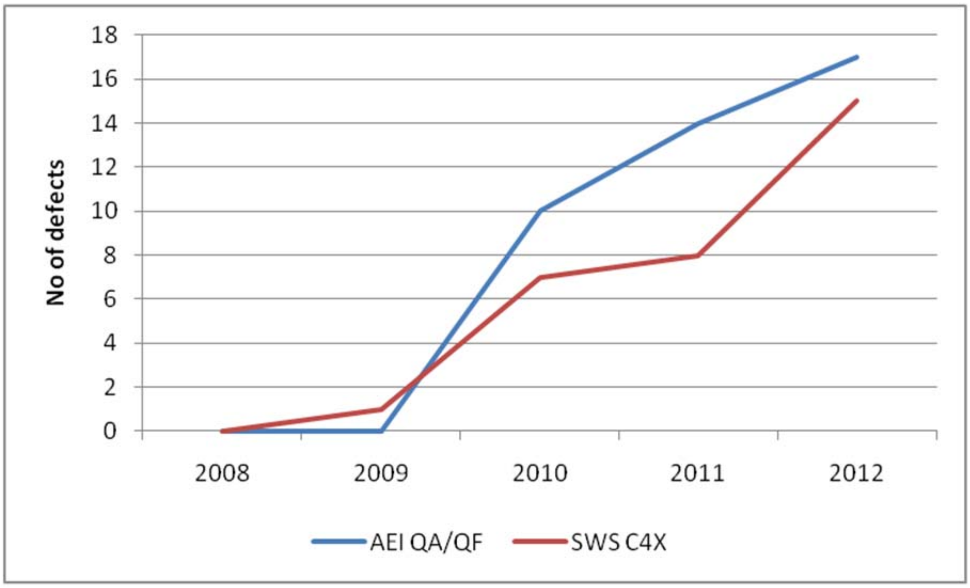


Figure 6 – Compound leaks by switchgear type

Source: 11kV GP Defect analysis Jan 2013

Figure 6 shows the increase in reported compound leaks for the two most popular oil circuit breaker types, and Figure 7 shows a typical leak.

Figure 7 – A typical compound leak from a cable box

3.2 Condition

3.2.1 Substation inspection

The main source of asset external condition data is from substation inspectors. As such, during the first half of DPCR5, a review of the *Substation Inspectors' Handbook* was carried out and a new handbook was issued. All inspectors were required to undertake a two-day training course and pass the theory and practical examinations before being certified as competent inspectors.

Figure 8 – Substation inspector with handheld device

In order to ensure good quality data is captured and recorded in the asset register in a timely manner, handheld devices (HHD) are used on site at the point of inspection. When an inspection HHD script is run, the user answers a set of questions, specific to each asset type, about the condition. This allows defects to be recorded, reviewed and cleared.

3.2.2 Maintenance

Maintenance fitters also use the same HHD technology to record their assessments of the internal and external conditions of the assets being maintained. This assessment is made twice, to provide condition data ‘as found’ and ‘as left’.

3.2.3 Examples of condition data

Examples of condition data collected at inspection and maintenance are shown in Table 7.

Measure	Inspection	CB operation	Maintenance
CB initial trip time	No	Yes	Yes
CB last trip time	No	No	Yes
Condition of bushing	If visible	No	Yes
Condition of isolating	No	No	Yes

Measure	Inspection	CB operation	Maintenance
contact			
Ductor reading	No	No	At full maintenance
External condition of housing	Yes	No	Yes
Oil containment	Yes	No	Yes
Oil test breakdown	No	No	At full maintenance
Operation of switchgear	No	Yes	Yes
Overall internal condition	No	No	At full maintenance

Table 6 – Condition points used in switchgear ARP models

EMS 10-0002 Inspection and Maintenance Frequency Schedule specifies the inspection and maintenance frequencies for all plant. Inspection is currently carried out every four months; CB operation every one or two years, depending on the function of the CB; and maintenance of the CB mechanism takes place every six years, with full maintenance after either three to six fault trips or 12 years, whichever comes first.

Condition is recorded as 1 (as new), 2 (normal for age, no work needed), 3 (remedial work needed) or 4 (replacement needed). Ductor and CB times are recorded in microhms/mS.

Figure 9 – Cable bushing in poor condition removed from AEI 'QF' switchgear at Hoddesdon Primary

Figure 9 shows an 11kV cable bushing removed from an AEI 'QF' switchboard at Hoddesdon Primary. Partial discharge activity had been picked up through routine inspection and investigation showed that the foil wound SRBP bushing was breaking down internally between foils. PD has been detected on other panels and the switchboard is scheduled for replacement in 2016.

3.3 Asset Age/Obsolescence

By the start of RIIO-ED1 in 2015, 25% of the population will be more than 45 years old; without any intervention, this figure will increase to 33% by the end of ED1.

In the ARP model, the 'average initial life' is defined as the life at which an item of plant is expected to show increased levels of deterioration and not the point at which it is replaced. For 11kV switchgear, the average initial life varies between 20 years and 55 years depending on the equipment type and design with the mean 'average initial life' for EPN being 44 years.

Note: The basic HI is capped so that switchgear with no adverse condition or defect data cannot rise above the equivalent of Ofgem HI3 irrespective of age.

The manufacturer no longer supports the majority of the 11kV switchgear population. Taking this into consideration, a spares/obsolescence factor is used in the ARP model to assist in calculating asset criticality:

1 – Still in production, supported by the manufacturer, all parts available.
2 – No longer in production, supported by the manufacturer, most parts still available.
3 – No longer in production, not supported by the manufacturer, limited parts available.
4 – No longer in production, not supported by the manufacturer, no parts available.

3.4 Fault Rate

The NAFIRS rates for switchgear faults since 2007 are shown in Figure 10.

Note: both 11kV grid and primary switchgear and 11kV distribution switchgear are included in the HV data. The proportion of faults attributed to ageing and wear rate has remained constant during this period.

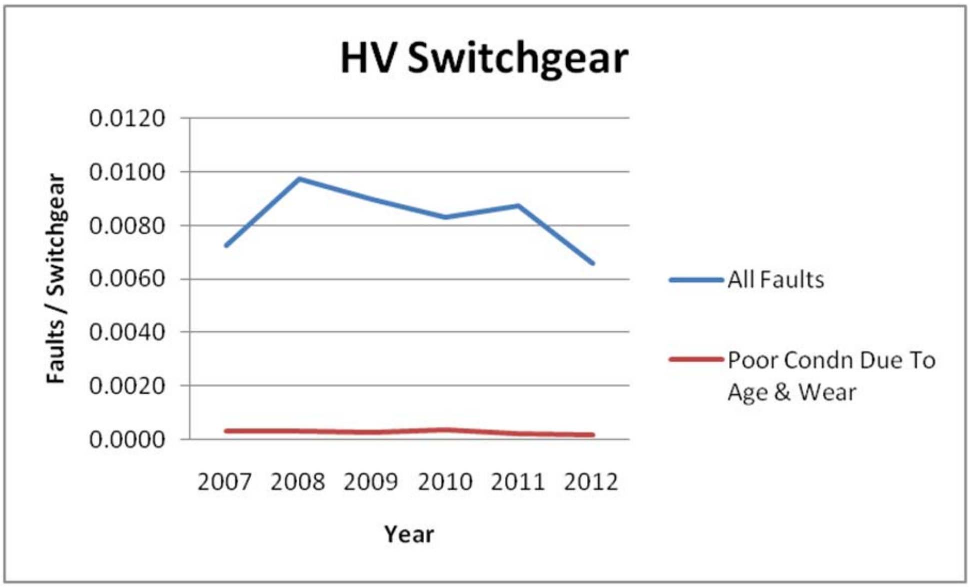


Figure 10 – EPN fault data

Source: Fault Analysis Cube 'EPN Fault Rates'

3.5 Mechanism Performance

The main function of a circuit breaker is to clear fault current promptly, so it is important to monitor the way the operating mechanism performs and intervene if trip times start to increase. Within UK Power Networks, two measures are used to monitor circuit breaker performance. The first is a subjective measurement based on the 'feel' of the mechanism when it is operated; the second is an objective measurement of the initial trip time in mS. Both have been captured in Ellipse since 2007.

For circuit breaker operation, 'satisfactory' means that the mechanism operates freely first time without undue resistance, while 'unsatisfactory' means the mechanism is stiff, fails to operate first time or doesn't operate at all. Ideally, there should be less than 1% 'unsatisfactory' operations recorded.

The initial trip time is measured using a Kelman Profile of Bowden timer and noting the results in Ellipse.

Grouping the results by equipment type highlights that certain switchgear types are suffering more mechanism issues than others. For instance, Figures 11 and 12 show that, over a six-year period, Crompton Parkinson type 'LA' switchgear initial trip times have risen by 84% and the switchgear has suffered 25 (8.2%) unsatisfactory operations. The affected switchgear will be replaced in ED1.

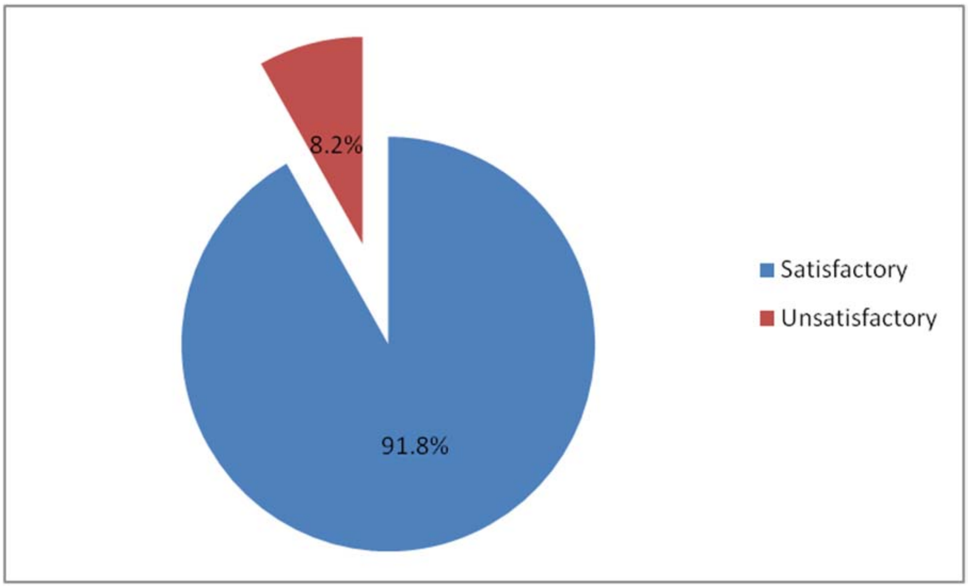


Figure 11 – CB operation history for Crompton Parkinson 'LA' switchgear

Source: Ellipse CBOPERATION condition point extract 22_01_2013

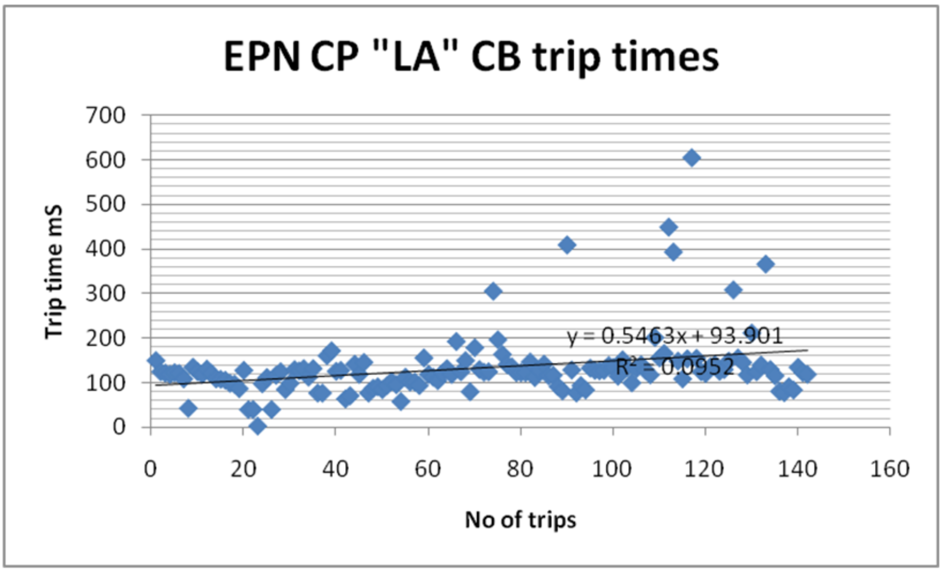


Figure 12 – CB trip times for Crompton Parkinson 'LA' switchgear

Source: Ellipse TRIPVALU1 condition point extract 14_01_2013

Another way of measuring CB performance is to note the number of 'stuck' CB incidents, where the CB fails to clear a fault and so back-up protection operates, resulting in an extended loss of supply. This has been closely monitored over the past 10 years. Figure 13 shows a steady increase over this period for EPN.

In the period 2009 to 2012 there have been seven stuck breaker incidents involving South Wales 'C4X' and four involving CP 'LA' breakers. These are included in the total volumes shown in Figure 13.

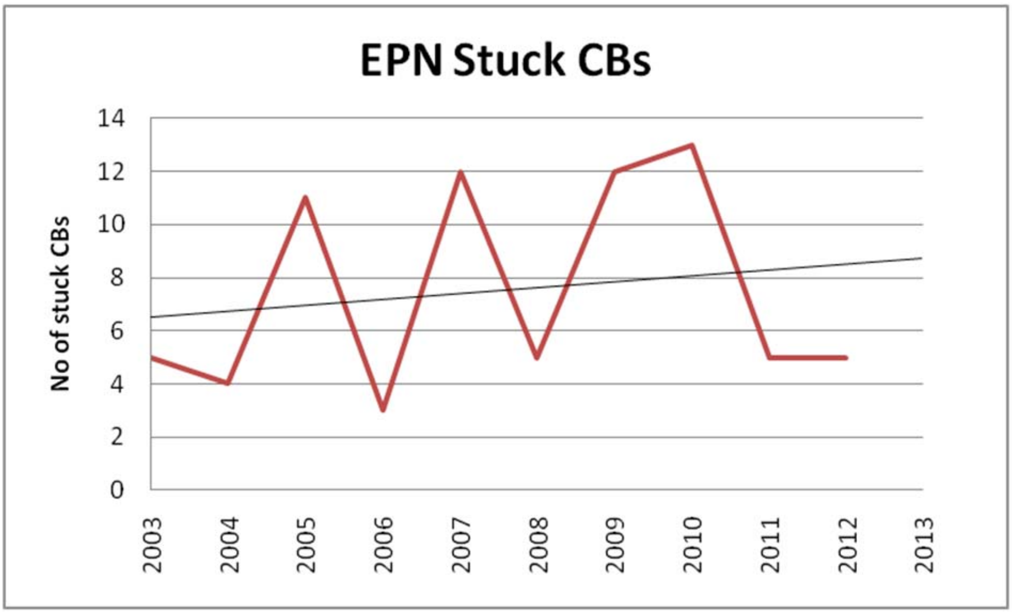


Figure 13 – History of stuck breakers

Source: Summary of stuck breakers v3 30_01_2013

There are a large number of Crompton Parkinson switchgear variants, making it economically unviable to develop a retrofit solution. As a result, six of the worst-performing switchboards are scheduled for replacement in ED1.

