Document 6
Asset Category – EHV Switchgear
EPN

Asset Stewardship Report 2014

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Document History

Version	Date	Details	Originator	Revision Class	Section Update
1.0	20/02/2014	July 2013 Submission	Richard Gould		
1.1	20/02/2014	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	20/02/2014	Updated Appendix 7 with list of scheme papers and added Appendices 8-10	Richard Gould	Minor	1.1, Appendix 7, 8, 9, 10
1.3	24/02/2014	Updated HI Profiles and added Preface	Richard Gould	Minor	7.2, 7.8, Appendix 2
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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 Table Reconciliation:** This section explains the 'line of sight' between the UKPN Network Asset Management Plan (NAMP) 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 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 1,426 items of EHV Switchgear with an estimated MEAV of £178m. The proposed investment including civils is £4.0m per annum, which equates to an average annual 2.2% 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	£19.7m	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 – 33kV Switch CV3 Row 74 – 33kV Switchgear other 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)
Replacement	£0.6	1.48	CV105

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, and not items of switchgear that are old. Older assets can remain on the network operating effectively due to no defects being recorded against them (refer to Figure 6).

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 255 replacements and no refurbishments across the eight years. This is a similar level of investment compared to that of DPCR5, which, when adjusted for an eight-year period, had 272 replacements and three refurbishments.

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 current and future Health Index for every 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 instead of replacement on 5% of plan.	(0.9)
Risk	The average initial life used in ARP model is over-optimistic, leading to an increase of 3.6% in the total number of HI4s and HI5s (Section 7) and more interventions are required.	6.5
Opportunity	The average initial life used in ARP model is under-optimistic, leading to a decrease of 3.4% in the total number of HI4s and HI5s (Section 7) and less interventions are required.	(6.1)

Table 2 – Risks and opportunities

2.0 Description of EHV Switchgear Population

2.1 33kV and 25kV Switchgear

There are 1,410 circuit breakers, ring main units and ground-mounted switches currently operating at 33kV on the network. These are distributed across 236 substation sites, with 703 units installed at indoor locations and 707 at outdoor locations. There are also 16 circuit breakers operating at 25kV across 10 sites. In total, 1,426 circuit breakers are split into three categories of switchgear (refer to Table 4).

Switchgear arc extinction method	Population
Oil	562
SF_6	184
Vacuum	680

Table 3 – EHV Switchgear type

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, meaning a large proportion of the population is approaching end of life. The average age is 26 years. The majority of the 1960s switchgear is located outdoors. The oldest 10% of these assets have an average age of 53 years.

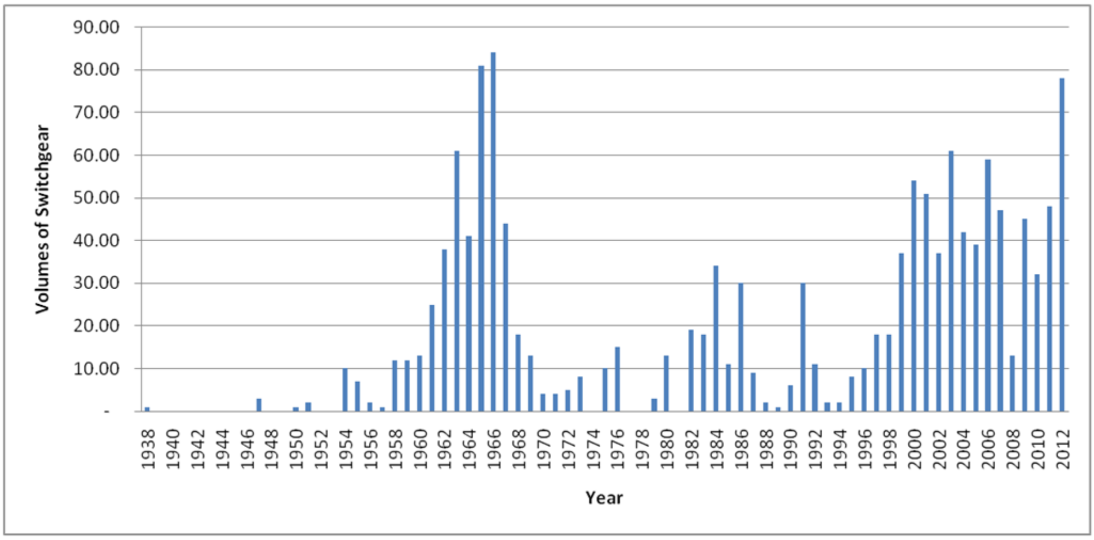


Figure 1 – EHV Switchgear age profile

Source: 2012 RIGs V5

The NAMP lines used for EHV 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

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

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.

