Document 6
Asset Category – EHV Switchgear
LPN

Asset Stewardship Report 2014

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Document History

Version	Date	Details	Originator	Revision Class	Section Update
1.0	21/02/2014	July 2013 Submission	Richard Gould		
1.1	21/02/2014	Expenditure tables and charts updated with 19th February S&R NAMP figures	Richard Gould	Major	Header, 1.1, 1.3, 1.5, 7.4, Appendix 5
1.2	21/02/2014	Updated Appendix 7 with list of scheme papers and added Appendices 8-10	Richard Gould	Minor	1.1, Appendix 7, 8, 9, 10
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1.4	26/02/2014	Figure and table numbers added to Appendices. Network risk removed from section 7.8.	Richard Gould	Minor	7.8, Appendix 1-10
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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 Business Plan Data Tables 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 about 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 LPN EHV Switchgear

1.1 Scope

This document details UK Power Networks' non-load related expenditure (NLRE) investment proposals for EHV switchgear for the RIIO-ED1 period. Indicative proposals for the ED2 period are also included.

In total, there are 510 items of EHV Switchgear with an estimated MEAV of £102m. The proposed investment including civils is £1.9m per annum, which equates to an average annual 1.9% of the MEAV for this asset category.

Replacement and refurbishment costs for these assets during ED1 can be seen in Table 1. Appendix 8 contains a reconciliation between NAMP volumes and RIGs volumes.

Investment type	ED1 total expenditure	NAMP line	RIGs reference
Replacement	£12.2m	1.48	Additions CV3 Row 69 – 33kV CB (Air Insulated Busbar)(ID)(GM) CV3 Row 70 – 33kV CB (Air Insulated Busbar)(OD)(GM) CV3 Row 71 – 33kV CB (Gas Insulated Busbar)(ID)(GM) CV3 Row 72 – 33kV CB (Gas Insulated Busbar)(OD)(GM) CV3 Row 73 – Switchgear (other) CV3 Row 77 – 66kV CB (Air Insulated Busbar)(ID)(GM) CV3 Row 78 – 66kV CB (Air Insulated Busbar)(OD)(GM) CV3 Row 79 – 66kV CB (Gas Insulated Busbar)(ID)(GM) CV3 Row 80 – 66kV CB (Gas Insulated Busbar)(OD)(GM) Removals CV3 Row 197 – 33kV CB (Air Insulated Busbar)(ID)(GM) CV3 Row 198 – 33kV CB (Air Insulated Busbar)(OD)(GM) CV3 Row 199 – 33kV CB (Gas Insulated Busbar)(ID)(GM) CV3 Row 200 – 33kV CB (Gas Insulated Busbar)(OD)(GM) CV3 Row 205 – 66kV CB (Air Insulated Busbar)(ID)(GM) CV3 Row 206 – 66kV CB (Air Insulated Busbar)(OD)(GM) CV3 Row 207 – 66kV CB (Gas Insulated Busbar)(ID)(GM) CV3 Row 208 – 66kV CB (Gas Insulated Busbar)(OD)(GM)
Refurbishment	£0.2m	1.48	CV5 Row 33 – 33kV CB (GM) CV5 Row 43 – 66kV CB (GM)

Table 1 – Investment plan

Source: 21st February 2014 ED1 Business Plan Data Tables

*Expenditure on this asset type is also included in CV6 Civils and CV3 Underground Cables.

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

1.2 Investment Strategy

The investment plan for ED1 for EHV switchgear has been developed using the Asset Risk and Prioritisation (ARP) model. The plan focuses on items of switchgear that are in poor condition or are providing poor service and reliability; not old items of switchgear.

The strategy for selecting the level of investment required has been to maintain the same level of risk throughout the period. This has been done by keeping a similar number of HI4s and HI5s at the start and end of the period.

1.3 ED1 Proposals

The proposal for ED1 includes 45 replacements, 10 disposals and no refurbishments across the eight years. This is a similar level of interventions as in DPCR5, which, when adjusted for an eight-year period, had 29 replacements and 26 refurbishments.

Appendix 9 benchmarks our ED1 proposals with reference to other DNOs July 2013 submissions. It shows that for EHV Switchgear we are proposing to replace 9% of our assets while other DNOs were seeking funding to replace 14% of these assets on average. This demonstrates the effectiveness of our asset risk management systems and the value for money of our proposals.

1.4 Innovation

As mentioned in section 1.2, the ARP model has been used to develop the investment plan. The model, which has been developed for EHV Switchgear as well as other asset categories, is industry-leading and uses environment, condition and manufacturer/model information to determine a Health Index for every current and future asset. This has been developed with EA Technology.

The model is able to calculate a criticality index for every asset, as well as a risk value in monetary terms, though this part of the model is still in development. The risk for individual assets has not been looked at in this way before.

1.5 Risks and Opportunities

	Description of similarly likely opportunities or risks arising in ED1 period	**Uncertainties (£m)**
Opportunity	Refurbishment option becomes available for 20% of plan	(2.4)
Risk	The average initial life used in ARP model is over-optimistic, leading to an increase of 11.5% in the total number of HI4s and HI5s (Section 7) and more interventions are required.	16.2
Opportunity	The average initial life used in ARP model is under-optimistic, leading to an decrease of 6.1% in the total number of HI4s and HI5s (Section 7) and more interventions are required.	(8.6)

Table 2 – Risk and opportunities

2.0 Description of EHV Switchgear Population

2.1 33kV, 25kV and 22kV Switchgear

There are 388 circuit breakers currently operating at 33kV, 25kV or 22kV on the network. These are distributed across 31 substation sites, with 382 units installed at indoor locations and six at outdoor locations. These are split into the three categories of switchgear as shown in Table 3.

Switchgear arc extinction method	Population
Oil	274
SF_6	18
Vacuum	96

Table 3 – 33kV, 25kV and 22kV switchgear types

Source: ARP Model 27th November 2012

It can be seen from the age profile in Figure 1 that there was significant investment in the 1960s, resulting in an ageing switchgear fleet – the average age is 43 years. The majority of the pre-1980s switchgear is Reyrolle L42T or L45T switchgear. The oldest 10% of these assets have an average age of 60 years.

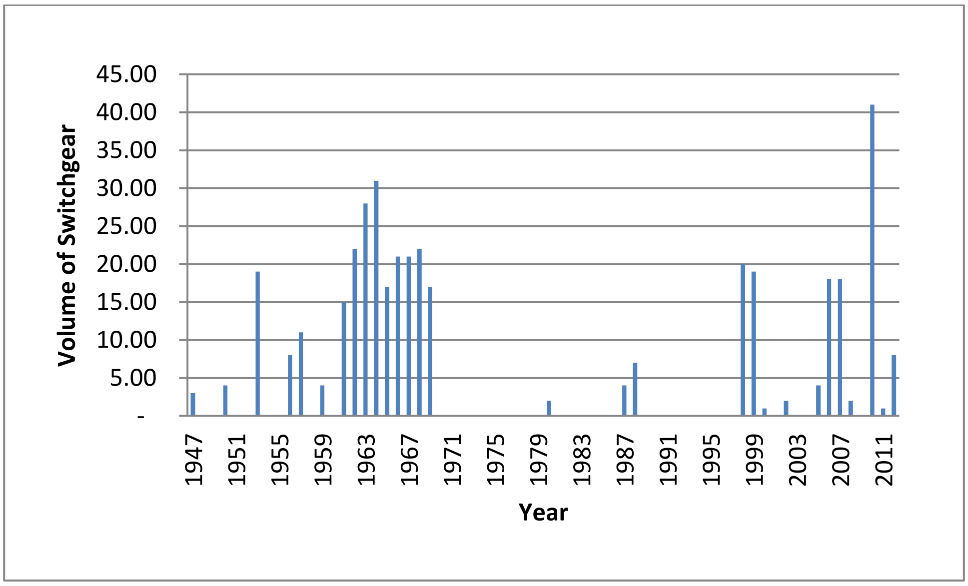


Figure 1 – 33kV, 25kV and 22kV switchgear age profile

Source: 2012 RIGs V5

The NAMP lines used for 33kV switchgear can be seen in Table 4.

NAMP line	Description
1.48.02	Replace 33kV switchgear
1.48.11	Replace with 33kV indoor GIS
1.48.12	Replace with 33kV outdoor open terminal CB
1.48.13	Replace with 33kV outdoor GIS

Table 4 – EHV Switchgear NAMP lines

Refer to Table 5 and Table 6 for the mappings for additions and removals in the RIGs tables.

Description	Table	Row
33kV CB (Air Insulated Busbar)(ID)(GM)	CV3	69
33kV CB (Air Insulated Busbar)(OD)(GM)	CV3	70
33kV CB (Gas Insulated Busbar)(ID)(GM)	CV3	71
33kV CB (Gas Insulated Busbar)(OD)(GM)	CV3	72
33kV CB (GM)	CV5	33

Table 5 – Additions RIGs mappings

Description	Table	Row
33kV CB (Air Insulated Busbar)(ID)(GM)	CV3	197
33kV CB (Air Insulated Busbar)(OD)(GM)	CV3	198
33kV CB (Gas Insulated Busbar)(ID)(GM)	CV3	199
33kV CB (Gas Insulated Busbar)(OD)(GM)	CV3	200

Table 6 – Removals RIGs mappings

2.2 66kV Switchgear

There are 122 circuit breakers currently operating at 66kV on the network. These are distributed across 11 substation sites, with 86 units installed at indoor locations and 36 at outdoor locations. These are split into the four categories of switchgear as shown in Table 7.

Switchgear type	Population
Air blast	29
Bulk oil	42
SF_6	30
GIS	21

Table 7 – 66kV Switchgear types

Source: ARP Model 27th November 2012

It can be seen from the age profile in Figure 2 that, due to the small number of circuit breakers on the 66kV network, there has been no peak in investment. The oldest circuit breakers on the network, manufactured in 1931, are being replaced during DPCR5. The average age of the population is 54 years. The oldest 10% of these assets have an average age of 70 years.