Many of the non-oil circuit breakers have ‘sealed for life’ operating mechanisms that are not readily accessible for normal maintenance. These will have to be stripped down and rebuilt when they reach their end-of-life, which the manufacturers estimate to be between 25 and 30 years. End-of-life will be indicated by rising CB trip times and incidences of ‘stuck’ mechanisms. Much of the Hawker Siddeley VMV and VMH equipment will reach this age during ED1 and there is evidence that some will need factory refurbishment – refer to Figures 14 and 15. It is likely that refurbishments will also be needed on other types of non-oil switchgear, so NAMP 1.50.01.8508 has been created as a provision for unspecified mechanism overhauls. Initially, it has been assumed that 10% of withdrawable pattern non-oil circuit breakers will require mechanism overhaul when they reach 25 years old.

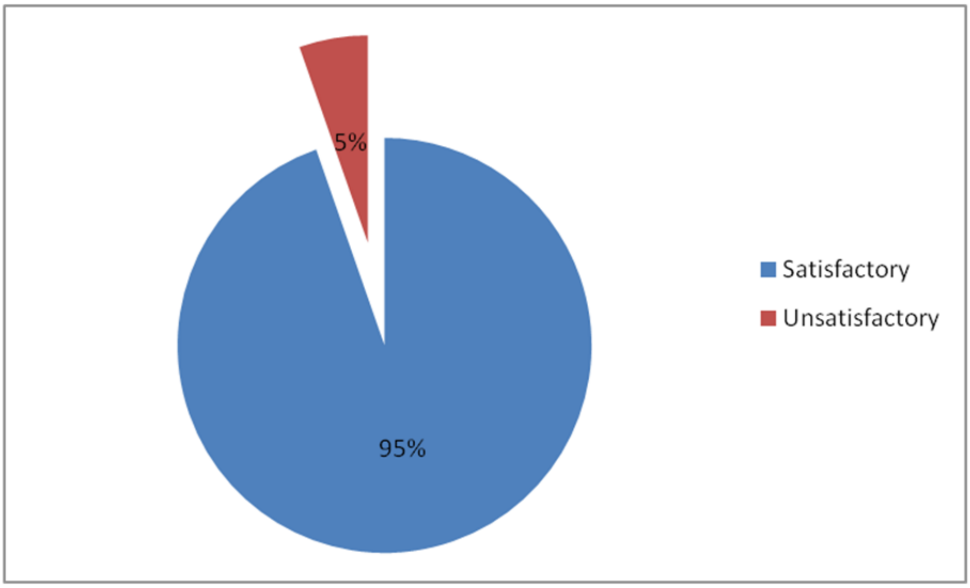


Figure 14 – CB operation history for Hawker Siddeley VMV and VMH

Source: Ellipse CBOPERATION condition point extract 22_01_2013

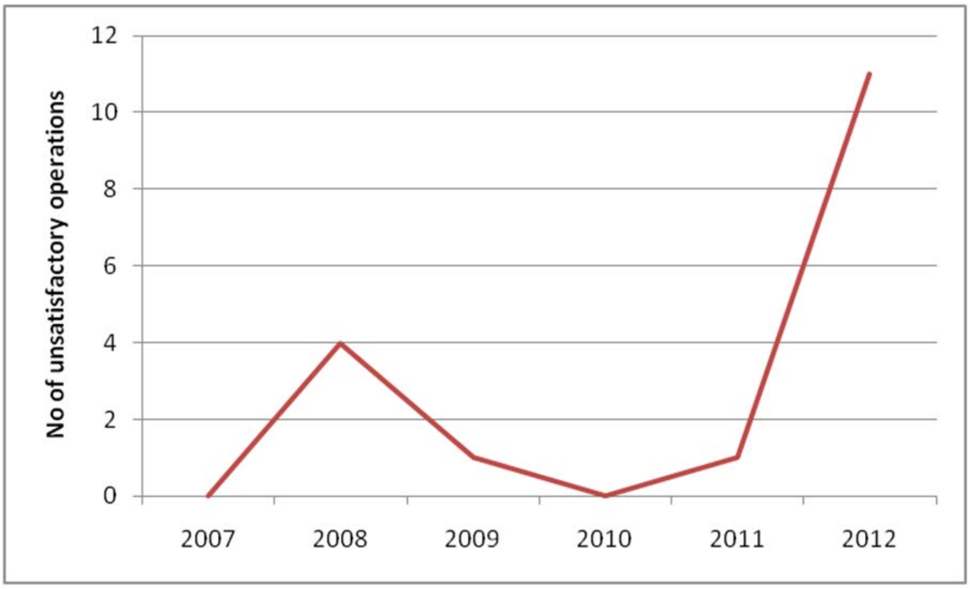


Figure 15 – Rising trend in unsatisfactory CB operations for Hawker Siddeley VMV/VMH

Source: Ellipse CBOPERATION condition point extract 22_01_2013

3.6 Partial Discharge Performance

Partial discharge can occur within voids in the insulation, across the surface of the insulation (tracking) or in the air around a conductor (corona). Switchgear operating at 11kV should essentially be free of partial discharge, so detecting it is a very useful indicator of the health of the insulation.

Increasing levels of PD often indicate deteriorating switchgear insulation, which, if left uncorrected, could lead to disruptive failure with serious public and operator safety implications.

At every inspection, checks are made for PD activity using the UltraTEV instrument. A discharge defect is recorded in Ellipse if the TEV activity is over 29dB or any ultrasonic activity is present. EA Technology used the national database of TEV readings to determine that a reading over 29dB places the equipment in the top 5% of discharge activity and so most at risk from disruptive failure. Figure 16 shows the percentage of discharge defects recorded at the last inspection for different types of switchgear.

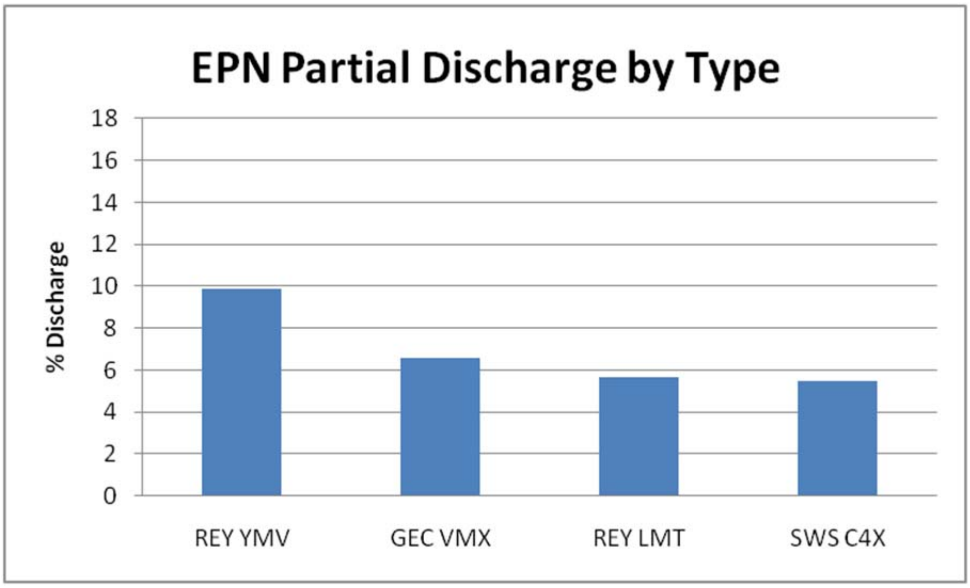


Figure 16 – Partial discharge history by switchgear type

Source: Ellipse Defect Visibility – Measure (DISCHARGE) 22_01_2013

Certain types of switchgear, such as the Reyrolle LMT, are prone to discharge, but can safely be left in service, as the insulation materials are sufficiently robust to prevent total breakdown. Others, such as the GEC VMX, must be promptly refurbished or replaced before a disruptive failure occurs. Figures 20 and 21 show the results of a disruptive failure.

3.6.1 Reyrolle YMV

The Reyrolle YMV is prone to VT failure caused by either incorrect fuse contact spring pressure or partial discharge on the surface of the plastic fuse housing. The primary isolating contact mechanisms are also prone to mechanical problems, which can result in partial discharge.

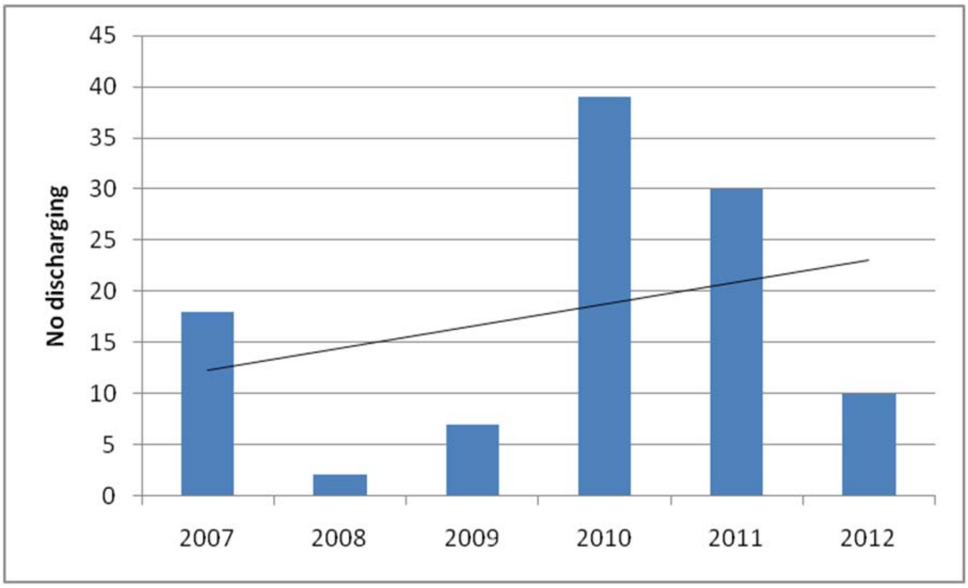


Figure 17 – Reyrolle YMV switchgear discharge reports

Source: CONDDISC 11_02_2013

Modifications are available to improve the performance of the fuse contact, which will be fitted in ED1 under NAMP 1.50.01.8508.

Figure 18 – Result of VT fuse failure for Reyrolle YMV

3.6.2 GEC type VMX circuit breakers

There are issues with the long-term reliability of this type of switchgear. It is a vacuum CB using cast-resin mouldings and is prone to partial discharge problems, which can result in failure. Figure 19 shows the failures reported nationally via the ENA National Equipment Defect Reporting Scheme (NEDeRS) system.

In EPN, there are 255 units, mainly as retrofit trucks, for GEC BVP switchgear.

Several modifications intended to improve the partial discharge performance have had varying degrees of success.

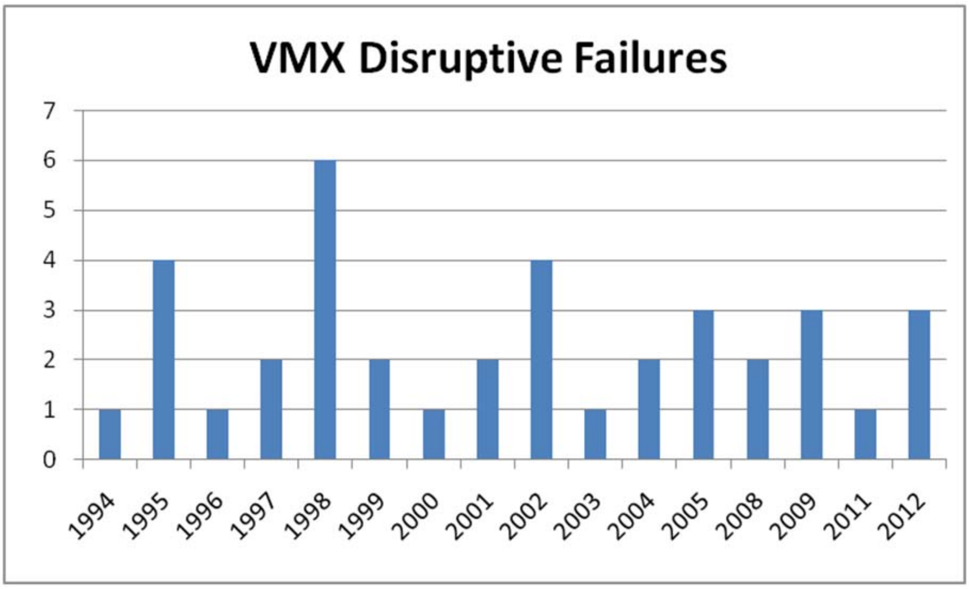


Figure 19 – GEC VMX disruptive failures reported nationally

Source: NEDeRS website 11_02_2013

Keeping the substation environment as clean and as dry as possible can reduce the inception of discharge. Even so, discharge does still occur and is expected to continue to occur in the future. Past experience has shown that refurbishing VMX units that have started to discharge does not work effectively, because the tracking damages the cast-resin material, so the only effective solution is replacement. For this reason, provision has been made to replace some of the VMX population over the ED1 period.