Figure 2 – Poor-condition support structure

As mentioned in section 2, there are a large number of outdoor circuit breakers installed on the network pre-1970. There is an increasing amount of problems with this type of circuit breaker.

The Switchgear and Cowans K30 oil circuit breaker is an outdoor free-standing fixed circuit breaker. There are currently 66 installed on the network at eight substation sites.

Figure 3 – Switchgear and Cowans K30 circuit breaker

In recent years, there have been five cases of this model of breaker either failing to trip or not operating within the required time. This results in the upstream protection operating, and has the potential to cause more customers to lose supply. This problem is caused because it is difficult to gain effective access to the operating mechanism to apply lubrication and so there is a build-up of material on the mechanism between maintenances (refer to Figure 4).

Figure 4 – Switchgear and Cowans K30 mechanism

This has already led to there being shorter periods between mechanism maintenance on this model of circuit breaker; although this has helped ease the problem, it has not solved it. Figure 5 shows the data recorded in Ellipse against 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.

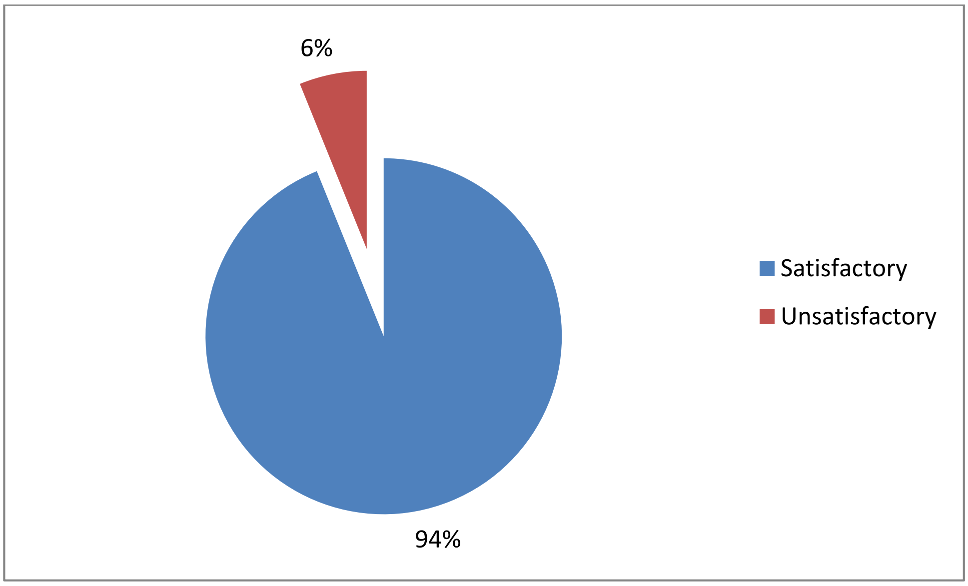


Figure 5 – Switchgear and Cowans K30 circuit breaker operation

The circuit breaker also contains asbestos, which is a risk that needs to be carefully managed during the life of the asset.

As mentioned at the start of this section, due to the type of circuit breaker, the condition of the support structures will also be considered as a driver for intervention. The proposed expenditure profile during ED1 will replace 52 of this model of breaker, with 14 remaining at the end of the period.

Another model of circuit breaker that has experienced problems in recent years is the South Wales Switchgear ET outdoor withdrawable oil circuit breaker. The switchgear has air-insulated busbars with a circuit breaker that racks out vertically downwards. There are currently 67 of this model of circuit breaker on the network at seven different sites.

The switchgear has known problems with the shutter and racking operating mechanism, which poses a safety risk to operators of the switchgear. The circuit breaker uses electric motors to rack it into position and there is a complex interlocking system to ensure that the circuit breaker can only be racked out when it is safe to do so. Due to its complexity, the racking shaft shear pins can easily fail following incorrect use of the interlocking systems. This can lead to the sheet steel shutters failing to open, and so being pushed up into the live busbar chamber above. There is currently a special operating condition, SOC-113-E, recorded against each circuit breaker of this type on the network in the operational diagram advising care during operations. By the end of ED1, it is proposed that there will be no circuit breaker of this type remaining on the network.