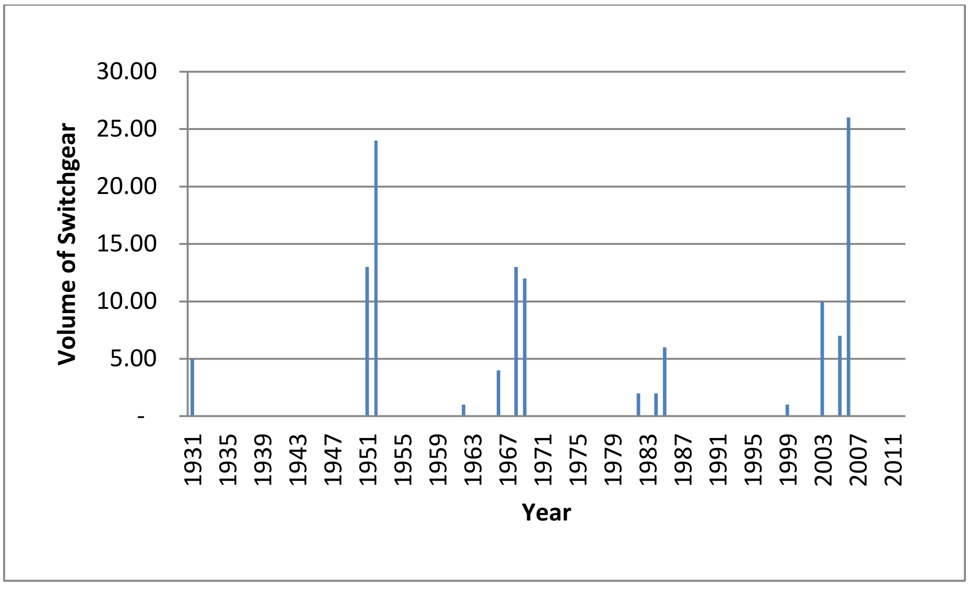


Figure 2 – 66kV age profile

Source: 2012 RIGs V5

The NAMP lines used for 66kV switchgear can be seen in Table 8.

NAMP line	Description
1.48.01	Replace 132kV/66kV switchgear
1.48.09	Replace 66kV CB

Table 8 – 66kV Switchgear NAMP lines

Refer to Table 9 and Table 10 for the mappings for additions and removals in the RIGs tables.

Description	Table	Row
66kV CB (Air Insulated Busbar)(ID)(GM)	CV3	77
66kV CB (Air Insulated Busbar)(OD)(GM)	CV3	78
66kV CB (Gas Insulated Busbar)(ID)(GM)	CV3	79
66kV CB (Gas Insulated Busbar)(OD)(GM)	CV3	80
66kV CB (GM)	CV5	43

Table 9 – Additions RIGs mappings

Description	Table	Row
66kV CB (Air Insulated Busbar)(ID)(GM)	CV3	205
66kV CB (Air Insulated Busbar)(OD)(GM)	CV3	206
66kV CB (Gas Insulated Busbar)(ID)(GM)	CV3	207
66kV CB (Gas Insulated Busbar)(OD)(GM)	CV3	208

Table 10 – Removals RIGs mappings

3.0 Investment Drivers

3.1 Investment Drivers

Investment drivers for switchgear can be split into two categories: internal condition and external condition. External condition factors include paint condition and corrosion of any part of the switchgear. On outdoor sites, the condition of air-insulated busbars and any concrete or steel support structures will also be considered. Internal considerations can include mechanism wear and circuit breaker trip times.

There are a number of switchgear defects that are seen as critical in the ARP model, which is described in section 4 of this document. As defects are found or cleared, they are recorded in the Ellipse asset register using the handheld device. Defects can be captured either on an ad hoc basis or at each inspection and maintenance.

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

Table 11 – Defects used in ARP model

In calculating the Health Index, the ARP model counts the total number of defects recorded against individual items of plant, not just those currently outstanding. These defects are described in more detail below.

- Compound leak – To provide an impulse voltage rating, bitumen compound was used as an insulation medium in busbars, CT (current transformer) chambers and cable termination boxes on 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 Customer Interruptions (CIs) and Customer Minutes Lost (CMLs).
- External connections – For 33kV circuit breakers, this records defects with the bushings of the switchgear and associated busbar connections. A problem here can result in overheating and eventual disruptive failure.
- Gasket – For oil-filled switchgear, this records defective gaskets. No action is needed immediately, but, if left unchecked, a 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 recorded. If left unchecked, it can result in disruptive failure.
- 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.

There is a large population of AEI OW bulk oil circuit breakers on the 66kV network. Currently there are 42 on the network and by the end of ED1 there will be 2. The circuit breaker can be located either indoors or outdoors and has air-insulated busbars. In some cases, the busbars are located indoors even if the actual circuit breaker is located outdoors.

The AEI OW has seen an increasing number of defects reported in the past five years, as shown in Figure 3.

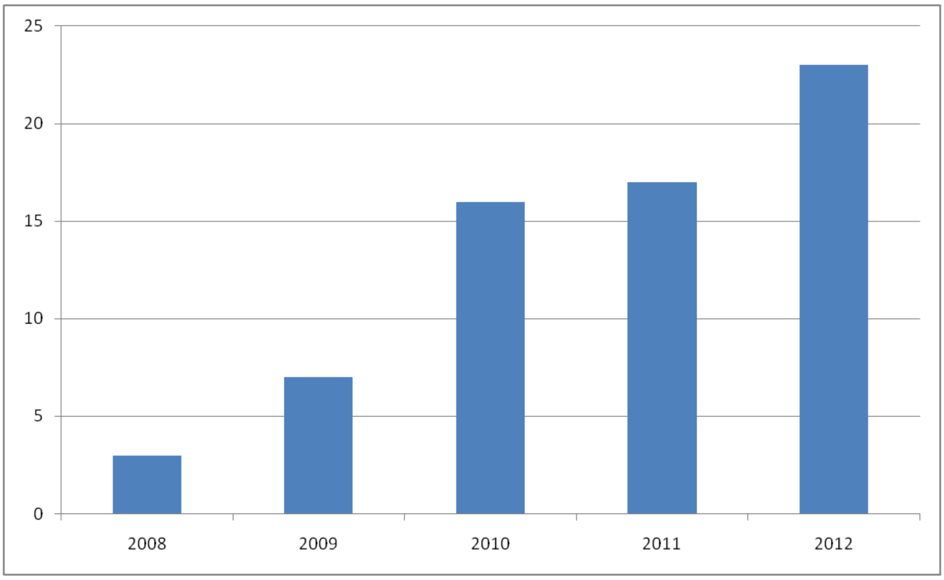


Figure 3 – AEI OW reported defects

Source: ARP Model 25th July 2012

The ages of assets when new defects were reported on them are shown in Figure 4. There are defects at ages where there are currently no assets, as those assets have either aged or been removed from the network since the defect was reported. This shows that the majority of defects occur on assets older than 40 years. There are no defects on assets less than 20 years old, despite this age range containing a significant proportion of the population. Defects recorded on an asset represent a big risk to not only the network, but also operator safety, due to the increased likelihood of a catastrophic failure.

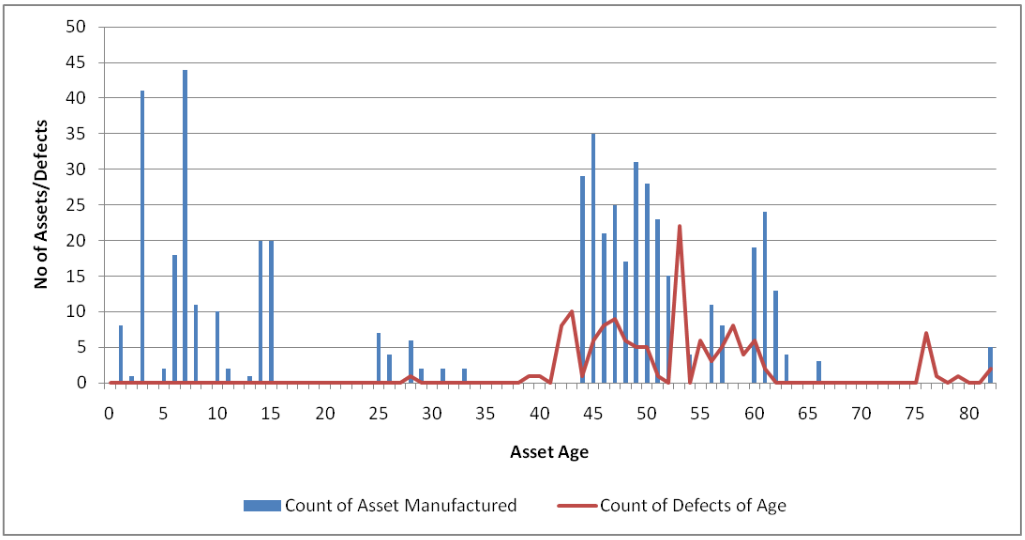


Figure 4 – Defects by asset age

Source: Ellipse Extract 19/02/2013 and 2012 RIGs V5

As mentioned in section 2 of this document, the majority of the pre-1980s switchgear on the 33kV network is Reyrolle L42T or L45T. These are indoor withdrawable oil circuit breakers, and there are 219 remaining on the network. The circuit breaker has generally proved to be reliable; refer to Figure 5, which shows the average trip time has remained constant since 2007. The circuit breaker trip time is the time a circuit breaker takes to open following a fault or an open command from control. In Figure 5, the x axis shows all of the recorded circuit breaker trips, sorted by earliest on the left of the graph and latest on the right. A slower trip time increases the chance of the circuit breaker upstream operating, as described in section 4.3, and is therefore a driver for intervention.

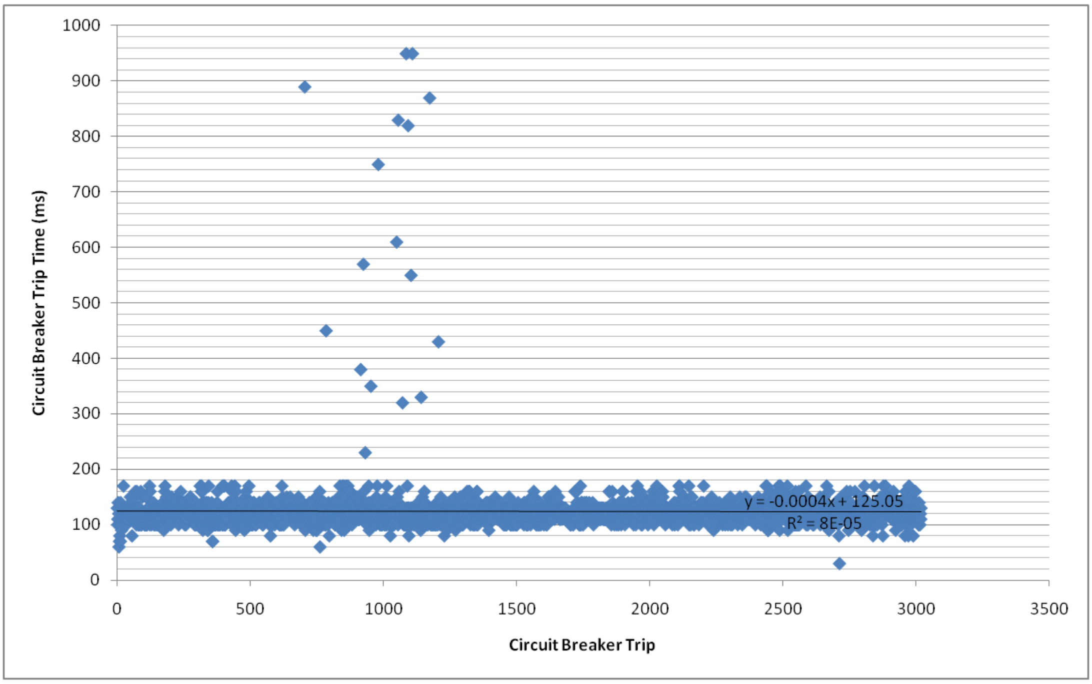


Figure 5 – Circuit breaker trip times, Reyrolle L42T and L45T

Partial discharge can occur within voids in the insulation, across the surface of the insulation (tracking) or in the air around a conductor (corona). Indoor switchgear operating at 33kV 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.