Figure 20 – GEC VMX: Tracking inside circuit spout

Figure 21 – GEC VMX: Failed 11kV panel

Figure 20 shows the inside of a cast-resin circuit isolating spout from a unit that has failed disruptively at a Marconi substation in Chelmsford (EPN). Signs of tracking can be seen from the isolating contact down to the edge of the spout.

Figure 21 shows the results of a circuit breaker that failed disruptively at Southwark Street substation in LPN. In this case, tracking had been taking place in the moulding that transmits drive to the vacuum bottles. Discharge had been recorded beforehand, but repairs were delayed.

3.7 Non-Oil Circuit Breaker Issues

3.7.1 SF_6 gas tightness

Gas pressure is checked at each inspection and maintenance. Generally, 11kV circuit breaker designs are proving to be gas-tight and there is no evidence yet of ageing of seals. However, there is one exception: the Yorkshire 'YSF6' circuit breaker is a 'first generation' design with a neoprene hose connecting the gas enclosure to the filler valve on the front face. The oldest units are now 28 years old and hoses are starting to perish. It has been proposed that the hoses are replaced and the operating mechanism refurbished, as the spring charging motors are prone to burn out due to hardened grease in the sealed drive sprockets causing the ratchet pawls to stick.

3.7.2 Vacuum bottle performance

All vacuum circuit breaker manufacturers suggest a bottle life of 25 years, but practice suggests that this is very conservative and bottles will last considerably longer. However, the first 11kV vacuum circuit breakers are now 40 years old and we have had vacuum bottle failures on three of the oldest Reyrolle LM23V units.

Figure 22 – Overheating caused by a failed LM23V vacuum CB at West Hanningfield substation

The current age profile of vacuum CBs in EPN is shown in Figure 23.

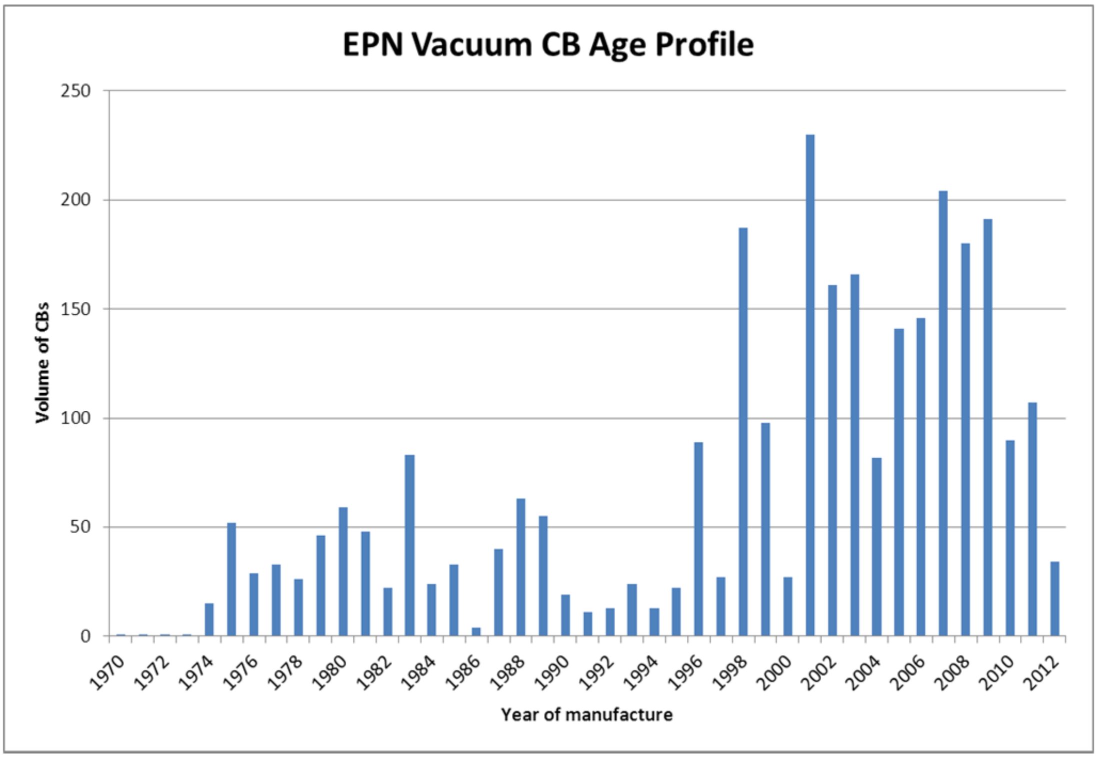


Figure 23 – Vacuum CB age profile

Source: ARP model Ph 1 11kV GP Sgr 25 July

At the end of ED1, there will be 520 vacuum CBs in EPN aged 35 years or greater, so NAMP line 1.50.01.8508 has been created to allow refurbishment of up to 70 11kV grid and primary CBs per year.

4.0 Asset Assessment

4.1 Asset Health

An innovative asset-health modelling tool, the Asset Risk and Prioritisation (ARP) model, has been developed for several asset categories, including 11kV grid and primary switchgear. The methodology behind the modelling is the same for all asset categories, but the switchgear model has been tailored specifically to use the data collected to assess against the identified investment drivers for switchgear.

The general methodology for the ARP model can be found in *Commentary 15: Model Overview*. The switchgear ARP models use the age, location information and condition data of an asset to calculate its Health Index. An initial HI is calculated based on the year of manufacture, expected average asset life, the environment the asset is installed in and the duty of the switchgear during its life. The environmental factors considered are the distance from coast, whether it's indoors or outdoors, and the level of pollution. The function of the switchgear, whether it is a feeder, bus section or transformer breaker, is used to account for the duty. An average asset life is assigned per make and model of switchgear to show the expected time from when the asset was manufactured to when it is likely to show signs of increased deterioration. The average asset life is not the time from when the asset is commissioned until it is decommissioned. This initial HI is capped at HI3.

A factor value is then calculated using condition, defects and switchgear reliability data. The condition and defect data is obtained from the asset register, Ellipse. The reliability is assigned based on the make and model of the switchgear. There are two condition points that force the HI to a minimum of HI5 regardless of asset age: the external condition of housing and the number of SF_6 top-ups.

This factor value is then combined with the initial HI to produce the current HI of the asset.

4.2 Asset Criticality

The ARP model can also be used to calculate the criticality of a particular switchgear asset. This is then output in the form of a Criticality Index 1 to 4, with 1 being the least critical and 4 being the most. A detailed methodology for calculating the criticality index can be found in *Commentary 15: Model Overview*.

In the switchgear ARP model, five main areas are considered when calculating the criticality of an asset – network performance, safety, operational expenditure, capital expenditure and environment – and key factors are considered in each of these areas.

For network performance, the key factors are the number of customers that the substation feeds and the function of the asset. The function of the bus section breaker is the most critical, and that of the feeder breaker is the least.

The factors considered for the safety criticality specific to switchgear are the arc extinction method and whether the switchgear is internal arc rated. Oil switchgear is considered the most hazardous method of arc extinction as far as the operator is concerned and therefore is the most critical. Similarly, switchgear that isn't internal arc rated is considered more critical than switchgear that is.

The operational and capital expenditure sections each consider the criticality between assets in terms of the difference in maintenance costs between makes and models of switchgear, and the difference in capital expenditure for different voltage levels.

Finally, the environment section considers the effects that different types of installation have on the environment. Oil switchgear is again considered the most critical, with the level increasing with the volume of oil.

4.3 Network Risk

The network risk in monetary terms can be calculated in the ARP model using the probability of failure, the criticality and the consequence of failure, although the methodology is still under development. The probability of failure is calculated using the current Health Index of the item of switchgear and the criticality is calculated as described in the previous section. The consequence of failure is the average cost to either repair or replace the item of switchgear following one of four failure modes – refer to Table 8.

Failure mode	Description
Failure to trip	No repair needed
Minor	Can be repaired in house
Significant	Can be repaired using external resource
Major	Beyond repair – disruptive failure or sent away for repair

Table 7 – ARP model failure modes

Although no repair is needed for the failure -to-trip mode, post-fault maintenance will be carried out to investigate the cause of the stuck circuit breaker. Stuck or slow operating breakers have a big impact on customers, as they result in increased CIs and CMLs. This is because the circuit breaker upstream will operate if a feeder circuit breaker fails to trip or is slow to trip during a fault. The circuit breaker upstream will usually be the transformer breaker that feeds the bus section, meaning the bus section will be lost. The loss of the bus section will result in a larger number of customers affected than if just the original feeder was lost.

4.4 Data Validation

All data used in the ARP model is subject to validation against a set of data requirements. The requirements ensure data is within specified limits, up to date and in the correct format for use in the model. On completion of the validation process, an exception report is issued, providing details of every non-compliance and allowing continual improvement of data quality to be achieved.

An example of this is the circuit breaker trip times that are used in the model. These values have to be between 10 and 1000ms, otherwise they are disregarded and not used in the model. There is also an age limit on the condition data that is used in the model – no data recorded more than five years ago is used. This is to ensure that the outputs of the model are describing the current asset rather than its past state.

4.5 Data Verification

A sampling approach to data verification follows each data upload to ensure accurate transfer into the models.

4.6 Data Completeness

The completeness, accuracy and timeliness of the data used in the ARP model are routinely checked. The results for the data used in the 11kV grid and primary switchgear are shown in Table 6.

The score is colour coded as follows:

- Green – Score of 85% or greater
- Amber – Score of 65% or greater
- Red – Score of less than 65%

Area	Result
Completeness	68%
Accuracy	89%
Timeliness	95%

Table 8– CAT scores

Source: Source: ARP Switchgear CB data quality report 08_02_2013

The completeness score is a combination of switchgear nameplate data and condition data. Information used on the nameplate includes the year of manufacture, operating voltage, circuit breaker function and any other information that will remain constant during an asset's life. Condition data is recorded by substation inspectors, as described in section 3.2, and will change with time. The completeness of any data used in the network risk section of the model is also included, such as customer numbers.

The completeness of the nameplate information is 91%. There has been investment in improving this area during DPCR5. The completeness of condition data is 45% – the result of a large variation in completeness between different condition measures. As with the nameplate information, there has been a project during DPCR5 to improve the completeness of the condition data, which has led to some new condition points being created. Due to this, in some cases the condition point may not be populated until the next maintenance.

The accuracy score is a measure of the reliability and correctness of the condition data stored in Ellipse. This is calculated by comparing the condition measure recorded by UK Power Networks with the same measure recorded by an independent third party, SKM.

The timeliness score shows the percentage of assets that have condition data recorded within the expected time period, as stated in EMS 10-0002, *Inspection and Maintenance Frequency Schedule*. UK Power Networks' asset risk methodology is to use asset data and defect data to drive a need for specific funding for refurbishment or replacement of those assets in ED1. This has required a comprehensive increase in asset condition data. As a consequence, UK Power Networks is prepared to carry the risk associated with missing asset and condition data.

5.0 Intervention policies

5.1 Interventions: Description of Intervention Options

Four categories of intervention have been considered for 11kV grid and primary switchgear: enhanced maintenance, refurbishment, retrofit and replacement. These are summarised in Table 10 and explained in more detail later in this section.

Note: The intervention policy for protection relays and instrumentation is included in the *Commentary 13: Protection and Control* document.

Option	Description	Advantages	Disadvantages
Enhanced maintenance	Decrease interval between maintenance interventions or introduce new maintenance intervention.	Usually cost-effective over short periods compared with replacement options.	Ties up maintenance resources. Not effective if mechanism wear is the issue.
Refurbishment	Replace complete operating mechanisms or refurbish gas systems of SF_6 units.	No civil costs. Can often be achieved on site.	Maintenance costs not reduced. Need to maintain existing CO_2 systems in switchrooms. Support from OEM often limited. May be type test issues if third parties used. At 11kV, cost tends to be similar to retrofit truck.
Retrofit CB truck	Replace entire CB truck with new vacuum unit	No civil costs. CO_2 systems in switchrooms can be decommissioned. No (11kV) cabling costs. Reduction in maintenance costs if oil breaker replaced. Can extend the life	Use of resin bushings in old housings can result in PD issues. Limited to certain types of equipment only. Needs careful design.

Option	Description	Advantages	Disadvantages
		of switchpanel by at least 25 years. No jointing needed.	
Replacement	Replace complete switchboard	No compatibility issues with existing housings. Longest potential life (40+) of all interventions. Maintenance costs reduced.	Usually incurs some civil costs. Longer outages as cables need to be transferred to the new board.

Table 9– Summary of intervention policies

5.1.1 Enhanced maintenance

Where condition and defect data show that mechanism performance is unsatisfactory, the first intervention considered is enhanced maintenance. Typically, this would be to alter the mechanism maintenance frequencies detailed in EMS 10-0002 or introduce additional mechanism maintenance between scheduled full maintenance. This can be successful if the underlying problem is inadequate lubrication. However, if wear is an issue, refurbishment is the better option.

5.1.2 Refurbishment

When several components have started to wear, an operating mechanism can become unreliable, either failing to close or failing to open. The entire mechanism can be replaced with one that has been refurbished by either the original manufacturer or a third party. Not all manufacturers offer this service and it may prove more economical to replace the entire circuit breaker truck with a retrofit device.

5.1.3 Retrofit CB truck

For withdrawable circuit breakers only, fitting a replacement vacuum CB in an existing oil CB housing has many advantages: the maintenance commitment is substantially reduced, especially the post-fault maintenance needed regularly on units protecting overhead line feeders; the new operating mechanism usually places a much less onerous duty on the substation battery; and remote control facilities can be easily incorporated.

UK Power Networks has been at the forefront of retrofit technology since the mid 1990s, with 1,622 units already installed, accounting for 14.1% of the 11kV grid and primary switchgear population.

Retrofit is only carried out on switchboards where the fixed portions are in good condition. A partial discharge survey is carried out to ensure there are no PD issues with the busbars, CT chamber and cable box. If the spot check PD shows any activity, a temporary online monitor may be installed for a few months.

The wide variety of switchgear types installed on the network, together with the fact that EPN already has 60% of UK Power Networks' population of retrofit units, limits the scope for future retrofitting work because small volume production is not usually economically viable. However, some C4X and BVP units have been identified as potentially suitable.