A number of switchgear defects 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 7 – 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 a defective gasket. No action is needed immediately, but, if left unchecked, this 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 is used to show 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, which, if left unchecked, 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.

The ages of assets when new defects were reported on them are shown in Figure 6. There are defects recorded at ages where there are currently no assets because 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 old. There are very few defects on assets less than 20 years old, despite this age range containing a large 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.

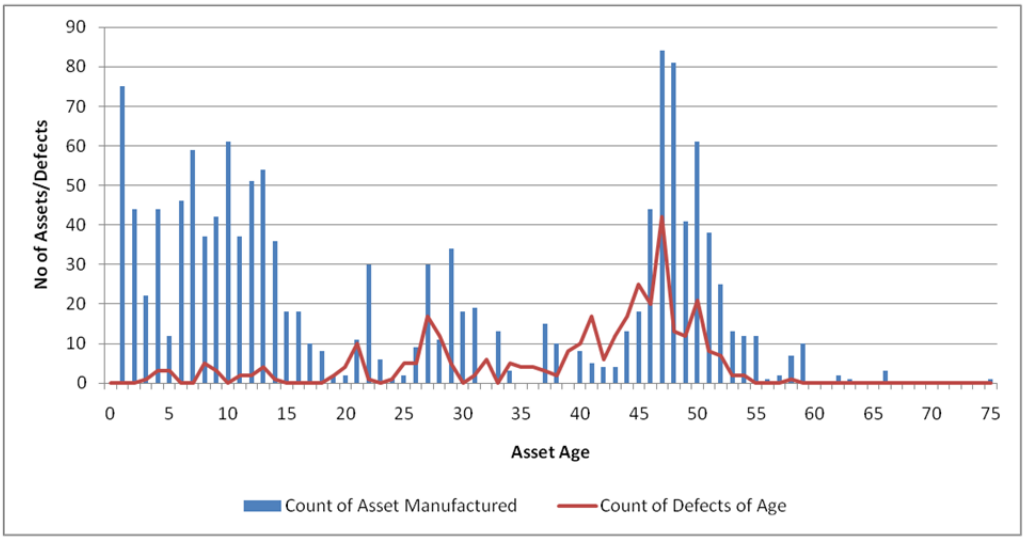


Figure 6 – Defects by asset age

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

Figure 7 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. However, with the ageing population and expected increase in the number of defects, there is potential for the fault level to increase unless the current level of investment is maintained.

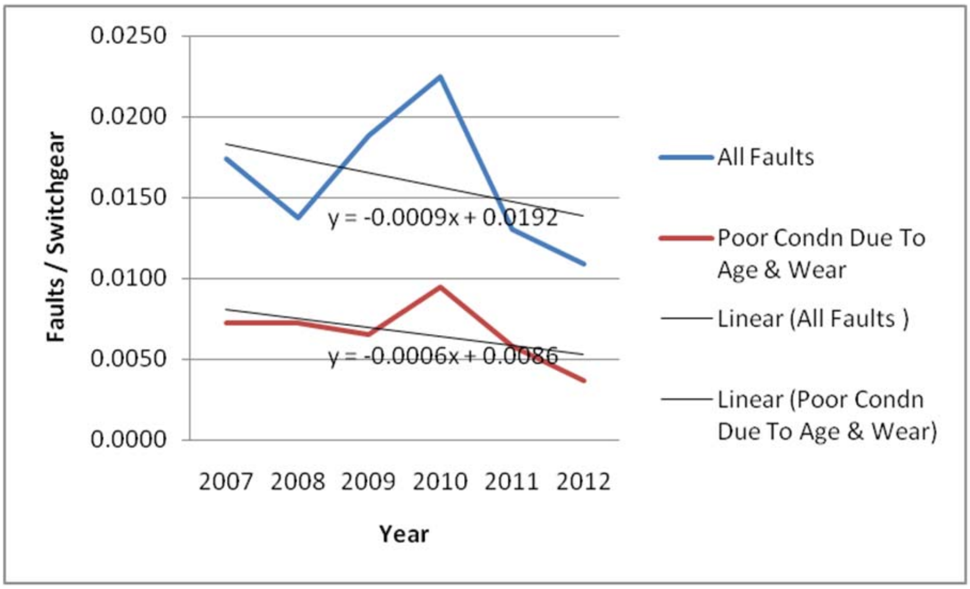


Figure 7 – EHV Switchgear fault rate

Source: UK Power Networks Fault Analysis Cube

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 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 to record it 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 full maintenance. The two maintenance tasks are carried out alternatively in six-year intervals, 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 two years for feeder breakers.