There is online partial discharge monitoring installed on the Reyrolle L42T switchboard at Bromley Grid. This will show if any problems are developing as it is monitored constantly and allow the board to remain in operation longer; therefore, no intervention is required in ED1.

Figure 6 shows the fault rate for all faults relating to switchgear and then split by i) faults caused by the condition of the switchgear and ii) non-condition-related faults. This shows that there is a decreasing amount of faults being caused by switchgear.

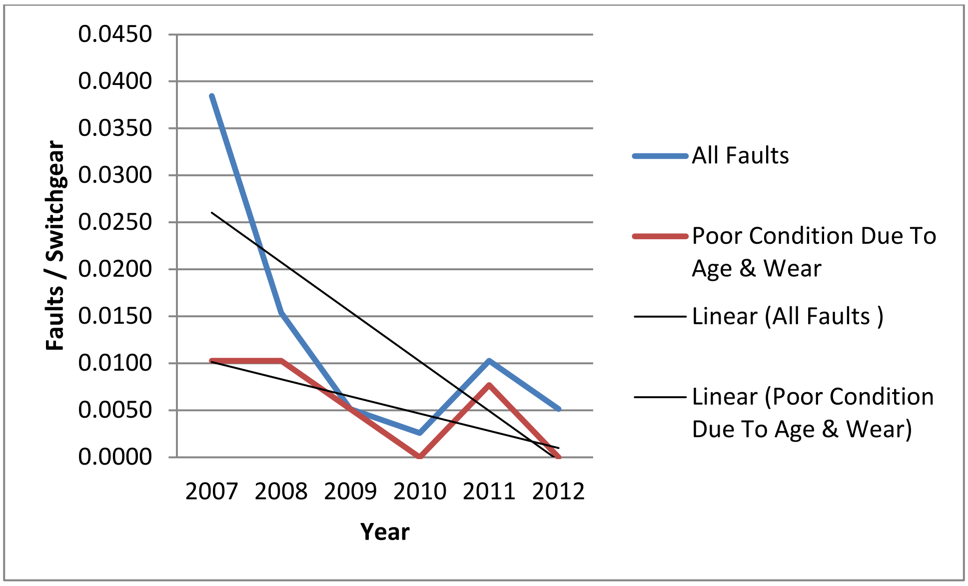


Figure 6 – EHV Switchgear fault rate

3.2 Condition Measurements

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. Each inspector was required to undertake a two-day training course and pass the theory and practical examinations before being certified as a competent inspector.

Figure 7 – 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 to record data in the correct format within the asset register

(Ellipse). When an inspection HHD script is run, the user answers set questions, specific to each asset type, about the condition. This allows defects to be recorded, reviewed and cleared. The inspection scripts have been designed to be as objective as possible, so that there is consistency across the whole network.

Inspections are carried out at a set frequency, which is recorded in EMS 10-0002 *Inspection and Maintenance Frequency Schedule*. For grid and primary substations with wet cell batteries, one major inspection and two minor inspections are carried out annually; for substations with dry cell batteries, one minor inspection and one major inspection are carried out annually. Switchgear is inspected at both minor and major inspections.

3.2.2 Maintenance

There are two routine maintenance tasks carried out on EHV switchgear: mechanism maintenance and a full maintenance. The two maintenance tasks are carried out alternatively at six-year periods, as recorded in EMS 10-0002 *Inspection and Maintenance Frequency Schedule*. A circuit breaker operation is also carried out yearly for bus section and transformer breakers, and every other year for feeder breakers.

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

The key condition points recorded at maintenance are the circuit breaker trip time, overall internal condition, condition of operating mechanism and condition of isolating contacts. For oil circuit breakers, an onsite oil test is also carried out.

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 EHV 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 Document 15: Model Overview*. The EHV switchgear ARP model uses 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 initial 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 initial life is assigned per make and model of switchgear to show the expected time from when the asset was manufactured until it shows signs of increased deterioration. It is not the time from when the asset is commissioned until it is decommissioned. This initial HI is capped at HI3 to ensure assets will never achieve a HI greater than 3 and therefore be considered for intervention on the basis of age alone.

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, and input into the model. The reliability is assigned based on the make and model of the switchgear. There are a number of condition points that force the HI to a minimum of HI5, including external condition of housing and the number of SF_6 top-ups. Assets showing poor condition in these measures regardless of asset age must be flagged, as they will have a higher probability of failure.

This factor value is 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 critical. A detailed methodology for calculating the criticality index can be found in *Commentary Document 15: Model Overview*. The criticality section of the ARP model is under development.

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

For network performance, the key factors for the switchgear model are the number of customers that the substation feeds and the function of the asset. The function of the switchgear can be either a feeder breaker, bus section or transformer breaker, with a bus section breaker being the most critical and a feeder breaker being the least critical.

The factors considered for the safety criticality specific to switchgear are the arc extinction method, and whether the switchgear is internally arc rated. The arc extinction method plays a large part in the safety of a particular type of switchgear, with oil switchgear considered the most dangerous method and therefore the most critical in the model. Items of switchgear that aren't internal arc rated are considered more critical that switchgear that is.

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

Finally, the environment section considers the effects that different types of insulation have on the environment. The volume of gas and oil is also considered.

4.3 Network Risk

The network risk in monetary terms can also be calculated in the ARP model. This is done using the probability of failure, the criticality, and the consequence of failure, although it 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 the four failure modes detailed in Table 12.

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

Table 12 – Network risk 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 an increased 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 that provides details of every non-compliance, allowing continual improvement of data quality.

An example of this is the circuit breaker trip times used in the model. These values have to be between 10 and 1,000ms, otherwise they are discarded and not used. There is also an age limit on the condition data 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 condition.

4.5 Data Completeness

The completeness, accuracy and timeliness of the data used in the ARP model are routinely checked and a CAT score is produced. The latest results for the data used in the EHV switchgear model are given in Table 13.

The score is colour coded as follows:

- Green – Score of 85% or greater
- Amber – Score of 65-84%
- Red – Score of less than 65%

Area	Score
Completeness	75%
Accuracy	89%
Timeliness	97%

Table 13 – EHV Switchgear CAT score

Source: Ellipse Extract 27/11/2012

The completeness score is a combination of switchgear nameplate data and condition data. Information used on the nameplate includes the year of manufacture, the 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, such as customer numbers, is also included.

There has been investment to improve and consolidate nameplate completeness during DPCR5. 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 done 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*.

5.0 Intervention Policies

5.1 Interventions: Description of Intervention Options

Two categories of intervention were initially considered for EHV Switchgear: replacement and refurbishment. Examples of refurbishment that could take place include replacement of the operating mechanism or replacement of seals and pipework to solve any problems with SF_6 leaks.

There are a number of options available for the replacement of switchgear depending on the plant that is currently on the site. These are shown in Table 14.

Option	Description	Advantages	Disadvantages
Outdoor AIS solution	This option uses outdoor circuit breakers, for example the Hawker Siddeley Switchgear Horizon (refer to Figure 8). Existing outdoor busbars can be reused, depending on their condition.	Cheaper than indoor solution. Can reuse existing busbar. Replacement of individual circuit breakers possible.	Requires a lot of space. Can't always reuse busbar due to poor condition support structures. Prone to deterioration as outdoors. Trespass risk resulting in security/safety issues.
Indoor GIS solution	Replacement of switchgear with panel type gear, such as the ABB ZX1.2 switchboard (refer to Figure 9). Will be located indoors.	Requires small foot compared to outdoor switchgear. Longer life as indoors, so less deterioration due to weather.	Civil costs can be expensive. May have to replace whole board for extensions of board.

Table 14 – Replacement options

Figure 8 – Hawker Siddeley Switchgear Horizon

Figure 9 – ABB ZX1.2 switchboard

5.2 Policies: Selecting Preferred Interventions

The process used for selecting interventions can be seen in Figure 10. The process differs depending on whether the switchgear is part of a switchboard or a standalone unit.

If the switchgear is part of a switchboard, replacement will require the whole board to be replaced, whereas refurbishment can be carried out on an individual unit. However, in most cases, the switchboard will contain circuit breakers of the same model, same year of manufacture, same environmental conditions and same maintenance engineers, so should be in similar health.

If the switchgear is a standalone unit, it can be either refurbished or replaced as an individual item of switchgear. If there are multiple items of switchgear on the site, the condition and health of the other assets have been considered in case it is efficient to replace them at the same time. If modern switchgear is replaced as part of one of these projects, this can be reused at a different site or as a strategic spare.