5.1.4 Replacement

If refurbishment or retrofit is not appropriate, replacement is considered. Switchboards are not necessarily replaced like for like, as the opportunity may be taken to consolidate the number of switchpanels. Within EPN, double busbar 11kV switchboards are no longer installed.

5.2 Policies: Selecting Preferred Interventions

The process used for selecting interventions for all categories of switchgear is shown in Figure 24. All 11kV grid and primary switchgear is part of a switchboard. Where more than 50% of the panels on a switchboard are HI4 or HI5 at the end of ED1, intervention was considered, with a retrofit solution being the preferred option where available.

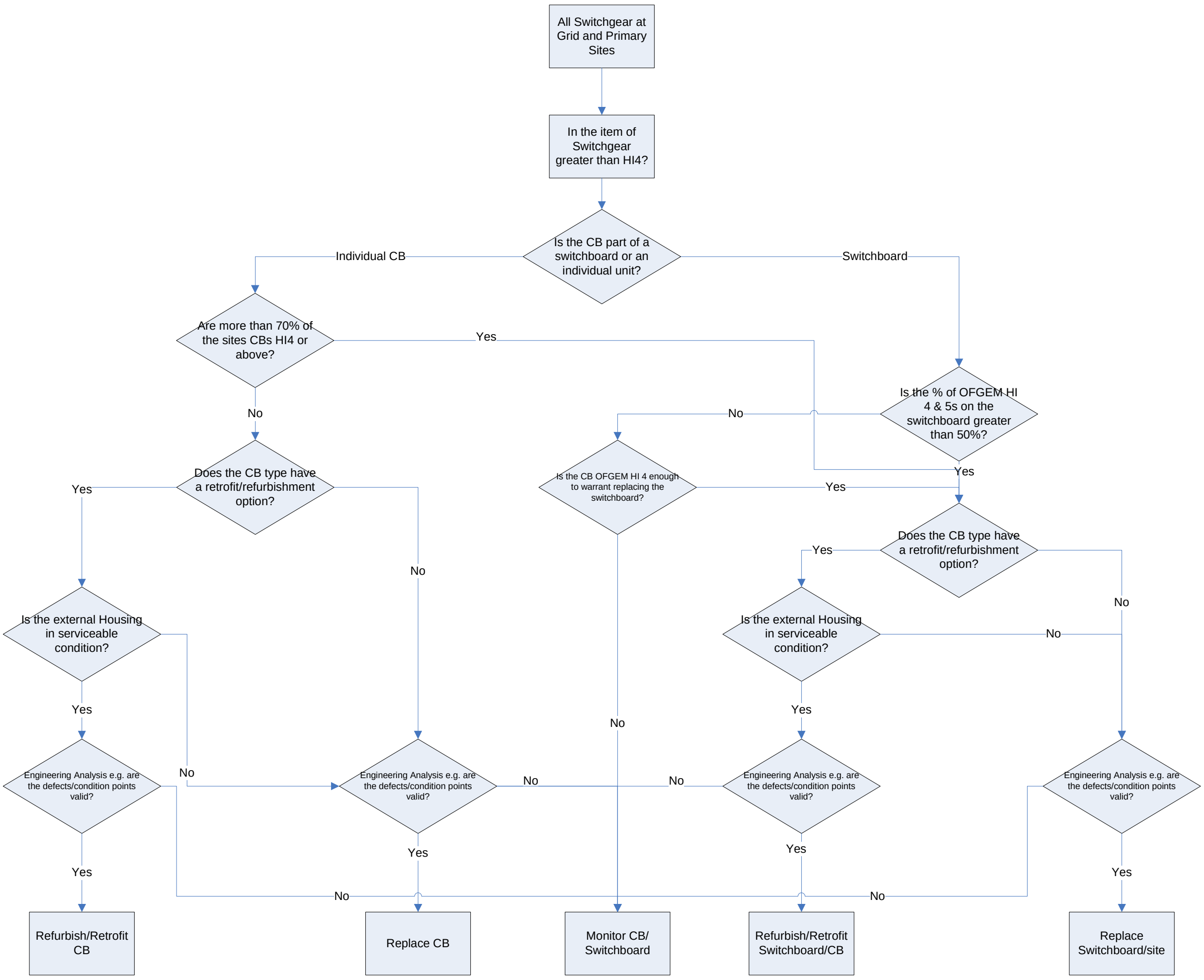


Figure 24 – Intervention decision flow chart

By implementing this programme of retrofitting, we will be able to manage the deterioration of the switchgear, addressing failure modes that would, left untreated, result in asset replacement. This will extend the life of the plant, reduce whole life costs and improve reliability and network risk while minimising short-term expenditure.

This capital expenditure programme – both replacement and retrofit interventions – will provide significant benefits to our operational expenditure. Oil switchgear has increased maintenance frequency and is likely to be less reliable and require more defect repair. By replacing it with non-oil switchgear, the maintenance requirements will reduce.

6.0 Innovation

6.1 Retrofit

New innovative designs for AEI type QA/QF are currently being developed using operating mechanisms with very few moving components, which should improve long-term reliability.

Retrofit is only being carried out on switchboards where the fixed portions are in good condition. A partial discharge survey is carried out beforehand to ensure there are no PD issues with the busbars, CT chamber and cable box. If the spot check PD shows any activity, a temporary online monitor may be installed for a few months to determine whether retrofit is viable.

6.2 Online Partial Discharge Monitoring

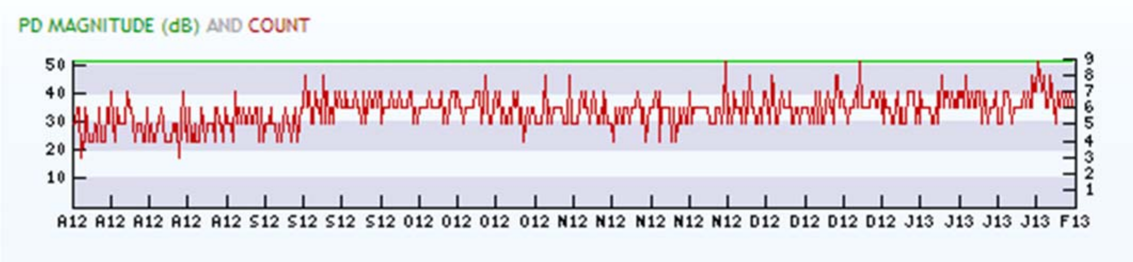
UK Power Networks is using online equipment to monitor the PD performance of grid and primary switchboards. This enables expenditure to be deferred while minimising the risk of disruptive failure.

The company providing the monitoring service sends text or e-mail alerts to flag significant increases or decreases in the level of activity, or changes in the nature of activity. On-site testing validates these, and replacement or refurbishment action is then taken as appropriate.

In EPN, four of the 11kV switchboards suffering from partial discharge activity have been fitted with permanent online PD monitoring equipment. This has enabled replacement to be deferred, while levels are closely monitored.

Figure 25 illustrates typical screen shots from the online PD monitoring system, particularly activity on a Reyrolle type LMT switchpanel at Canvey Primary substation over a six-month period from August 2012 to January 2013. The green line on the TEV graph is the level of PD activity in dB, while the red line is the count of TEV impulses per cycle. The low TEV count indicates that breakdown is occurring six times per cycle and the green polar graph shows that the TEV counts are generally 180 degrees apart. This indicates that the insulation breakdown is occurring at the peaks and that there is a relatively high inception voltage.

Provision has been made to replace this switchboard in ED1.



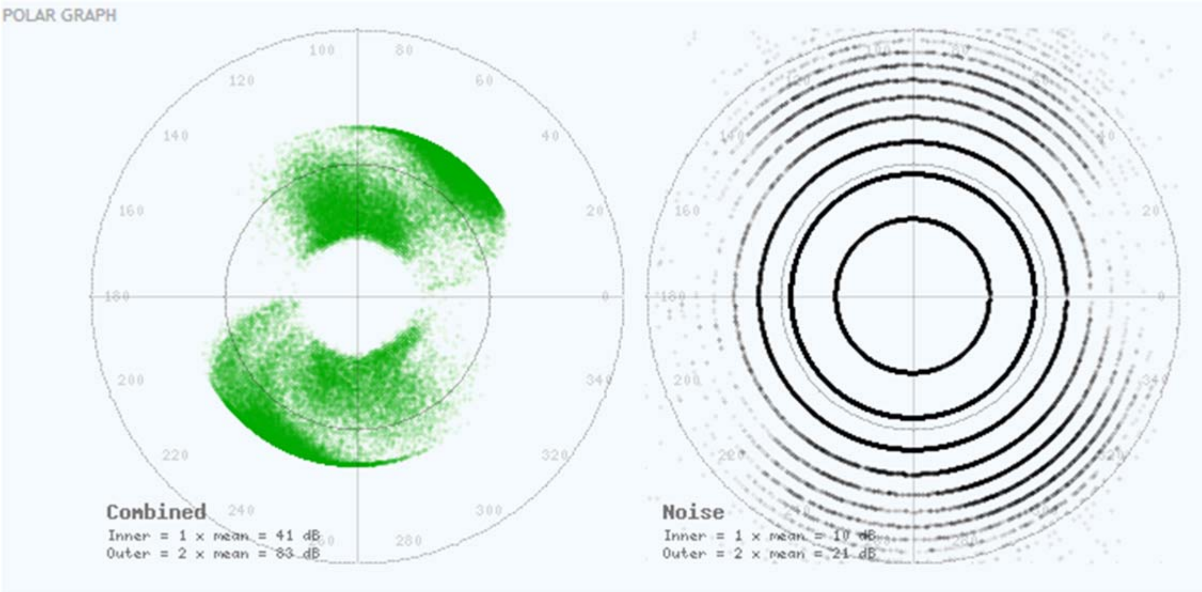


Figure 25 – Online PD monitoring records Canvey Primary Polar Graph

7.0 ED1 Expenditure Requirements for 11kV Grid and Primary Switchgear

7.1 Method

Figure 26 shows an overview of the method used to construct the RIIO-ED1 NLRE investment plans.

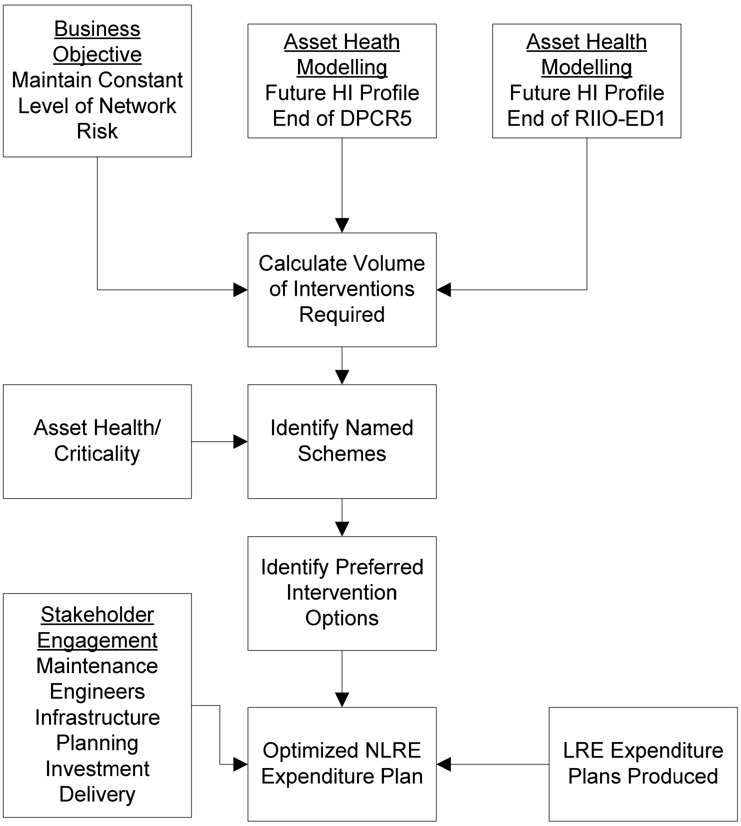


Figure 26 – Constructing the RIIO-ED1 NLRE Plan

7.2 Constructing the Plan

7.2.1 Intervention volumes

The business objective throughout the planning process for RIIO-ED1 NLRE was to maintain an approximately constant level of risk within each asset category. To achieve this, the ARP model was used to determine the HI profiles at the end of DPCR5 and the end of RIIO-ED1, which in turn projected how the number of HI4s and HI5s would increase without investment. This provided the basis for the volume of interventions required during RIIO-ED1, These sites were then assessed individually to see what level of intervention, if any, was appropriate based on the type of switchgear.

7.2.2 Intervention types

For withdrawable switchgear, retrofitting is the preferred option if an approved design currently exists or is scheduled for approval during ED1. For retrofits, only those circuit breaker trucks identified as HI4 or HI5 at the end of ED1 have been put into the plan, rather than all trucks on the switchboard.

7.2.3 Optimising the plan

Stakeholder engagement was an important part of the process to finalise the RIIO-ED1 plan. Maintenance engineers were consulted as they are most familiar with the assets. They ensured that the data being used in the ARP model reflected their own assessments of each asset's condition. There was also detailed consultation with those involved in constructing the RIIO-ED1 LRE expenditure plans to ensure the optimal investment for maximum achievement.

7.2.4 HI profiles

The HI profiles for the start and end of ED1, with and without investment, are given in Figure 27. The HI profiles are derived from condition related investment only and exclude the contribution from load related expenditure. The 'without investment' HI figures include investment during the DPCR5 period.