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’.

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 based on 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 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 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 than 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 of different types of insulation 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 four failure modes (refer to Table 8). The effect of risk can be seen in section 7.8.

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

Table 8 – Network risk failure modes

Although no repair is needed in 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 greater 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 enabling continual improvement of data quality.

An example of this is the circuit breaker trip times that are used in the model. These values have to be between 10 and 1,000ms, otherwise they are discarded 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 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. For the latest results of the data used in the EHV switchgear model, refer to Table 9.

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	79%
Accuracy	89%
Timeliness	96%

Table 9 – 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 the nameplate completeness during DPCR5. As with the nameplate information, there has also 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*.

It should be noted that any missing condition or defect data will cause an under-reporting in the number of assets requiring intervention during ED1, and therefore the risk will be with UK Power Networks, rather than the customer.

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 10.

Option	Description	Advantages	Disadvantages
Outdoor AIS solution	This option uses outdoor circuit breakers, for example the Hawker Siddeley Switchgear Horizon (refer to Figure 9). Existing outdoor busbars can be reused, depending on the condition.	Cheaper than indoor solution. Can reuse existing busbar. Replacement of individual circuit breakers is possible.	Requires a lot of space. Can't always reuse busbar due to poor-condition support structures. Prone to deterioration as located 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 10). 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 10 – Replacement options

Figure 9 – Hawker Siddeley Switchgear Horizon

Figure 10 – ABB ZX1.2 switchboard

5.2 Policies: Selecting Preferred Interventions

The process used for selecting interventions can be seen in Figure 11. The process is different depending on whether the switchgear is part of a switchboard or a standalone unit.

If the switchgear is part of a switchboard, then 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 they 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.

Although refurbishment was considered, there isn't any in the ED1 plan as it was not economical to use it on the assets that required intervention.