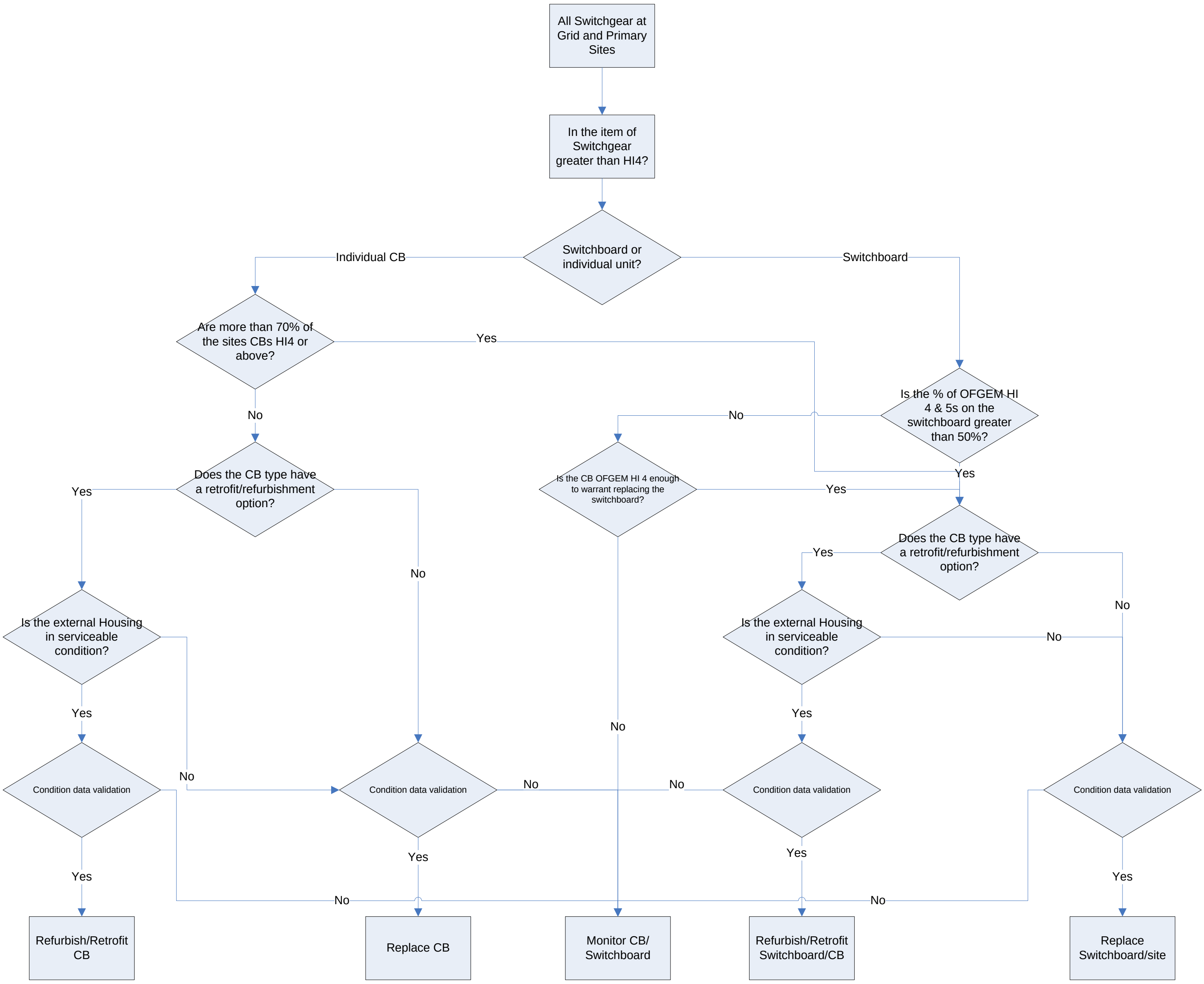


Figure 10 – Intervention strategy process

The capital expenditure plan for EHV Switchgear can lead to cost savings in operational expenditure. The maintenance costs of oil switchgear are higher than modern equivalents, so replacement of oil switchgear will reduce maintenance costs.

Figure 11 shows the cost of maintenance for 33kV switchgear over a 58-year period, which is the average initial life of an asset. This value is calculated as an average across all 3 of UK Power Networks licence areas (refer to *Commentary Document 15: Model Overview*, section 8, for an explanation of average life). The maintenance costs of oil circuit breakers are 470% more than an SF_6/vacuum withdrawable circuit breaker. All circuit breakers planned for replacement are oil circuit breakers.

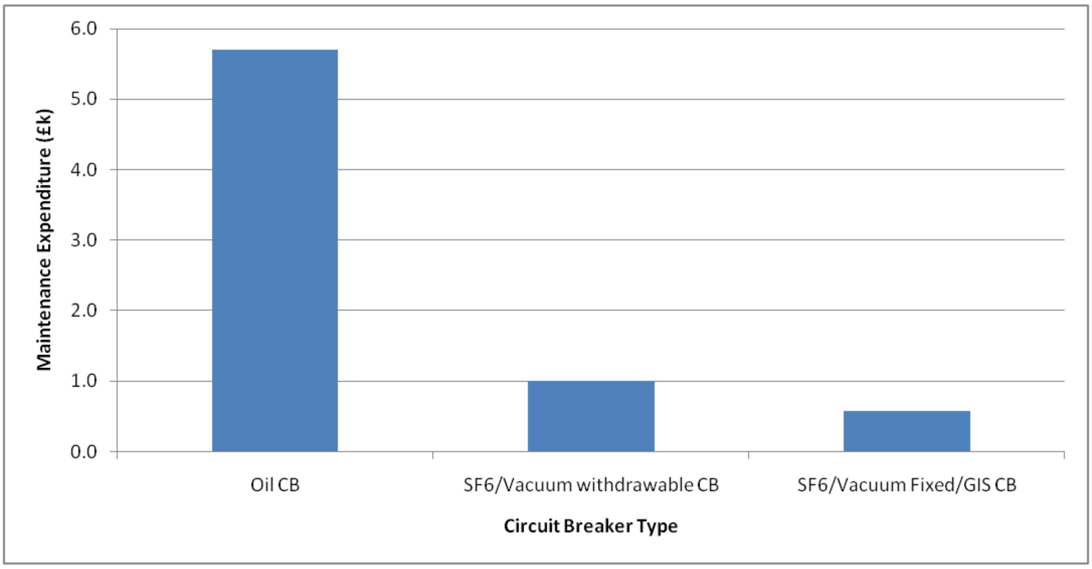


Figure 11 – 33kV switchgear maintenance costs

Source: EMS 10-0002 Inspection and Maintenance Frequency Schedule

Figure 12 shows the same information for 66kV circuit breakers. Oil circuit breakers cost 31% more than SF_6 circuit breakers and GIS.

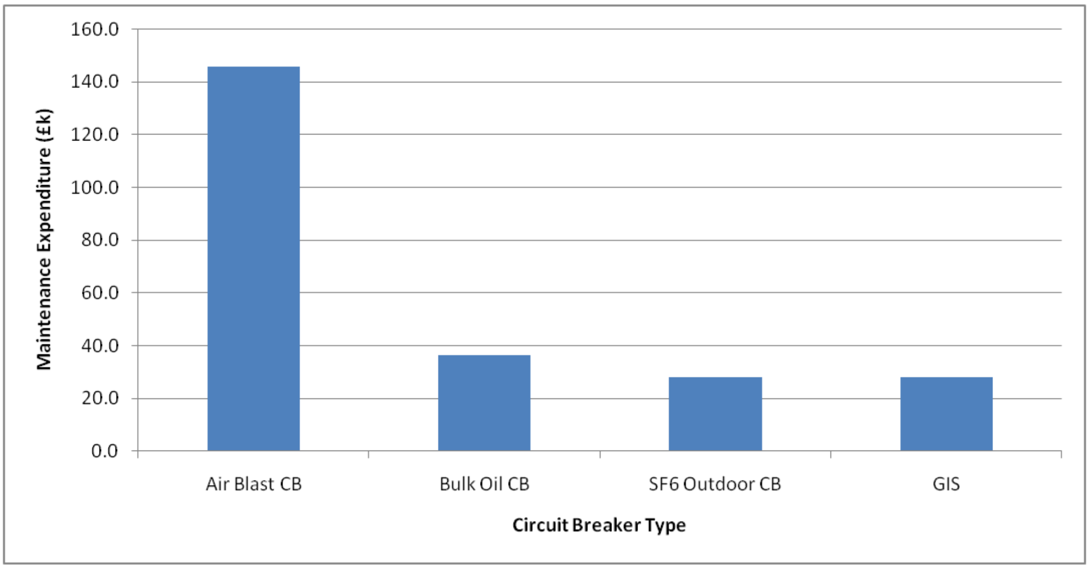


Figure 12 – 66kV switchgear maintenance costs

Source: EMS 10-0002 Inspection and Maintenance Frequency Schedule

6.0 Innovation

As mentioned in section 4, an innovative new model has been used to develop the plan, the Asset Risk and Prioritisation (ARP) model. The model, which has been developed for EHV Switchgear as well as other asset categories, is industry-leading and uses environment, condition and manufacturer/model information to determine a Health Index for every asset currently and in the future. This has been developed with EA Technology.

The model is able to calculate a criticality index for every asset, as well as a risk value in monetary terms, though this part of the model is still in development. The risk for individual assets has not been looked at in this way before.

7.0 ED1 Expenditure Requirements for EHV Switchgear

7.1 Method

Figure 13 shows an overview of the method used to construct the RIIO-ED1 NLRE investment plans.

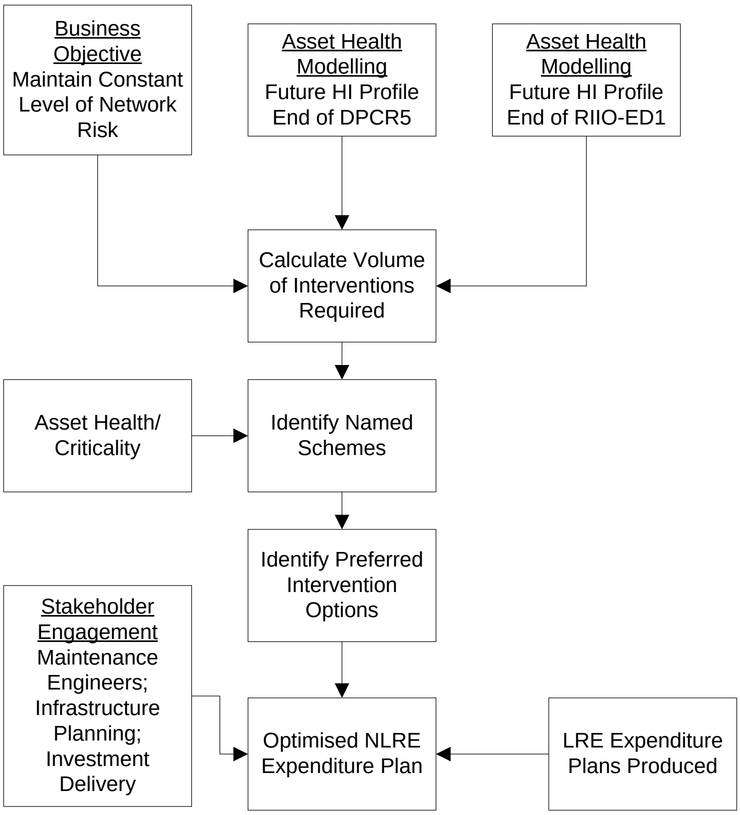


Figure 13 – Programme development methodology

7.2 Constructing the Plan

The overall strategy for non-load related expenditure on EHV switchgear during ED1 has been to maintain the level of risk, so that it is the same at the end of the period as it is at the beginning – keeping the number of HI4s and HI5s at the beginning and end of the period the same. The HI profiles are outputs from the ARP model. Refer to Figure 14 for the HI profiles at the beginning and end of ED1.

The percentage of HI4s and HI5s on the network at the beginning of ED1 is 8% of the total asset population, and 9% at the end of the period.

The HI profiles indicated are derived from condition related investment only and exclude the contribution from load related expenditure.