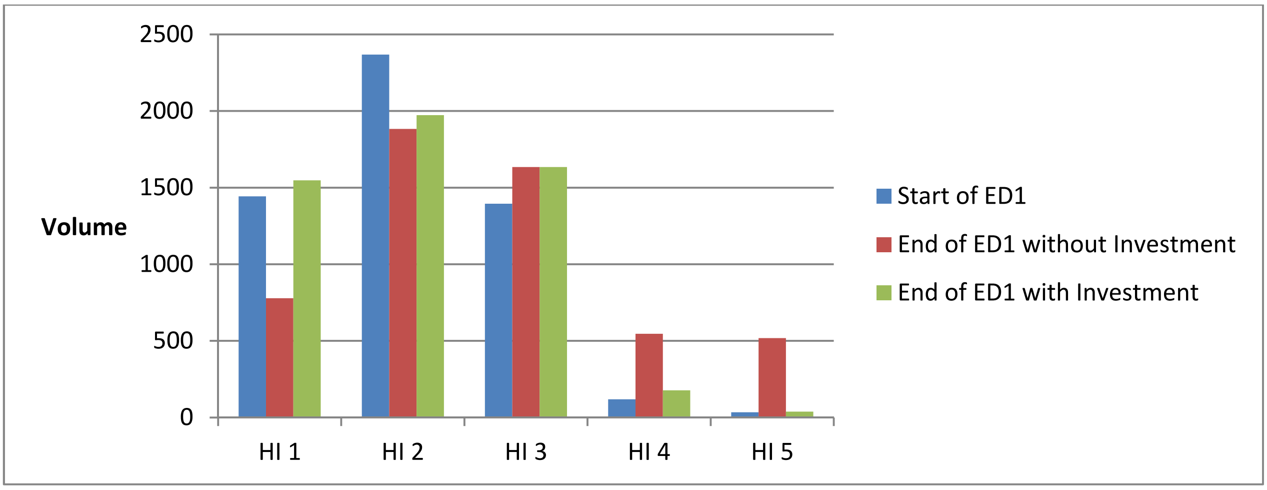


Figure 27 – HI profiles

Source: 21 February 2014 ED1 RIGS

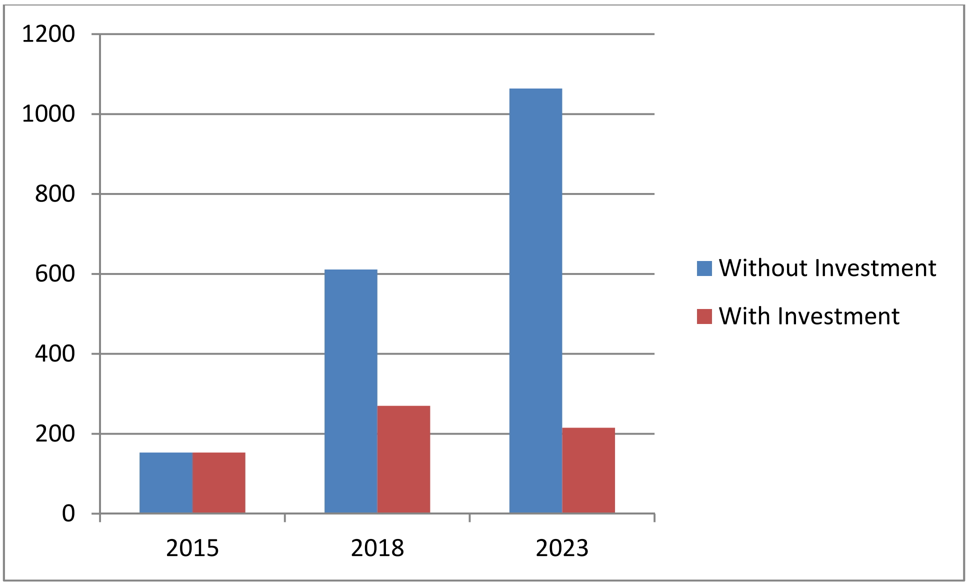


Figure 28 – Sum of HI4 and HI5

Source: 21 February 2014 ED1 RIGS

The number of HI4 and HI5 circuit breakers will rise slightly through ED1 from 153 at the start of the period to 215 at the end. However, this represents less than 1% of the installed population.

Consideration was given to replacing or retrofitting more units during ED1 to maintain a level or reducing number of HI4 and HI5 circuit breakers. The remaining units are spread across a large number of substations which made replacement of the whole switchboard unattractive as it would have meant replacing relatively healthy units and retrofitting was discounted because it was felt that the level of risk did not warrant investment at this stage.

7.3 Additional Considerations

The NAMP (Network Asset Management Plan) has been used to ensure that the proposed switchgear projects are not duplicated in the Non Load Related LRE and Load Related plans. Similarly, to optimise time spent at site, the NAMP was used to ensure transformer replacements coincide with switchgear replacements where practicable.

7.4 Asset Volumes and Expenditure

The proposed asset replacement and retrofit volumes for ED1 are shown in Figure 29, along with volumes for DPCR4, DPCR5 and ED2 for comparison. In total, there are 849 interventions during ED1, which represent 17% of the installed population.

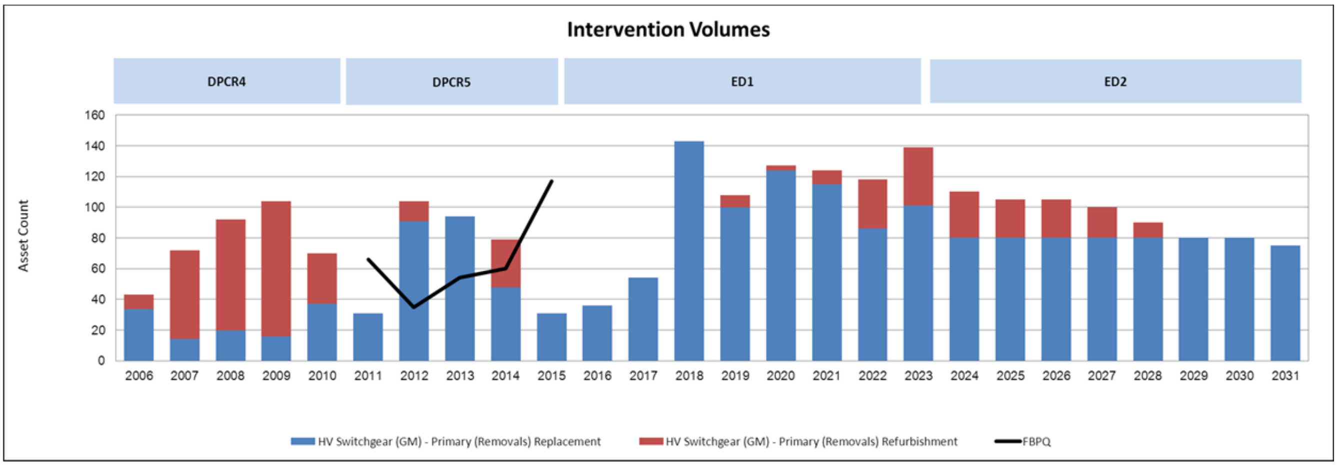


Figure 29 – EPN 11kV Grid & Primary Switchgear intervention volumes

Sources:

- DPCR4 volumes: Table NL3 (DPCR5 FBPQ)
- DPCR5 volumes: First three years – RIGs CV3 table
- DPCR5 volumes: Last two years – 14 June 2013 NAMP (Table O)
- DPCR5 FBPQ volumes: EPN FBPQ Mapping NAMP data
- ED1 volumes: 19 February 2014 NAMP (Table O)
- ED2 volumes: Analysis from Statistical Asset Replacement Model (SARM1)

Note: Volumes for DPCR4 are not readily available, as both distribution and grid and primary 11kV CBs were reported together in RRP. However, it has been assumed that, for EPN, 30% of the 11kV CB (GM) removals were at grid and primary sites with the remainder being distribution switchgear. The split between replacement and refurbishment work was estimated using Ellipse commissioning work orders as the basis.

The proposed asset replacement and refurbishment expenditures for ED1 are shown in Figure 30 along with expenditure for DPCR4 and 5 for comparison.

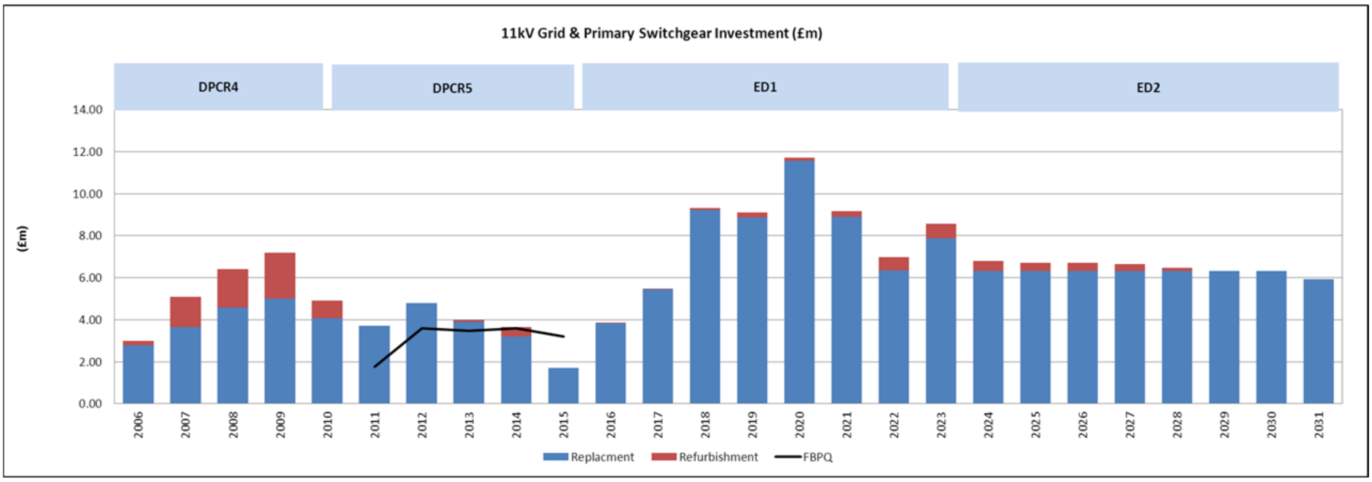


Figure 30 – EPN 11kV Grid & Primary Switchgear intervention expenditure

Sources:

- DPCR4 costs: Table NL1 (DPCR5 FBPQ)
- DPCR5 costs: First three years – RIGs CV3 table
- DPCR5 costs: Last two years – 14 June 2013 NAMP (Table JLI)
- DPCR5 FBPQ costs: EPN FBPQ Mapping NAMP data
- ED1 costs: 19 February 2014 NAMP (Table JLI)
- ED2 costs: Volumes from SARM1 * UCI of £79k for replacement and UCI of £16k for refurbishment

7.5 Commentary

In order to tackle the main problem areas of deteriorating CB mechanism performance on Crompton Parkinson 'LA' and South Wales 'C4X' switchgear and the poor partial discharge performance of GEC VMX, it is necessary to increase the volume of interventions slightly compared with DPCR4 and DPCR5. Because relatively few of the remaining switchboards requiring intervention are suitable for retrofitting, the bulk of these interventions will be replacements. This has resulted in an increase in expenditure compared to DPCR4 and DPCR5.

In ED2, the SARM model predicts that volumes will return to DPCR4 and DPCR5 levels. In the first half, approximately one-third will be refurbishment, but, by the end, all interventions will be replacements.

Removing around 600 oil and 250 vacuum circuit breakers during ED1 will have an impact on the I&M opex budget, specifically on the following NAMP lines:

- 4.24.01 Maint Full 11/6.6kV OCB TSC
- 4.24.05 Maint Mech 11/6.6kV OCB TSC
- 4.06.10 Maint Full 11/6.6kV OCB Feeder
- 4.06.06 Maint Mech 11/6.6kV OCB Feeder
- 4.24.03 Maint Full 11/6.6kV SF6/Vac CB F/B TSC
- 4.24.02 Maint Full 11/6.6kV SF6/Vac CB W/B TSC
- 4.06.02 Maint Full 11/6.6kV SF6/Vac CB F/B Feed

- 4.06.01 Maint Full 11/6.6kV SF6/Vac CB W/B Feed

Based on an analysis of Maintenance Scheduled Task predictions from the Ellipse database, a total of 16% is expected to be saved across these lines.

7.6 Sensitivity Analysis and Plan Validation

An independent report has been carried out by Decision Lab to understand how the Health Index profile of assets may change if the average asset life does not turn out as predicted.

Average life change	**2015** percentage HI profile					Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5		HI1	HI2	HI3	HI4	HI5
-4	27.2	33.9	33.1	4.4	1.5	-4	29.1	31.8	27.5	7.1	4.5
-2	27.8	38.3	29.7	3.2	1.0	-2	31.3	31.2	29.5	5.7	2.3
-1	27.8	40.0	28.6	2.8	0.7	-1	31.8	31.9	31.0	4.2	1.1
0	28.0	41.9	27.1	2.3	0.7	0	32.2	32.9	31.0	3.2	0.7
1	28.4	44.2	24.8	2.0	0.5	1	33.6	33.2	29.9	2.7	0.5
2	28.7	46.8	22.5	1.7	0.4	2	33.6	34.4	29.6	2.2	0.2
4	30.4	49.1	19.8	0.5	0.2	4	36.0	35.7	26.7	1.6	0.0

Table 10 – Results of sensitivity analysis

Source: Decision Lab analysis Appendix 6

In Table 11, each average asset life change of years +/- 1, 2 and 4 are represented as a percentage of the current population. With each change in average asset life, there is a subsequent movement in the percentage of population in each Health Index. An average asset life at 0 represents the current population split within each Health Index with intervention strategies applied. The two tables range from the start of ED1 (2015) and the end of ED1 (2023).

These tables show the percentage population movements over the eight-year period and the impact any change in average asset life will have on the asset group's HI profile.

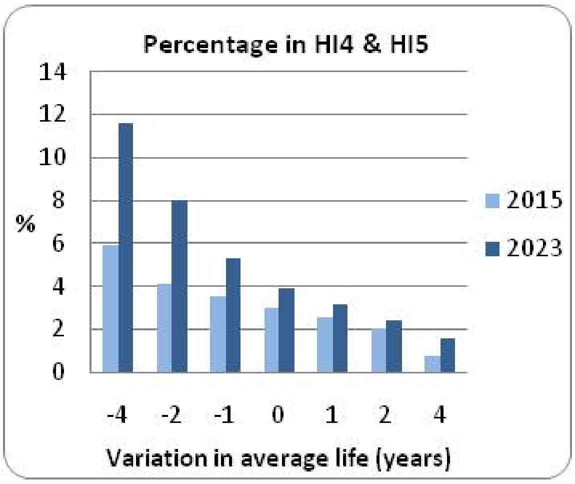


Figure 31 – Effect of average asset life variation on volumes of HI4 and HI5

Source: Decision Lab analysis Appendix 6

Figure 31 represents summed HI4s and HI5s as a percentage of the population, showing the change at each average asset life iteration comparing 2015 and 2023.