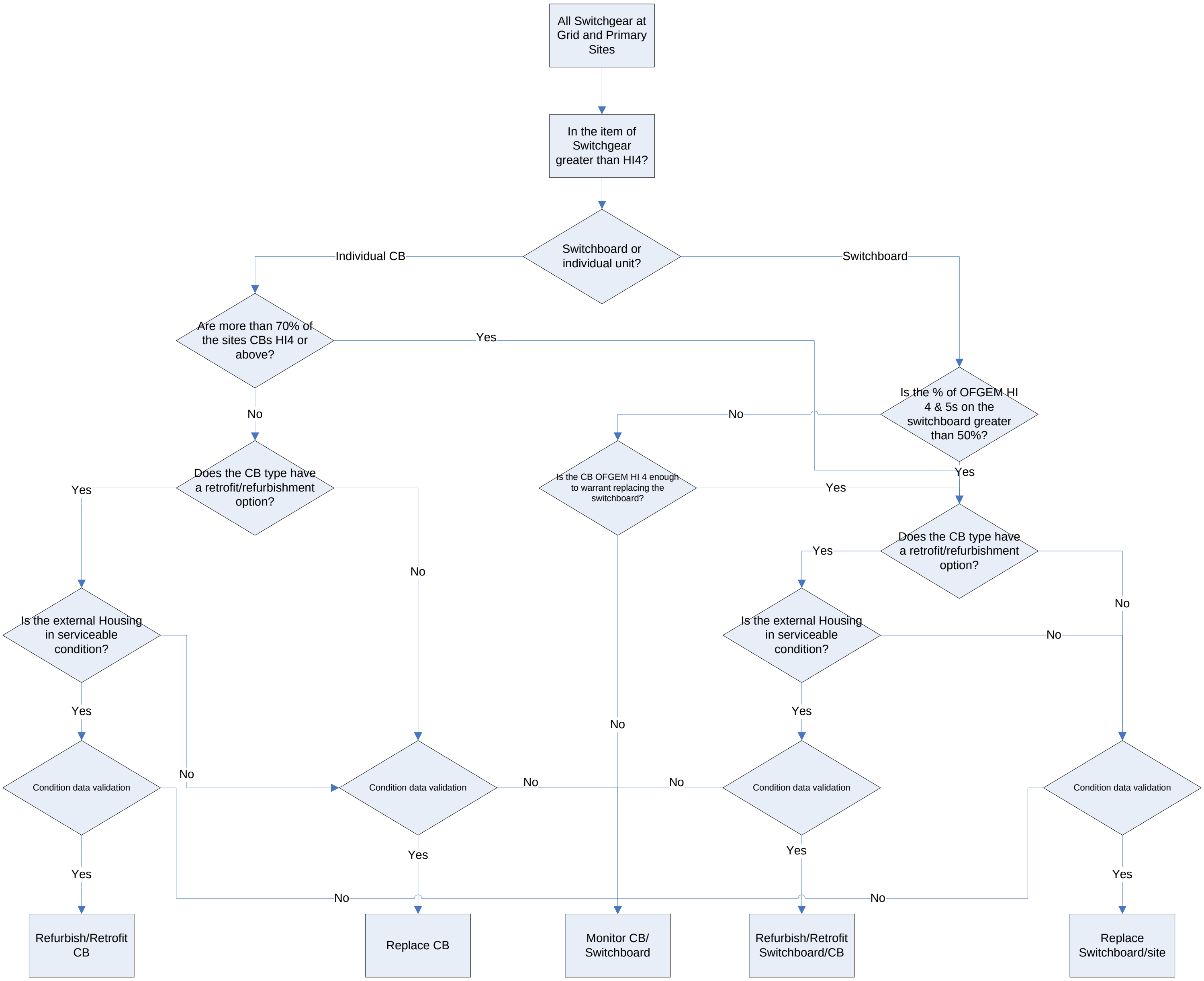


Figure 11 – Intervention strategy process

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

Figure 12 shows the cost of maintenance over a 58-year period, which is the average asset life of an asset across all of UK Power Networks. The figure would be lower if EPN was considered on its own due to a larger proportion of the switchgear being located outdoors and therefore having a shorter expected life compared to the other 2 licence areas (refer to section 8 of *Commentary Document 15: Model Overview* for an explanation of average life). The maintenance costs of oil circuit breakers are eight times more than those of an SF_6/vacuum outdoor circuit breaker. Oil circuit breakers account for 90% of the replacements during ED1.

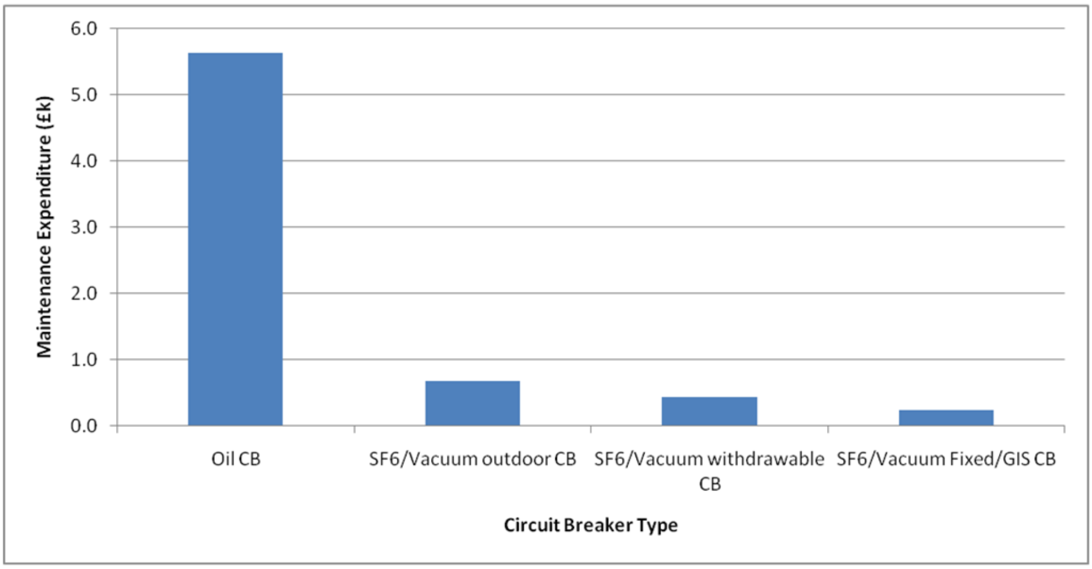


Figure 12 – EHV Switchgear maintenance costs

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.