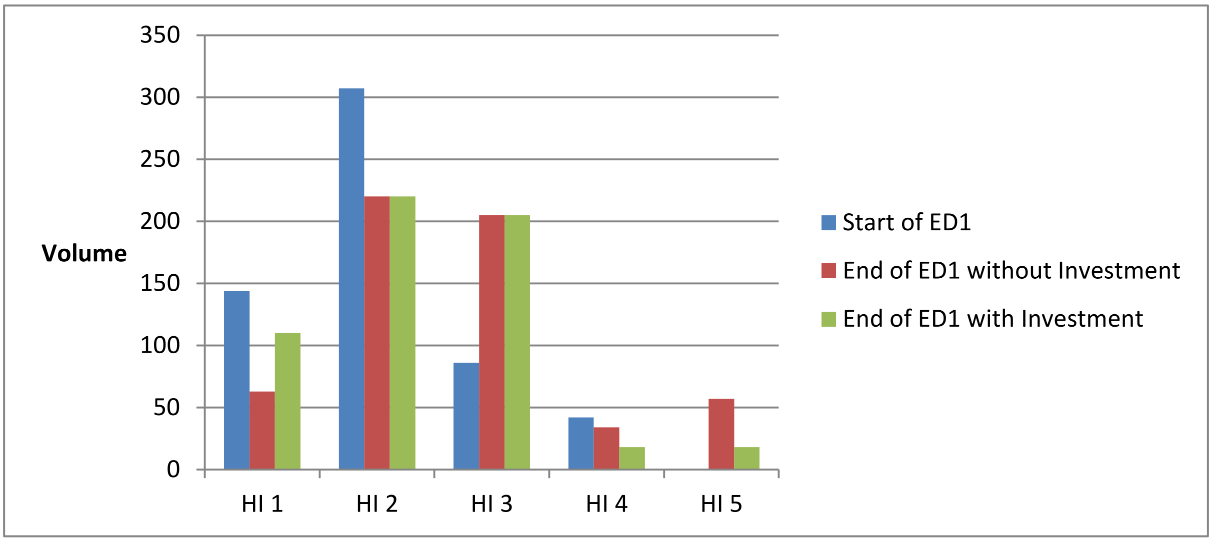


Figure 14 – ED1 HI profiles

Source: ARP Model 25th July 2012

Figure 15 shows the number of HI4s and HI5s with and without investment currently, and at the beginning, middle and end of ED1.

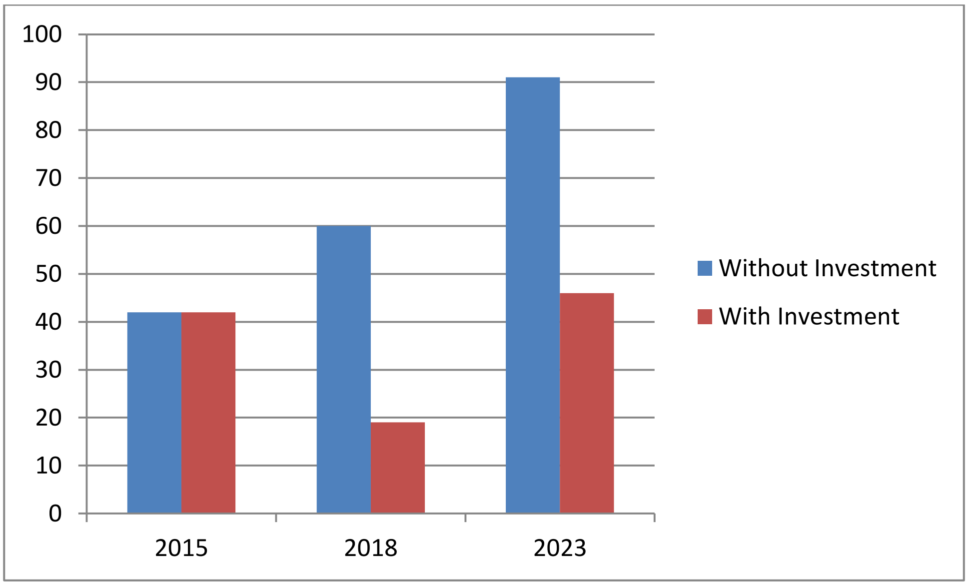


Figure 15 – Total number of HI4 and HI5s

Source: ARP Model 25th July 2012

7.3 Additional Considerations

There are a number of additional requirements that need to be considered when constructing the plan, with the two major factors being other NLRE investments and LRE investments required at sites during ED1.

The main NLRE schemes that will affect EHV switchgear projects are switchgear of other voltages interventions and transformer interventions. If these schemes are within five years of the EHV switchgear scheme, consideration has been given as to whether cost efficiencies are possible by combining the schemes. Combining the schemes can mean that site establishment (CDM) costs are reduce and project administration can be combined, and there is the possibility of combining network outages.

Any LRE requirements at a project site may mean that the project needs to be rephrased. Where a project has both NLRE and LRE drivers, the NLRE is used as the primary driver.

7.4 Asset Volumes and Expenditure

Figure 16 shows the year-on-year volumes of EHV switchgear interventions from the start of DPCR4 to the end of ED2. For a list of named schemes refer to Appendix 7.

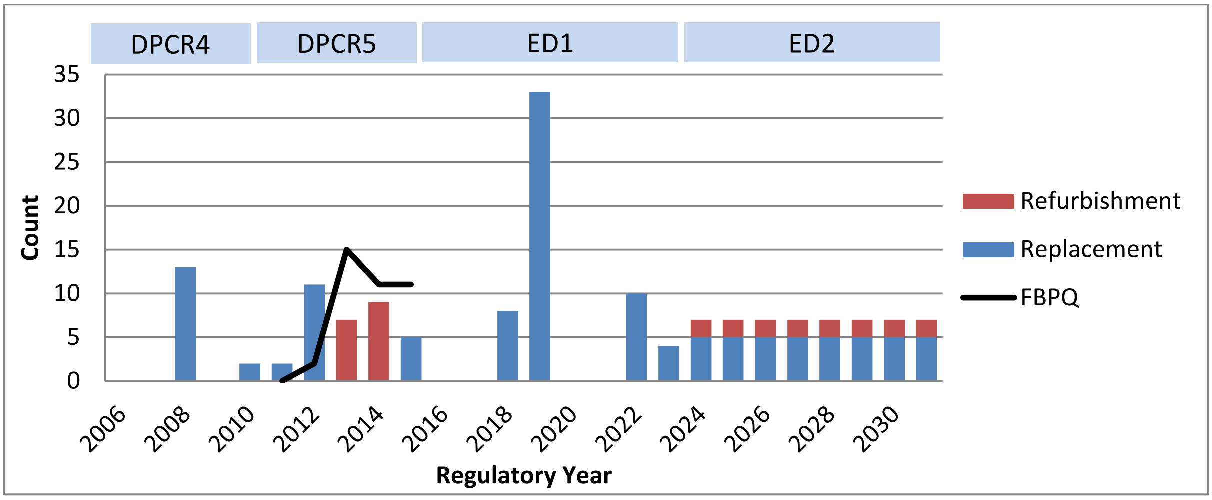


Figure 16 – EHV Switchgear yearly interventions

Source: DPCR5 FBPQ, 2011 to 2013 RIGs, 19th February 2014 S&R NAMP, and Age Based Model

Refer to Figure 17 for EHV Switchgear expenditure during DPCR5 and ED1.

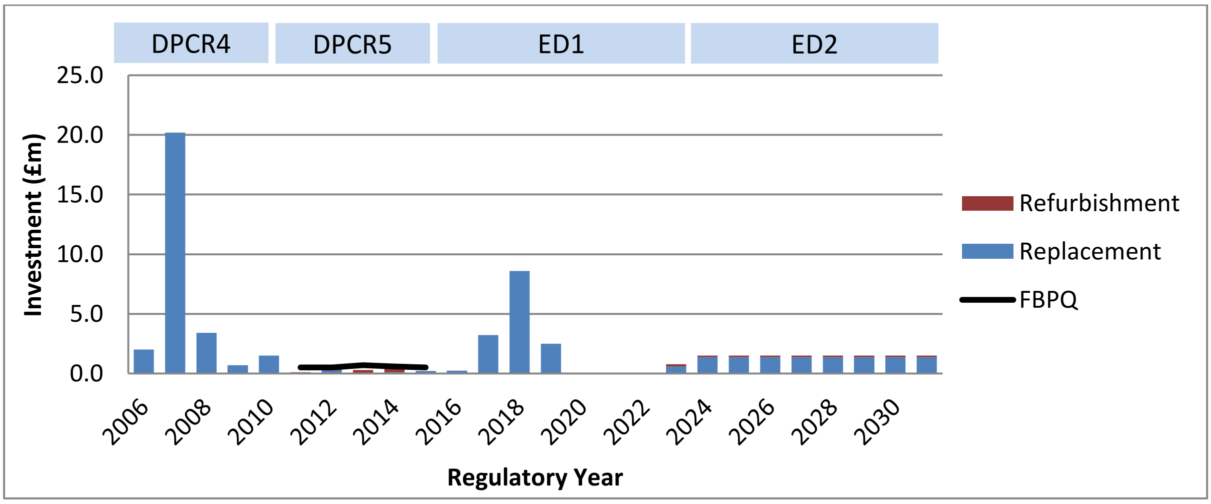


Figure 17 – EHV Switchgear yearly expenditure

Source: DPCR5 FBPQ, 2013 RIGs, 19th February 2014 S&R NAMP, and Age Based Model

Full page versions of Figure 16 and Figure 17 can be found in Appendix 5.

7.5 Commentary

The yearly average number of interventions during DPCR4 was three, and the projected yearly average for DPCR5 is seven items of switchgear. This compares to a yearly average for ED1 of seven items of switchgear. During ED1, there are 45 replacements, 10 disposals and no refurbishments. The large number of replacements in one year is due to a large project at Hackney to replace 33 66kV circuit breakers. The expenditure in the years prior to this is for design work and site set-up costs.

The interventions currently planned for DPCR5 show a reduction of four circuit breakers to those that were forecast in the FBPQ. This is due to a better understanding of asset condition and risk management.

The level of interventions has remained fairly constant between DPCR5 and ED1. This is due to the continued reliability of the Reyrolle L42T and L45T circuit breakers on the 33kV network. The interventions taking place on the 66kV network account for 66% of all the interventions.

The expenditure shows an increase from a yearly average of £0.3m in DPCR5 to £1.9m in ED1, but is a reduction of the DPCR4 yearly average, which was £5.6m. The increase between DPCR5 and ED1 is due to the large project at Hackney to replace 33 66kV circuit breakers with a GIS board, which has higher costs compared to a 33kV switchboard replacement. There are also refurbishments taking place in DPCR5 (which have a lower UCI) that aren’t in ED1 as this refurbishment option is not available on the assets requiring intervention. There is £200k in 2023 for projects that are coming to fruition on ED2.

The ED2 figures shown figure 16 and figure 17 have been derived from age-based modelling. Asset condition and health will be used nearer to ED2 to reassess the volume of interventions required.

7.6 Sensitivity Analysis and Plan Validation

Sensitivity analysis has been carried out on the ARP models to see how changes in the average initial life affect the HI profile.

Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	25.5	34.7	31.0	8.8	0.0
-2	27.8	40.8	22.9	8.4	0.0
-1	28.2	43.9	19.6	8.2	0.0

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	15.1	28.2	37.6	14.5	4.5
-2	21.2	23.5	42.7	10.8	1.8
-1	21.2	25.7	42.0	9.4	1.8

0	28.2	46.7	16.9	8.2	0.0
1	28.2	47.6	15.9	8.2	0.0
2	28.2	51.8	11.8	8.2	0.0
4	28.2	53.3	11.2	7.3	0.0

Table 15 – 2015 Sensitivity Analysis

0	21.2	29.6	41.8	6.5	1.0
1	21.2	35.3	38.8	3.7	1.0
2	21.2	38.8	36.1	3.1	0.8
4	21.2	45.7	31.8	0.8	0.6

Table 16 – 2023 Sensitivity Analysis

Source: Decision Lab Analysis February 2013

In Table 15 and Table 16, each average initial life change of years +/- 1, 2 and 4 are represented as a percentage of the current population. With each change in average initial life, there is a subsequent movement in the percentage of population in each Health Index. An average initial 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 initial life will have on the HI profile.

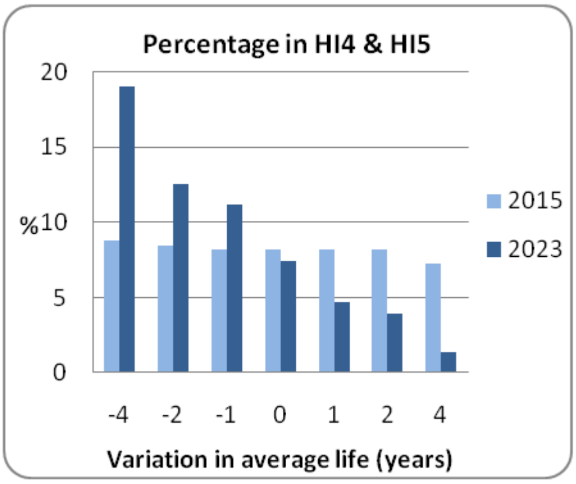


Figure 18 – Total HI4s and HI5s Sensitivity Analysis

Source: Decision Lab Analysis February 2013

Figure 18 represents the number of HI4s and HI5s as a percentage of the population, showing the change at each average initial life iteration, comparing 2015 and 2023.

The analysis shows that the model is sensitive with a difference of 1.5% in the number of HI4s and HI5s in 2015 for a change of eight years in the average initial life. There is a larger difference of 18% in 2023, meaning that the model is more sensitive to changes in average initial life in future years. This is due to the peak of investment that took place in the 1960s. Currently, few problems are being experienced with the Reyrolle L42T and L45T and the average life has been set accordingly. However, reducing the average initial life of these models of switchgear will start to bring them into ED1 as shown in this analysis.

If the average initial lives turn out to be less than assumed in the ARP models the number of interventions required in ED1 will rise by 11.5%. Conversely, if average initial lives in ED1 transpire to be slightly longer than assumed, then the required number of interventions to maintain the same number of HI4 and HI5s in ED1 will drop by 6.1%. Accordingly, the company is carrying more of the risk than customers for uncertainty in the average initial life of these assets in the ED1 regulatory period.

7.7 Model Testing

The ARP model had undergone rigorous testing to ensure it meets 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, and 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 and negative numbers, and included 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 are used in the model, which required testing to ensure correct performance. A test script was created to identify the functional requirement, 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

In order to ensure data presented in the ARP upload files passes into the model correctly, data flow testing has been carried out. The test carries out data counts to check that the number of records input to the model is the same as the number shown in the final model.

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 displays operate correctly and the outputs respond correctly to changes in calibration settings.

7.8 Network Risk

As mentioned in section 4, 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 18 and Table 19 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	
EHV Switchgear	Low	No. CB	27	3	9	1	0	40
	Average	No. CB	42	135	21	26	0	224
	High	No. CB	66	127	43	12	0	248
	Very High	No. CB	9	42	13	3	0	67

Table 17 – 2015 HI and criticality matrix

Source: ARP Model (HI: 25th July 2012, Criticality: 27th November 2012)

Asset categories	Criticality	Units	Estimated asset health and criticality profile 2023					Asset register
			Asset Health Index					2023
			HI1	HI2	HI3	HI4	HI5	
EHV Switchgear	Low	No. CB	15	14	1	9	1	40
	Average	No. CB	40	99	71	2	14	226
	High	No. CB	46	85	102	2	3	238
	Very High	No. CB	9	22	31	5	0	67

Table 18 – 2023 HI and Criticality Matrix

Source: ARP Model (HI: 25th July 2012, Criticality: 27th November 2012)

8.0 Deliverability

The number of interventions taking place during ED1 is in line with those delivered during DPCR5, so resources are available and consideration of network outage issues has taken place during project phasing. A large number of the interventions take place over two years, which has been accounted for.

All projects will be created in the Network Asset Management Plan (NAMP) and this will be used to manage the project portfolio internally.

Appendices

Appendix 1 – Age Profiles

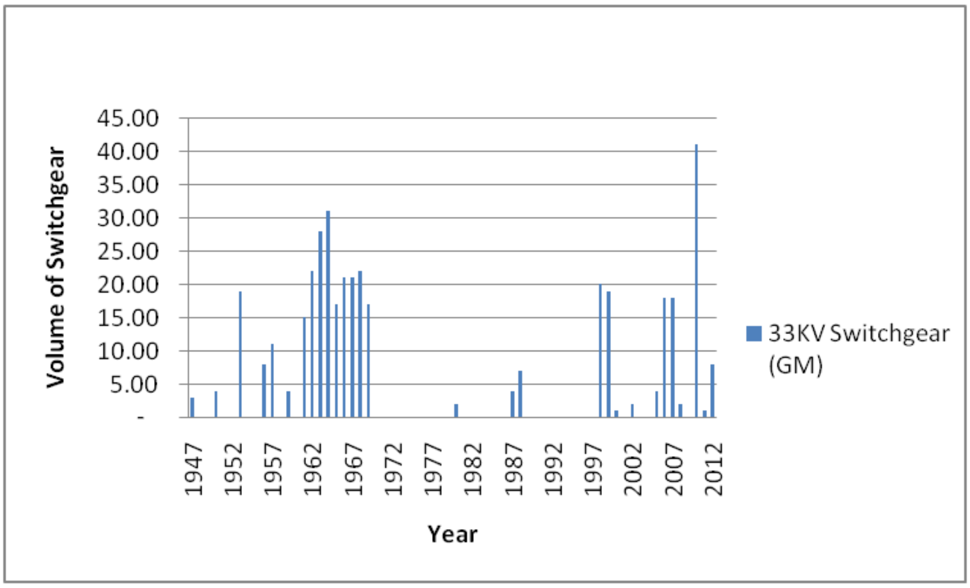


Figure 19 – 33kV Switchgear age profile

Source: 2012 RIGs V5

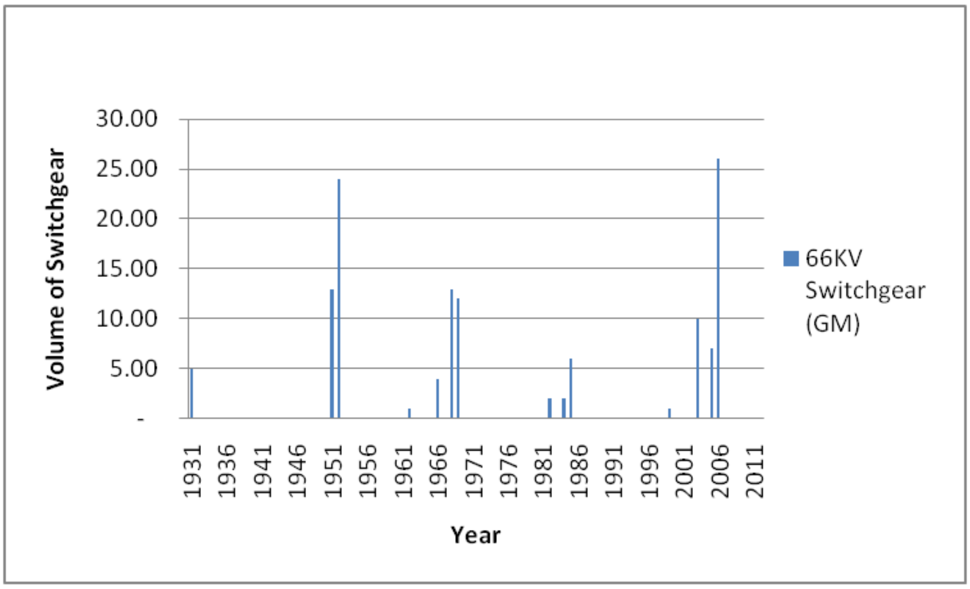


Figure 20 – 66kV Switchgear age profile

Source: 2012 RIGs V5

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	
EHV Switchgear	Low	No. CB	27	3	9	1	0	40
	Average	No. CB	42	135	21	26	0	224
	High	No. CB	66	127	43	12	0	248
	Very High	No. CB	9	42	13	3	0	67

Table 19 – 2015 HI and criticality matrix

Source: ARP Model (HI: 25th July 2012, Criticality: 27th November 2012)

Asset categories	Criticality	Units	Estimated asset health and criticality profile 2023					Asset register
			Asset health index					2023
			HI1	HI2	HI3	HI4	HI5	
EHV Switchgear	Low	No. CB	15	14	1	9	1	40
	Average	No. CB	40	99	71	2	14	226
	High	No. CB	46	85	102	2	3	238
	Very High	No. CB	9	22	31	5	0	67

Table 20 – 2023 HI and criticality matrix

Source: ARP Model (HI: 25th July 2012, Criticality: 27th November 2012)

Appendix 3 – Fault Data

	2007	2008	2009	2010	2011	2012
All faults	15	6	2	1	4	2
Corrosion	0	0	0	0	0	0
Deterioration due to ageing or wear (excluding corrosion)	4	4	2	0	3	0
Deterioration due to ageing or wear (including corrosion)	4	4	2	0	3	0

	2007	2008	2009	2010	2011	2012
All faults	0.0385	0.0154	0.0051	0.0026	0.0103	0.0051
Poor condition due to age and wear	0.0103	0.0103	0.0051	0.0000	0.0077	0.0000