The full results are shown in Appendix 6 and conclude that the ED1 replacement plan for EPN HV primary switchgear is moderately sensitive to a variation in average asset life of up to four years.

EPN switchgear is the youngest of the three licence areas, but there is still a substantial population of older switchgear that is either approaching or beyond the average asset life used in the ARP model. Reducing the average asset life by four years will increase the number of HI4s and HI5s in 2023 by 7.7%.

7.7 Model Testing

The ARP model had undergone rigorous testing to ensure it met the defined requirements prior to acceptance. There were four distinct subsets to the testing process: algorithm testing, software testing, data flow testing, and user and methodology testing. Each test is designed to capture potential errors in specific parts of the system. The completion of all tests provides assurance that a thorough evaluation has been carried out to ensure correctness and validity of the outputs.

7.7.1 Algorithm testing

The ARP model comprises a set of algorithms implemented within the database code. The tester in a spreadsheet mimics each algorithm, with the results compared with those of the ARP algorithm for a given set of test data inputs. The test data comprised data within normal expected ranges, low-value numbers, high-value numbers, floating point numbers, integers, negative numbers and unpopulated values. In order to pass the test, all results from the ARP algorithm are required to match the spreadsheet calculation.

7.7.2 Software testing

A number of new software functions used in the model required testing to ensure they performed correctly. A test script was created to identify the functional requirement, the method to carry out the function and the expected outcome. In order to pass the test, the achieved outcome had to match the expected outcome.

7.7.3 Data flow testing

Data flow testing was carried out to ensure that data presented in the ARP upload files passes into the model correctly. Data counts from the ARP model upload files were compared with data successfully uploaded to the model. To pass the test, counts of the data had to match within specified tolerances.

7.7.4 User and methodology testing

The aim of the user and methodology testing is to ensure that the models are fit for purpose. A test script has been created to check that displays operate correctly and that outputs respond appropriately to changes in calibration settings.

7.8 Network Risk Sensitivity

As mentioned in section 4 of this document, the ARP model is able to produce a criticality index (C1 to C4) for each individual asset, although this is a very new concept and is still being developed. The Criticality Index can be used with the Health Index to give an indication of the level of risk that can be seen on the network. Table 12 and Table 13 show the HI and criticality matrix for 2015 and 2023 with investment during ED1.

Asset categories	Criticality	Units	Estimated Asset Health and Criticality Profile 2015					Asset Register
			Asset health index					2015
			HI1	HI2	HI3	HI4	HI5	
11kV grid and primary switchgear	Low	No. CB	1055	1042	885	52	12	3,046
	Average	No. CB	261	967	397	50	20	1,695
	High	No. CB	127	359	113	17	2	618
	Very High	No. CB	0	0	0	0	0	0

Table 11– 2015 HI and criticality matrix

Source: 21 February 2014 ED1 RIGS

The total volumes for 2015 and 2023 differ slightly as the number of CBs removed and installed as part of a project are not always identical.

Asset categories	Criticality	Units	Estimated Asset Health and Criticality Profile 2023					Asset Register
			Asset health index					2023
			HI1	HI2	HI3	HI4	HI5	
11kV grid and primary switchgear	Low	No. CB	997	1158	785	91	21	3,052
	Average	No. CB	398	626	583	74	17	1,698
	High	No. CB	153	189	266	12	0	620
	Very High	No. CB	0	0	0	0	0	0

Table 12– 2023 HI and criticality matrix

Source: 21 February 2014 ED1 RIGS

7.9 Whole Life Cost

Before a project is approved for implementation an estimate of the whole life cost is produced which quantifies purchase, installation and maintenance costs over a nominal 30 year period. An example is given in Appendix 4.

8.0 Deliverability

UK Power Networks is on target to meet DPCR5 volumes for 11kV Grid and Primary switchgear. The volume of work proposed in ED1 is higher than that achieved in DPCR4 and DPCR5, but, as it is spread fairly evenly across the network, access and outage availability issues are not anticipated.

EDS 08-0105 specifies the maximum number of any type of distribution switchgear that may be installed on the network to avoid operational difficulties in the event of a type defect.

All ED1 projects have been created in the Network Asset Management Plan. The majority of projects are for specifically named schemes but where this is not possible, a financial provision has been created.

Appendix 1 – Age Profiles

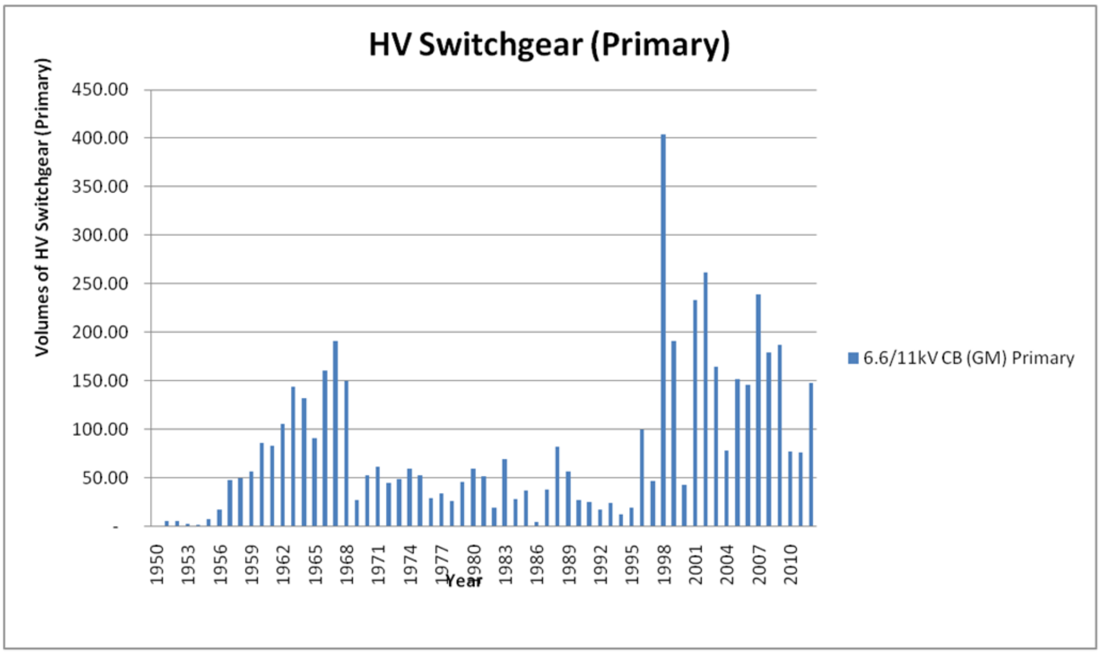


Figure 32 – 11kV Grid and Primary switchgear age profile at the start of ED1

Source: 2012 RIGs submission V5

The age profile for 11kV grid and primary switchgear is shown in Figure 32. The switchgear in EPN is the youngest in the UK Power Networks area – the average age at the start of ED1 is 26 years, but the oldest 10% of the population has an average age at the start of ED1 of 54 years.

Appendix 2 – HI and Criticality Profiles

Asset categories	Criticality	Units	Estimated Asset Health and Criticality Profile 2015					Asset Register
			Asset Health Index					2015
			HI1	HI2	HI3	HI4	HI5	
11kV grid and primary switchgear	Low	No. CB	1055	1042	885	52	12	3046
	Average	No. CB	261	967	397	50	20	1695
	High	No. CB	127	359	113	17	2	618
	Very High	No. CB	0	0	0	0	0	0

Asset health and criticality – 2015 Yr1

Asset categories	Criticality	Units	Estimated Asset Health and Criticality Profile 2023					Asset Register
			Asset health index					2023
			HI1	HI2	HI3	HI4	HI5	
11kV grid and primary switchgear	Low	No. CB	997	1158	785	91	21	3052
	Average	No. CB	398	626	583	74	17	1698
	High	No. CB	153	189	266	12	0	620
	Very High	No. CB	0	0	0	0	0	0

Asset health and criticality – 2023 Yr10

Appendix 3 – Fault Data

EPN							
Assets		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
HV switchgear	All faults	254	341	313	290	305	230
	Corrosion	1	2	0	5	2	1
	Deterioration due to ageing or wear (excluding corrosion)	10	10	9	13	8	5
	Deterioration due to ageing or wear (including corrosion)	11	12	9	18	10	6
Assets		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
HV switchgear	All faults	0.0073	0.0098	0.0090	0.0083	0.0087	0.0066
	Poor condition due to age and wear	0.0003	0.0003	0.0003	0.0004	0.0002	0.0001

Table 13– EPN fault data

Source: Fault Analysis Cube 'EPN Fault Rates'

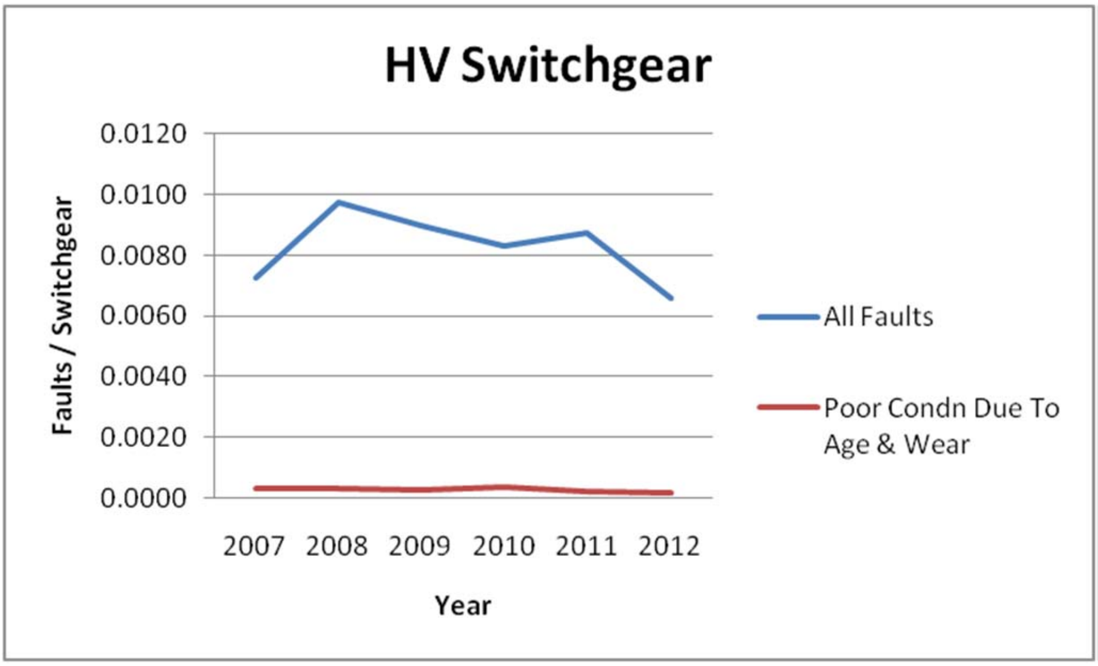


Figure 33 – EPN fault data

Source: Fault Analysis Cube 'EPN Fault Rates'

Appendix 4 – WLC Case Study

Whole life cost description	Wix Primary 11kV CB: replacement v refurbishment analysis.
Starting assumption (same for all scenarios)	The OCBs are 52 years old at the beginning of the scenario, that it has a current new purchase cost of £100k/panel and an average useful operating life of 50 years. The switchboard is 8 panels and can be replaced without major civil works. The only options considered are retrofit and replacement.

Scenario 1	At end of life a replacement vacuum CB is purchased.
Assumptions specific to this scenario	At year 1 a replacement switchboard is purchased.

Description of costs/(income) items	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Totals
Notional purchase cost of a 52 year old oil OCB switchboard (No remaining service life)	0																														0
I&M costs of original oil CB board	2																														2
Purchase of replacement vacuum CB in year 1	800																														800
I&M costs of replacement vacuum CB	1	1	1	1	1	10	1	1	1	1	1	10	1	1	1	1	1	10	1	1	1	1	1	10	1	1	1	1	1	10	71
Residual value of replacement vacuum CB b0ard at end of scenario (i.e.: 15 years remaining life)																														-266	-266
Net cash flow	803	1	1	1	1	10	1	1	1	1	1	10	1	1	1	1	1	10	0.5	1	0.5	0.5	0.5	10	0.5	1	0.5	0.5	0.5	-256	607

Discount rate: Select 6.85%	6.85%
Discounted whole life cost	742

Scenario 2	Housing is retrofitted with a vacuum CB truck to extend life by 20 yrs.
Assumptions specific to this scenario	Refurbishment intervention adds 20 years to the asset life. Replaced in Yr 21

Description of costs/(income) items	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Totals
Notional purchase cost of a 55 year old oil OCB switchboard (No remaining service life)	0																														0
I&M costs of original oil CB	5																														5
Purchase of retrofit CB trucks in Yr 1 & 2	200																														200
I&M costs of replacement vacuum CB		1	1	1	1	1	10	1	1	1	1	1	10	1	1	1	1	1	10	1	1										42
Purchase of replacement vacuum CB board in in Yr 23/24																						800									800
I&M costs of new switchboard																							1	1	1	1	1	10	1		16
Residual value of replacement panel at end of scenario (i.e.: 37 years remaining life)																														-658	-658
Net cash flow	205	1	0.5	0.5	0.5	1	10	1	0.5	0.5	0.5	1	10	1	0.5	0.5	0.5	1	10	1	0.5	800	1	1	1	1	1	10	1	-657.77	405

Discount rate: Select 6.85%	6.85%
Discounted whole life cost	310

Appendix 5 – NLRE Expenditure Plan

Investment (£'m)	DPCR4 (FBPQ)					DPCR5 (Actual and Forecast from RIgs)				
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
FBPQ						1.77	3.58	3.46	3.58	3.21
Replacment	2.77	3.66	4.59	5.00	4.08	3.71	4.80	3.89	3.19	1.70
Refurbishment	0.23	1.44	1.81	2.20	0.82	0.00	0.00	0.07	0.46	0.00

Investment (£'m)	ED1 Plan								ED2 Plan							
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
FBPQ																
Replacment	3.84	5.44	9.23	8.87	11.57	8.91	6.34	7.87	6.32	6.32	6.32	6.32	6.32	6.32	6.32	5.93
Refurbishment	0.03	0.05	0.08	0.22	0.14	0.25	0.63	0.70	0.48	0.40	0.40	0.32	0.16	0.00	0.00	0.00

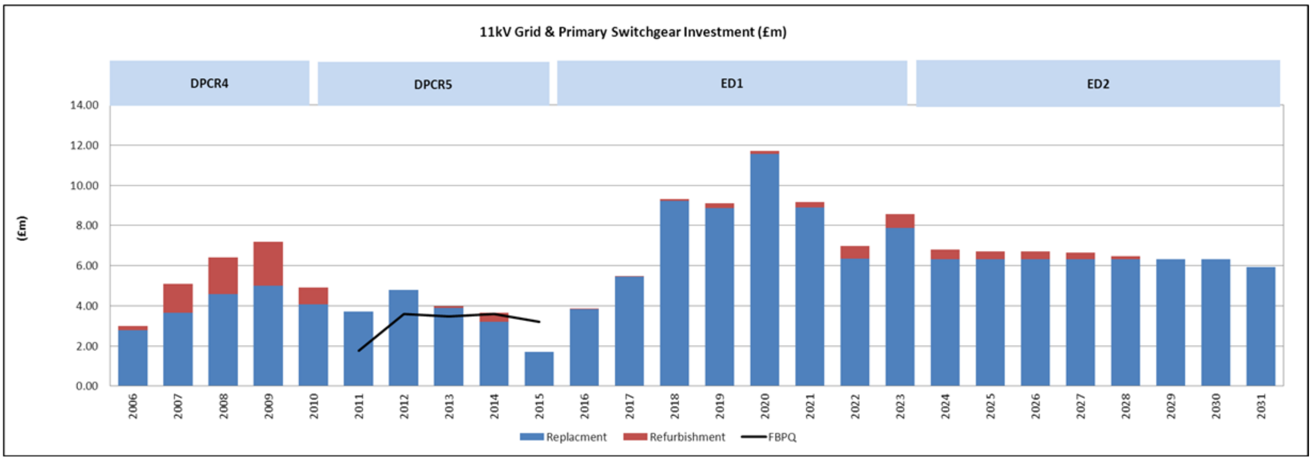


Figure 34: EPN 11kV Grid & Primary switchgear expenditure

Sources:

- DPCR4 costs: Table NL1 (DPCR5 FBPQ)
- DPCR5 costs: First three years – RIGs CV3 table
- DPCR5 costs: Last two years – 14 June 2013 NAMP (Table JLI)
- DPCR5 FBPQ costs: EPN FBPQ Mapping NAMP data
- ED1 costs: 19 February 2014 NAMP (Table JLI)
- ED2 costs: Volumes from SARM1 * UCI of £79k for replacement and UCI of £16k for refurbishment

Volumes	DPCR4 (FBPQ)					DPCR5 (Actual and Forecast from RIgs)				
Year end	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
HV Switchgear (GM) - Primary FBPQ (Removals only)						66	35	54	60	117
HV Switchgear (GM) - Primary (Removals) Replacement	34	14	20	16	37	31	91	94	48	31
HV Switchgear (GM) - Primary (Removals) Refurbishment	9	58	72	88	33	0	13	0	31	0

Volumes	ED1 Plan								ED2 Plan							
Year end	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
HV Switchgear (GM) - Primary FBPQ (Removals only)																
HV Switchgear (GM) - Primary (Removals) Replacement	36	54	143	100	124	115	86	101	80	80	80	80	80	80	80	75
HV Switchgear (GM) - Primary (Removals) Refurbishment	0	0	0	8	3	9	32	38	30	25	25	20	10	0	0	0

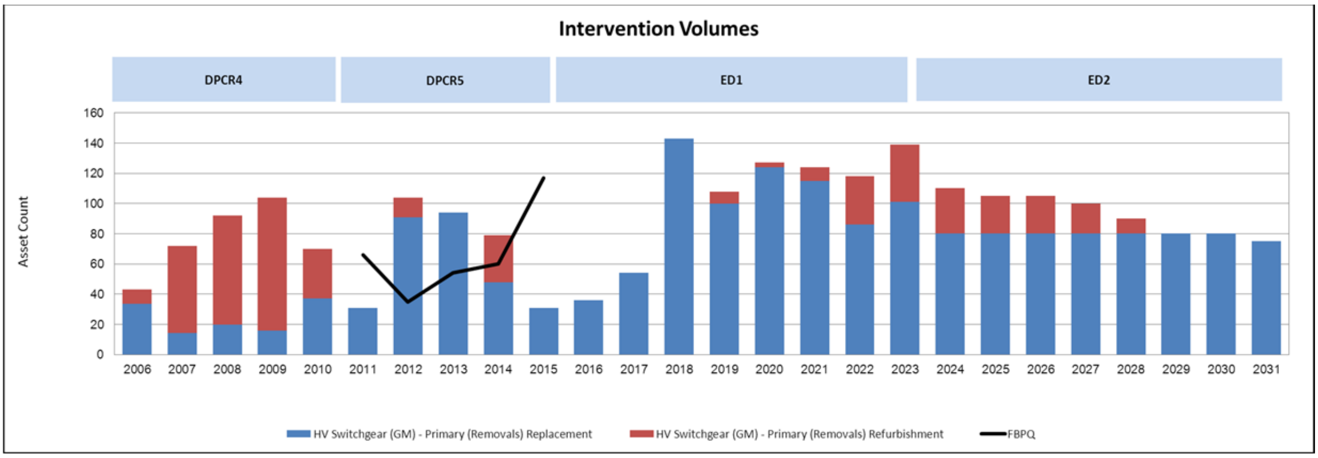


Figure 35: EPN 11kV Grid & Primary switchgear replacement volumes

Sources:

- DPCR4 volumes: Table NL3 (DPCR5 FBPQ)
- DPCR5 volumes: First three years – RIGs CV3 table
- DPCR5 volumes: Last two years – 14 June 2013 NAMP (Table O)
- DPCR5 FBPQ volumes: EPN FBPQ Mapping NAMP data
- ED1 volumes: 19 February 2014 NAMP (Table O)
- ED2 volumes: Analysis from Statistical Asset Replacement Model (SARM1)

Appendix 6 – Sensitivity Analysis

Sensitivity Analysis:

Asset Risk and Prioritisation Model for EPN HV Primary Switchgear (written by Decision Lab)

Introduction

This is a report on the sensitivity analysis conducted on the Asset Risk and Prioritisation (ARP) Model developed by EA Technology and used to support the asset replacement and investment strategy for EPN HV primary switchgear, which is included in the ED1 plan.

The objective is to understand how the Health Index profile of assets may change if the average asset life does not turn out as predicted.

An input to the ARP model is the starting asset population in each Health Index, which is different in each region. Therefore, sensitivity analysis has been done on a region-by-region basis.

The Asset Risk and Prioritisation Model

The ARP model uses database information about each individual asset, and models many parameters to predict the Health Index of each asset in the future. Significant parameters are age, location, loading and current average asset life.

Sensitivity Analysis

Variation in average asset life can occur, but this is significantly less than the variation in individual asset lives.

Standard average asset lives are used in the ARP model. These range from 20 to 55 years. In 2012, about 76% had a current average asset life in the range of 45 to 55 years. This study covered the full population of EPN HV primary switchgear.

Using 2012 asset data and the replacement plans up to 2023, the ARP model was used to predict the Health Index of each asset at the beginning and end of ED1. This was then repeated, varying each current average asset life by +/- 1, 2 and 4 years.

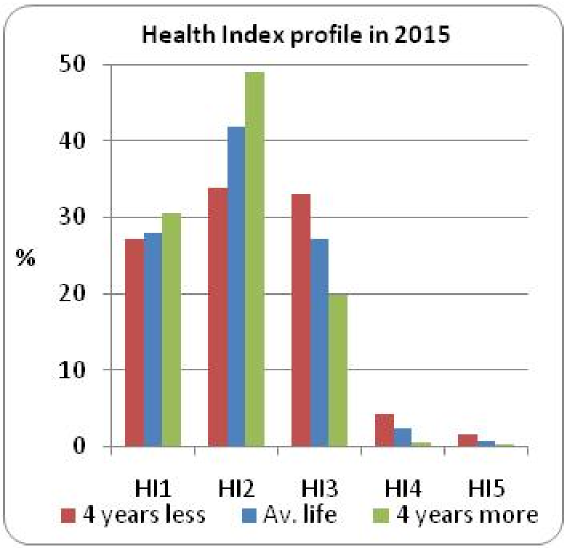
All results are shown below as the percentages of the population.

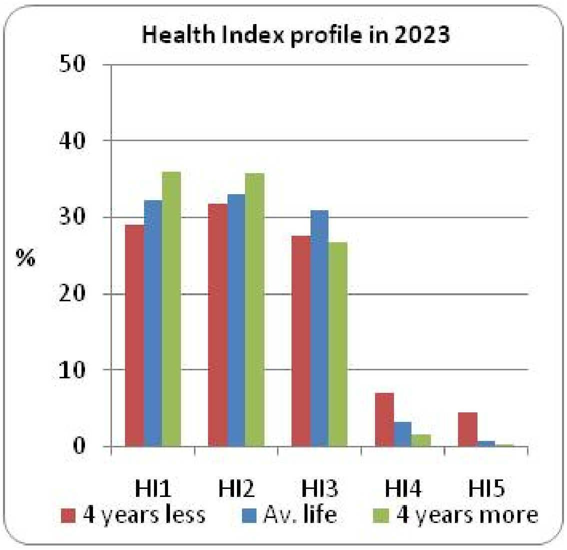
Average life change	2015 percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	27.2	33.9	33.1	4.4	1.5
-2	27.8	38.3	29.7	3.2	1.0
-1	27.8	40.0	28.6	2.8	0.7
0	28.0	41.9	27.1	2.3	0.7
1	28.4	44.2	24.8	2.0	0.5
2	28.7	46.8	22.5	1.7	0.4
4	30.4	49.1	19.8	0.5	0.2

Average life change	2023 percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	29.1	31.8	27.5	7.1	4.5
-2	31.3	31.2	29.5	5.7	2.3
-1	31.8	31.9	31.0	4.2	1.1
0	32.2	32.9	31.0	3.2	0.7
1	33.6	33.2	29.9	2.7	0.5
2	33.6	34.4	29.6	2.2	0.2
4	36.0	35.7	26.7	1.6	0.0

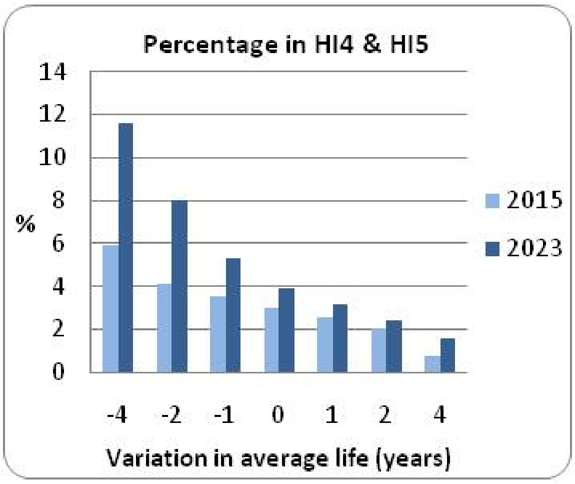
As the percentages above are rounded, the sum of a row may be 0.2% above or below 100%.

The upper and lower and current average asset life cases are charted below.





For all cases modelled, the sums of assets in Health Indices HI4 and HI5 are plotted below.



The results show:

- Variations in asset life will affect the proportion of HI4 and HI5 assets in 2015 and 2023
- In 2015, if the average asset life is four years longer, the proportion of HI4 and HI5 assets will reduce from 3.0% to 0.7%; if four years shorter, it will increase to 5.9%.
- In 2023, if the average asset life is four years longer, the proportion of HI4 and HI5 assets will reduce from 3.9% to 1.6%; if four years shorter, it will increase to 11.6%.

Conclusion

The ED1 replacement plan for EPN HV primary switchgear is moderately sensitive to a variation in average asset life of up to four years.

Appendix 7 – Named Schemes

Ref	Project ID	DNO	Description	Switchgear Type	Volume
1.50.01.7627	7627	EPN	Abbots Central 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	9
1.50.01.7668	7668	EPN	Adelaide St 33/11kV Primary Substation - Retrofit 11kV Switchgear	C4X	3
1.50.01.7628	7628	EPN	Amersham 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	13
1.50.01.7629	7629	EPN	Arnos Grove 33/11kV Primary Substation - Replace 11kV Switchgear	V1R/RVCB	15
1.50.01.7671	7671	EPN	Barsham 33/11kV Primary Substation - Retrofit 11kV Switchgear	C4X	8
1.50.01.7630	7630	EPN	Bassingbourn 33/11kV Primary Substation - Replace 11kV Switchgear	BVAC	8
1.50.01.7632	7632	EPN	Boxted 33/11kV Primary Substation - Replace 11kV Switchgear	LA	7
1.50.01.5846	5846	EPN	Braiswick 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	11
1.50.01.7673	7673	EPN	Brantham 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	10
1.50.01.2464	2464	EPN	Brockenhurst 33/11kV Primary Substation - Replace 11kV Switchgear	QF	9
1.50.01.7633	7633	EPN	Brogborough 33/11kV Primary Substation - Replace 11kV Switchgear	LA	10
1.50.01.7634	7634	EPN	Bruce Grove 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	14
1.50.01.7636	7636	EPN	Canvey 33/11kV Primary Substation - Replace 11kV Switchgear	LMT	12
1.50.01.7637	7637	EPN	Cheddington 33/11kV Primary Substation - Replace 11kV Switchgear	BVAC	7
1.50.01.7638	7638	EPN	Cherry Green 33/11kV Primary Substation - Replace 11kV Switchgear	BVAC	7
1.50.01.2087	2087	EPN	Cherry Tree 33/11kV Primary Substation - Replace 11kV Switchgear	FA	10
1.50.01.7675	7675	EPN	Colindale 132/11kV Grid Substation - Retrofit 11kV Switchgear	BVP/RVCB	25
1.50.01.7676	7676	EPN	Cotton 33/11kV Primary Substation - Retrofit 11kV Switchgear	C4X	7
1.50.01.2467	2467	EPN	Cranley Gardens 33/11kV Primary Substation - Replace 11kV Switchgear	QF	13
1.50.01.2506	2506	EPN	Crouch End 33/6.6kV Primary Substation - Replace 6.6kV Switchgear	UA/RVCB	12
1.50.01.7677	7677	EPN	Cuffley 33/11kV Primary Substation - Retrofit 11kV Switchgear	C4X	6
1.50.01.7680	7680	EPN	Dock Rd 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	10
1.50.01.5811	5811	EPN	Downham Market 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	8
1.50.01.7681	7681	EPN	East Bay 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	9
1.50.01.7682	7682	EPN	East Harpenden 33/11kV Primary Substation - Replace 11kV Switchgear	QF	6
1.50.01.7684	7684	EPN	Elm Park 33/11kV Primary Substation - Retrofit 11kV Switchgear	VSI	5
1.50.01.7686	7686	EPN	Exning 33/11kV Primary Substation - Replace 11kV Switchgear	LMT	8
1.50.01.7642	7642	EPN	Fornham 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	10
1.50.01.2091	2091	EPN	Gardiners Lane 33/11kV Primary Substation - replace switchgear (2000A)	C4X	11
1.50.01.3315	3315	EPN	Great Missenden 33/11kV Primary Substation - Replace 11kV Switchgear	VMX	10
1.50.01.7644	7644	EPN	Grove Mill 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	12
1.50.01.7689	7689	EPN	Halesworth 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	10
1.50.01.7691	7691	EPN	Hardwick Rd 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	11
1.50.01.7692	7692	EPN	Hartspring 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	14