Table 21 – EHV Switchgear Faults data

Source: UKPN Faults cube

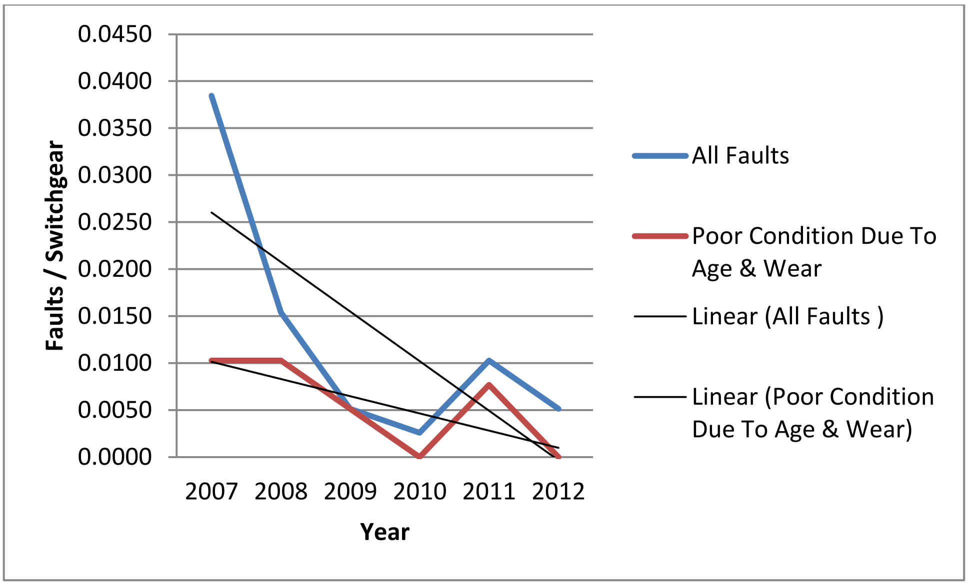


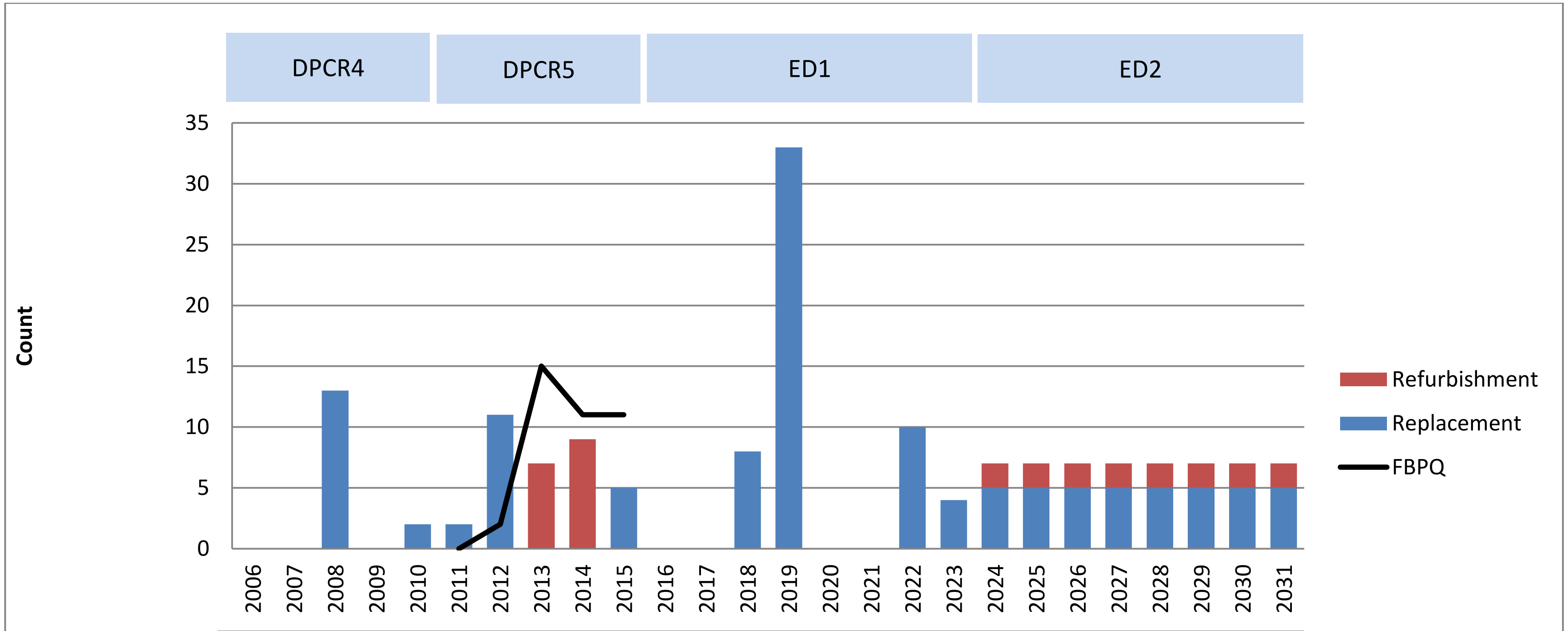
Figure 21 –Fault Rate EHV Switchgear in LPN

Source: UKPN Faults Cube

Appendix 4 – WLC Case Studies

Section not applicable.

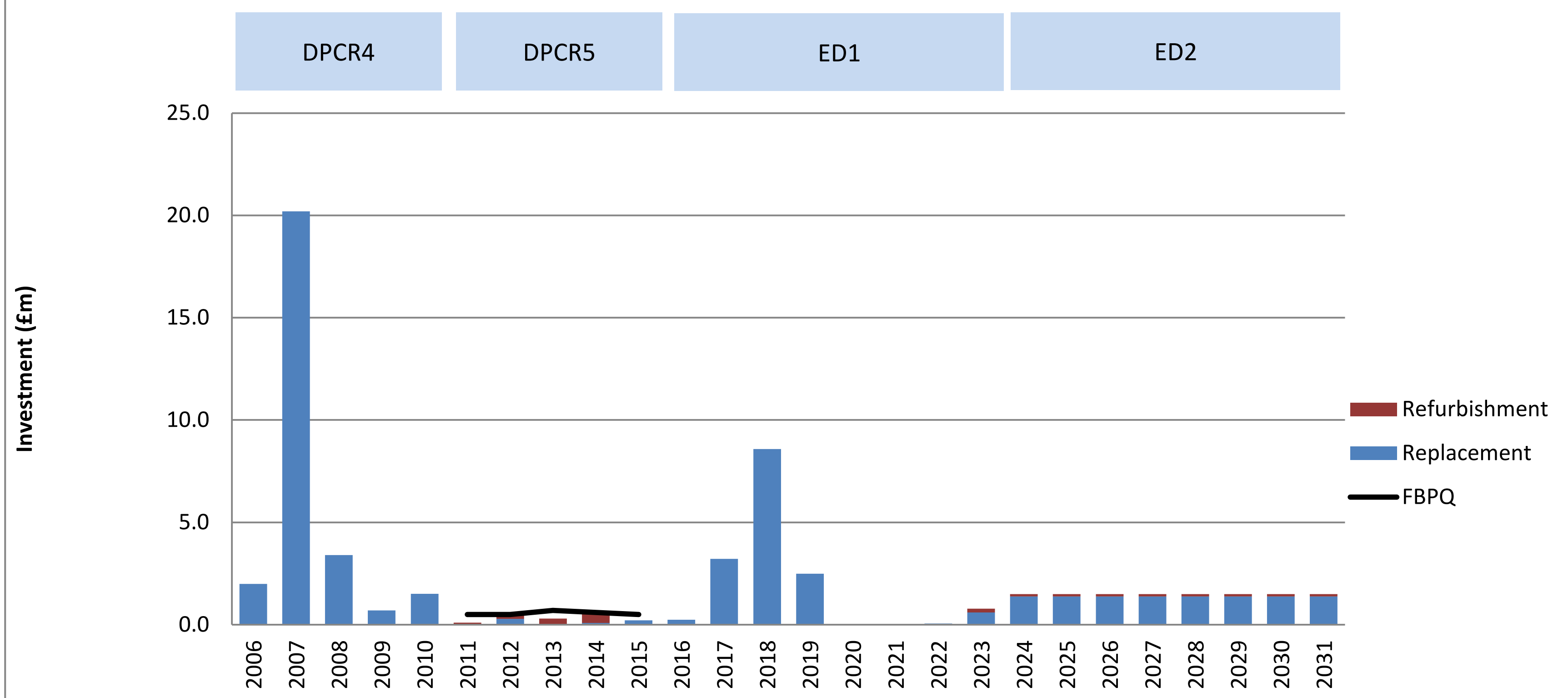
Appendix 5 – NLRE Expenditure Plan



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Refurbishment	0	0	0	0	0	0	0	7	9	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2
Replacement	0	0	13	0	2	2	11	0	0	5	0	0	8	33	0	0	10	4	5	5	5	5	5	5	5	5
FBPQ						0	2	15	11	11																

Figure 22 – EHV Switchgear yearly interventions

Source: DPCR5 FBPQ, 2013 RIGs, 19th February 2014 S&R NAMP, and Age Based Model



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Refurbishment	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Replacement	2.0	20.2	3.4	0.7	1.5	0.0	0.3	0.0	0.1	0.2	0.2	3.2	8.6	2.5	0.0	0.0	0.1	0.6	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
FBPQ						0.5	0.5	0.7	0.6	0.5																

Regulatory Year

Figure 23 - EHV Switchgear yearly expenditure

Source: DPCR5 FBPQ, 2013 RIGs, 19th February 2014 S&R NAMP, and Age Based Model

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Appendix 6 – Sensitivity Analysis

Sensitivity Analysis:

EA Technology's Asset Risk and Prioritisation Model for LPN EHV Switchgear

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 LPN EHV 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 life of assets 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 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 are from 40 to 55 years. In 2012, the current average life values of the population had a mean of 52.1 years. This study covered the full population of LPN EHV 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.

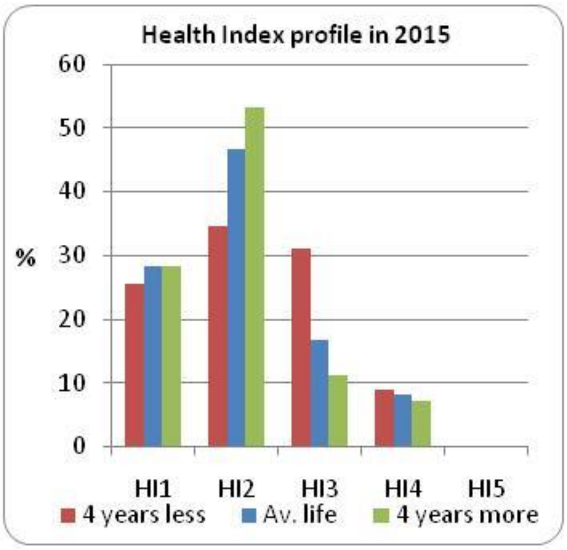
All results are shown below as the percentages of the population.