Ref	Project ID	DNO	Description	Switchgear Type	Volume
1.50.01.7693	7693	EPN	Hemblington 33/11kV Primary Substation - Retrofit 11kV Switchgear	LMT	8
1.50.01.7646	7646	EPN	High Street 33/11kV Primary Substation - Replace 11kV Switchgear	BVAC	14
1.50.01.7648	7648	EPN	Hitcham 33/11kV Primary Substation - Replace 11kV Switchgear	BVAC	8
1.50.01.2344	2344	EPN	Hoddesdon 33/11kV Primary Substation - Replace 11kV Switchgear	FA	13
1.50.01.2017	2017	EPN	Hornchurch Local 33/11kV Primary Substation - Replace 11kV Switchgear	FA	16
1.50.01.7649	7649	EPN	Houghton Regis 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	14
1.50.01.2016	2016	EPN	Hutton 33/11kV Primary Substation - Replace 11kV Switchgear	FA	11
1.50.01.7694	7694	EPN	Icklingham 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	7
1.50.01.7650	7650	EPN	Kenninghall 33/11kV Primary Substation - Replace 11kV Switchgear	LA	7
1.50.01.7695	7695	EPN	Kings Langley 33/11kV Primary Substation - Retrofit 11kV Switchgear	LMT	3
1.50.01.7653	7653	EPN	Long Rd 33/11kV Primary Substation - Replace 11kV Switchgear	VMX	11
1.50.01.7654	7654	EPN	Longstanton 33/11kV Primary Substation - Replace 11kV Switchgear	UA	7
1.50.01.7655	7655	EPN	Lt Massingham 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	4
1.50.01.7656	7656	EPN	Luton North 132/11kV Grid Substation - Replace 11kV Switchgear	BVP/VMX	20
1.50.01.7657	7657	EPN	Magdalen Way 33/11kV Primary Substation - Replace 11kV Switchgear	VMX	9
1.50.01.7696	7696	EPN	Manor Road 33/11kV Primary Substation - Retrofit 11kV Switchgear	BVP/VMX	9
1.50.01.7697	7697	EPN	Marks Tey 33/11kV Primary Substation - Retrofit 11kV Switchgear	C4X	3
1.50.01.2088	2088	EPN	May & Baker 33/11kV Primary Substation - Replace 11kV Switchgear	FA	8
1.50.01.7699	7699	EPN	Mildenhall 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	12
1.50.01.2512	2512	EPN	Noak Hill 33/11kV Primary Substation - Replace 11Kv switchgear (2000A)	FA	12
1.50.01.2248	2248	EPN	North Chingford 33/11kV Primary Substation - Replace 11kV Switchgear	QF	13
1.50.01.2472	2472	EPN	North Enfield 33/11kV Primary Substation - Replace 11kV Switchgear	UA	11
1.50.01.7701	7701	EPN	Outwell Moors 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	7
1.50.01.7702	7702	EPN	Park St 33/11kV Primary Substation - Retrofit 11kV Switchgear	C4X	6
1.50.01.7703	7703	EPN	Peasenhall 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	8
1.50.01.2358	2358	EPN	Ponders End 33/11kV Primary Substation - Replace 11kV Switchgear	V1R	13
1.50.01.7659	7659	EPN	Rickmansworth 132/11kV Grid Substation - Replace 11kV Switchgear	BVP/VMX	19
1.50.01.7660	7660	EPN	Romford 33/11kV Primary Substation - Replace 11kV Switchgear	BVP/VMX	25
1.50.01.2057	2057	EPN	Romford North 33/11kV Primary Substation - Replace 11kV Switchgear	FA	10
1.50.01.7704	7704	EPN	Roundwood Rd 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	12
1.50.01.7661	7661	EPN	Saunderton 33/11kV Primary Substation - Replace 11kV Switchgear	LA	8
1.50.01.7662	7662	EPN	Scottow 33/11kV Primary Substation - Replace 11kV Switchgear	BVAC	8
1.50.01.2052	2052	EPN	Selinas Lane 33/11kV Primary Substation - Replace 11kV Switchgear	FA	13
1.50.01.2285	2285	EPN	Shenley 33/11kV Primary Substation - Replace 11kV Switchgear	QF	10
1.50.01.2473	2473	EPN	South Chingford 33/11kV Primary Substation - Replace 11kV Switchgear	QF	11

Ref	Project ID	DNO	Description	Switchgear Type	Volume
1.50.01.5499	5499	EPN	South Ruislip 33/11kV Primary Substation - Replace 11kV Switchgear	LA	11
1.50.01.7705	7705	EPN	Stewartby 33/11kV Primary Substation - Retrofit 11kV Switchgear	QF	3
1.50.01.7706	7706	EPN	Stonegrove 33/11kV Primary Substation - Replace 11kV Switchgear	QF	6
1.50.01.2499	2499	EPN	Stowmarket 132/11kV Grid Substation - Replace 11kV Switchgear	UA	15
1.50.01.7707	7707	EPN	Sudbury 33/11kV Primary Substation - Replace 11kV Switchgear	C4X	12
1.50.01.7708	7708	EPN	Sundon 33/11kV Grid Substation - Replace 11kV Switchgear	LMT	9
1.50.01.7665	7665	EPN	Tattingstone 33/11kV Primary Substation - Replace 11kV Switchgear	BVAC	9
1.50.01.2475	2475	EPN	Waltham Abbey 33/11kV Primary Substation - Replace 11kV Switchgear	QF	11
1.50.01.2476	2476	EPN	Watsons Road 33/11kV Primary Substation - Replace 11kV Switchgear	UA/RVCB	15
1.50.01.2477	2477	EPN	Wealdstone 33/11kV Primary Substation - Replace 11kV Switchgear	QF	14
1.50.01.7666	7666	EPN	West Beckham 33/11kV Primary Substation - Replace 11kV Switchgear	BVAC	10
1.50.01.2356	2356	EPN	West Green 33/11kV Primary Substation - Replace 11kV Switchgear	V1R	11
1.50.01.7667	7667	EPN	Whapload Road 33/11kV Primary Substation - Replace 11kV Switchgear	UA	9
1.50.07.8311	8311	EPN	Unnamed provision for retrofit	Unknown	4

Table 4 – EPN 11kV grid and primary switchgear: Summary of interventions

Type	Retrofit	Replace
BVAC		71
BVP/RVCB	25	
BVP/VMX	9	162
C4X	33	130
FA		93
LA		43
LMT	11	29
QF	3	93
UA		42
UA/RVCB		27
V1R		24
V1R/RVCB		15
VMX		30
VSI	5	
Unknown	4	
Total	**90**	**759**

Note that further details of project 2476 (Watsons Road 33/11kV Primary Substation - Replace 11kV Switchgear) are given in a separate NLRE Scheme Justification Paper.

Appendix 8 – Output NAMP/ED1 Business Plan Data Table Reconciliation

Outputs		Asset Stewardship Report									Business Plan Data Table										
Investment description	NAMP Line	2015 /16	2016 /17	2017 /18	2018 /19	2019 /20	2020 /21	2021 /22	2022 /23	Total	RIG Table	RIG Row	2015 /16	2016 /17	2017 /18	2018 /19	2019 /20	2020 /21	2021 /22	2022 /23	Total
HV Switchgear (GM) - Primary (Removals) Replacement	1.50.01	36	54	143	100	124	115	86	101	759	CV3	161	36	54	143	100	124	115	86	101	**759**
HV Switchgear (GM) - Primary (Removals) Refurbishment	1.50.01	0	0	0	8	3	9	32	38	90	CV5	19	0	0	0	8	3	9	32	38	**90**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
										0											**0**
Total		**36**	**54**	**143**	**108**	**127**	**124**	**118**	**139**	**849**			**36**	**54**	**143**	**108**	**127**	**124**	**118**	**139**	**849**

Table 2: Output NAMP/ED1 Business Plan Data Table Reconciliation

Source: 19th February 2014 NAMP Table O
21st February 2014 ED1 Business Plan Data Tables

Appendix 9 – Efficiency benchmarking with other DNO's

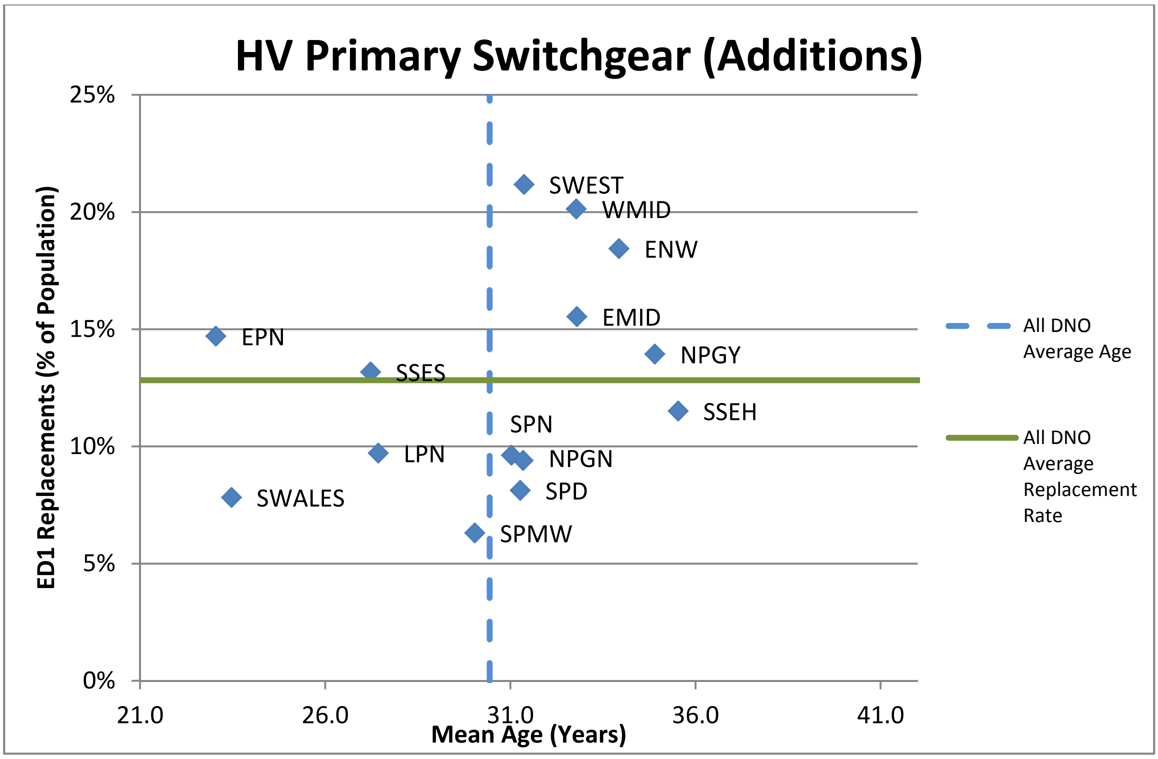


Figure 36 Efficiency Benchmarking

Source: DNO Datashare_2013

The graph above shows that the proposed replacement volumes in EPN are above the industry average and the average age is the lowest of any DNO.

Historically, unlike LPN and SPN, much of the 11kV primary switchgear in EPN did not have remote control facilities and so from the mid-1990s onwards there was an extensive programme of replacement and retrofitting with quality of supply improvement as the sole driver. The age profile in Appendix 1 illustrates this.

This has left EPN with the youngest average age of any DNO but also with a significant population of older switchgear in poor condition, much of it in the North London area where the predominantly underground cable network with a low fault rate meant there was no previous investment. Additionally, many of the older switchpanels that were retrofitted to give remote control facilities now require attention again due to the condition of the fixed portions or partial discharge activity on the circuit breaker trucks.

Appendix 10 – Material changes since the July 2013 ED1 submission

Changes between the July 2013 submission and the March 2014 re-submission are summarised and discussed below.

Asset type	Action	Change type	2013 submission	2014 submission	Difference (Reduction)	Comment
6.6/11kV CB (GM) Primary	Replace (CV3)	Volume (additions)	770	770	0	
		Volume (removals)	759	759	0	
		Investment (£m)	19.52	19.11	(0.41)	
		UCI (£k)	25.4	24.8	(0.6)	
6.6/11kV CB (GM) Primary	Refurbish (CV5)	Volume	90	90	0	
		Investment (£m)	2.1	2.1	0	
		UCI (£k)	23.4	23.4	0	

Table 3: Material Changes Since July 2013 ED1 Submission

Source: ED1 Business Plan Data Tables following the OFGEM Question and Answer Process
21st February 2014 ED1 Business Plan Data Tables

Switchgear – 6.6/11kV CB (GM) Primary

Between the time of the original submission and the current resubmission a review of replacement costs has identified some efficiency savings.