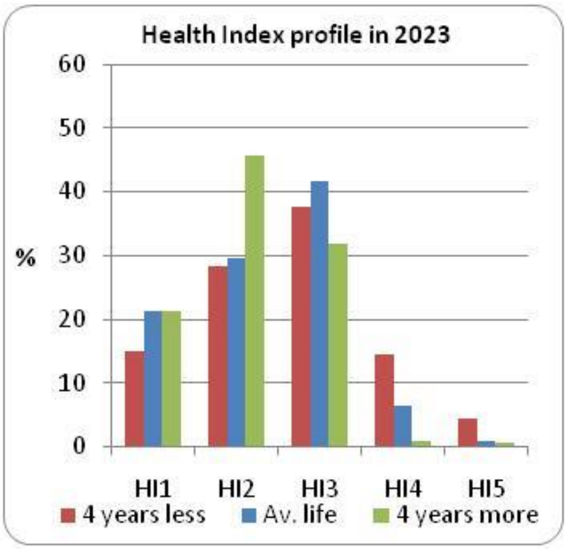
Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	25.5	34.7	31.0	8.8	0.0
-2	27.8	40.8	22.9	8.4	0.0
-1	28.2	43.9	19.6	8.2	0.0
0	28.2	46.7	16.9	8.2	0.0
1	28.2	47.6	15.9	8.2	0.0
2	28.2	51.8	11.8	8.2	0.0
4	28.2	53.3	11.2	7.3	0.0

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	15.1	28.2	37.6	14.5	4.5
-2	21.2	23.5	42.7	10.8	1.8
-1	21.2	25.7	42.0	9.4	1.8
0	21.2	29.6	41.8	6.5	1.0
1	21.2	35.3	38.8	3.7	1.0
2	21.2	38.8	36.1	3.1	0.8
4	21.2	45.7	31.8	0.8	0.6

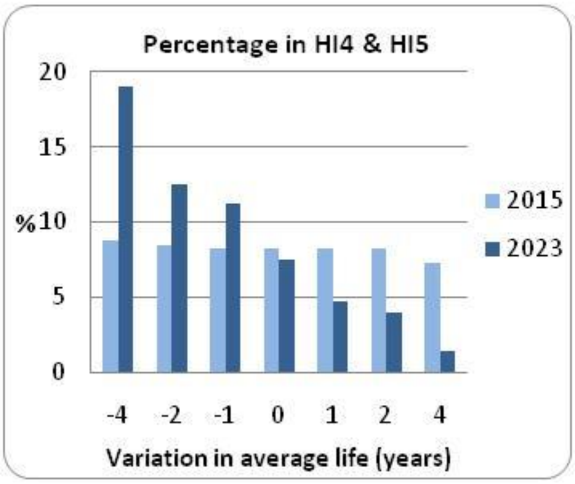
As the percentages above are rounded, the sum of a row may be 0.2% above or below 100%.

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





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



The results show:

- A variation in asset life will affect the proportions of HI4 and HI5 assets in 2015 and 2023.
- In 2015, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 8.2% to 7.3%; but if four years shorter, it will increase to 8.8%.
- In 2023, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 7.5% to 1.4%; but if four years shorter, it will increase to 19.0%.

Conclusion

The ED1 replacement plan for LPN EHV switchgear is 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	Scheme Paper
1.48.01.2589	2589	LPN	Hackney 66kV: Replace Switchgear	AEI OW	33	Yes
1.48.01.2750	2750	LPN	Moscow Rd 66kV: Switchgear asset replacement	AEI OW	2	No
1.48.02.7784	7784	LPN	Willesden B.R. 25kV: Replace 33kV Switchgear	Switchgear and Cowans WB	2	No
1.48.11.2535	2535	LPN	Acton Lane 22kV: Circuit breaker replacement	Ferguson and Palin VDP	4	No
1.48.11.7785	7785	LPN	Grove Lodge 33kV: Replace 33kV Switchgear	South Wales Switchgear EO1	4	No
1.51.01.8964	8964	LPN	Deptford 22kV - decommissioning of transformers and switchgear	Reyrolle L42T	10	No

Table 22 – EHV Switchgear Named Schemes

Source: 19th February NAMP 2014 Table J Less Indirect

Appendix 8 – Output NAMP/ED1 Business Plan Data Tables 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**	RIGs Table	RIGs Row	2015 /16	2016 /17	2017 /18	2018 /19	2019 /20	2020 /21	2021 /22	2022 /23	**Total**
											CV3	197	0	0	2	0	0	0	0	0	**2**
	1.48.02										CV3	198	0	0	4	0	0	0	0	0	**4**
	1.48.09										CV3	199	0	0	0	0	0	0	10	4	**14**
EHV Switchgear Removals	1.48.11	0	0	8	33	0	0	10	4	55	CV3	200	0	0	0	0	0	0	0	0	**0**
	1.48.12										CV3	205	0	0	0	0	0	0	0	0	**0**
	1.48.13										CV3	206	0	0	2	33	0	0	0	0	**35**
	1.51.01										CV3	207	0	0	0	0	0	0	0	0	**0**
											CV3	208	0	0	0	0	0	0	0	0	**0**
EHV Switchgear Refurbishment	1.55.02	0	0	0	0	0	0	0	0	0	CV5	33	0	0	0	0	0	0	0	0	**0**
											CV5	43	0	0	0	0	0	0	0	0	**0**
Total		**0**	**0**	**8**	**33**	**0**	**0**	**10**	**4**	**55**			**0**	**0**	**8**	**33**	**0**	**0**	**10**	**4**	**55**

Table 23 - NAMP to ED1 Business Plan Data Table Reconciliation

Source: 19th February 2014 NAMP Table J less indirects and 21st February 2014 ED1 Business Plan Data Tables

Appendix 9 – Efficiency Benchmarking with other DNOs

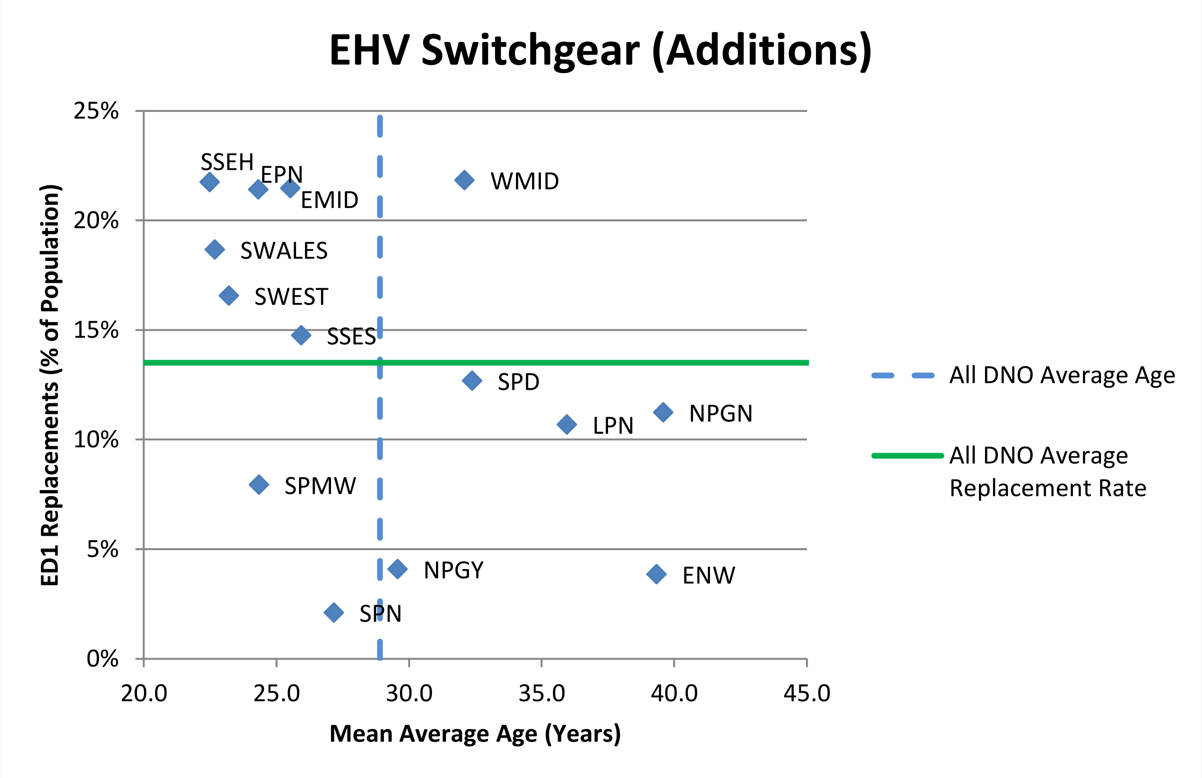


Figure 24 – Efficiency Benchmarking

Source: DNO Datashare_2013

The graph above shows the LPN percentage of the population replaced during ED1 is less than the industry average. The LPN switchgear is also older than the industry average. This low replacement rate is possible despite the higher than average age is possible due mainly to the continued reliability of Reyrolle L42T circuit breakers, which account for a large proportion of the 33kV switchgear population.

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
33kV CB (Gas Insulated Busbars)(ID) (GM)	Replace	Volumes (Additions)	4	4	0	Scheme reclassified as NLRE rather than LRE
		Volumes (Removals)	4	14	10	
		Investment (£m)	0.357	0.365	0.008	
		UCI (£k)	89.3	91.1	0.8	
33kV Switch (GM)	Replace	Volumes (Additions)	12	0	(12)	Volumes moved to 33kV Switchgear (Other) line
		Volumes (Removals)	0	0	0	
		Investment (£m)	0.15	0	(0.15)	
		UCI (£k)	12.7	0	(12.7)	
33kV Switchgear (Other)	Replace	Volumes (Additions)	0	12	12	Volumes moved from 33kV Switch (GM) line and removal
		Volumes (Removals)	0	10	10	

		Investment (£m)	-1.49	0.18	1.67	volumes added
		UCI (£k)	-	15.3	15.3	
66kV CB (Air Insulated Busbars)(OD) (GM)	Replace	Volumes (Additions)	21	21	0	Costs moved from 132kV CB line to 66kV CB line
		Volumes (Removals)	35	35	0	
		Investment (£m)	6.83	6.95	0.12	
		UCI (£k)	325.3	331.1	7.8	

Table 24 - Material Changes to July 2013 ED1 Submission (CV3)

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

33kV CB (Gas Insulated Busbars)(ID)(GM)
As part of the ED1 scheme at Neckinger, the current 22/11kV transformers at the site are being replaced with 132/11kV transformers. Following the replacement the site will be supplied from New Cross 132kV rather than Deptford West 22kV. As Neckinger is the only site that is fed from Deptford West 22kV the 10 circuit breakers at the site will become redundant and can be removed from the network. In the 2013 submission the circuit breakers were included in the LRE submission, however because the driver for the Neckinger scheme is condition they have been moved to NLRE.

33kV Switch (GM) & 33kV Switchgear (other)
The volumes and costs on the 33kV Switch (GM) line in the July submission were incorrectly mapped to this line and as a result of Ofgem question Ph1-146 were moved to the 33kV Switchgear (other) line. As part of this question removal volumes were also add. The negative expenditure in the July 13 submission represented the savings expected as part of partial discharge monitoring. As part of Ofgem question Ph1-82 this was moved to the 6.6/11kV Transformer (GM) line.

66kV CB (Air Insulated Busbars)(OD) (GM)
This expenditure increase are costs mapped incorrectly to the 132kV CB (Air Insulated Busbars)(OD) (GM) line in the July 13 submission moving to the 66kV CB (Air Insulated Busbars)(OD) (GM) line. The costs relate to the 66kV switchgear replacement at Hackney and where moved following Ofgem question Ph1-14.The following Ofgem questions were answered relating to EHV Switchgear:

- Ph1-14
- Ph1-82
- Ph1-84
- Ph1-146