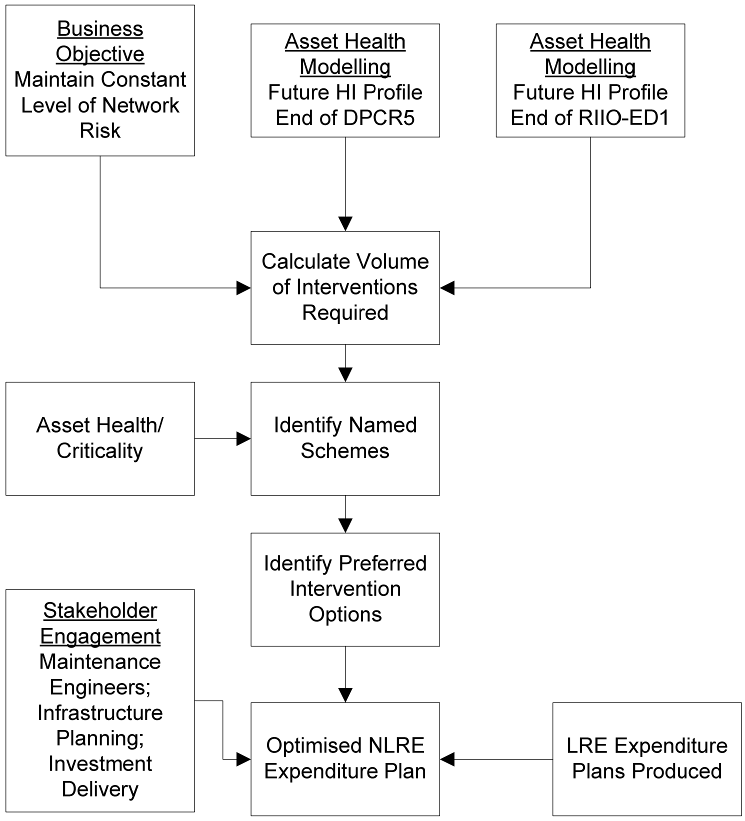


Figure 13 – Programme development methodology

7.2 Constructing the Plan

The overall strategy for non-load related expenditure on EHV Switchgear during ED1 has been to maintain the same level of risk at the end of the period as at the beginning. This is achieved by keeping the sum of HI4s and HI5s broadly the same at the beginning and end of the period. The HI profiles are outputs from the ARP model. The HI profiles for the start and end of ED1 can be seen in Figure 14.

At the start of the period, the sum of HI4s and HI5s is 17% of the total population, which is similar to the figure of 16% 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.

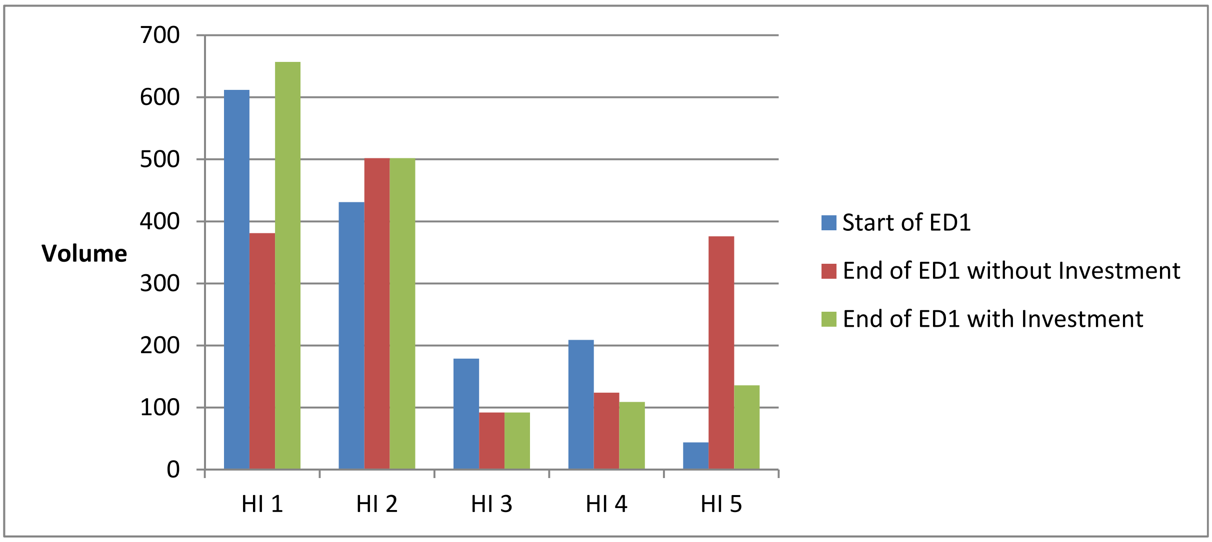


Figure 14 – ED1 HI profiles

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.

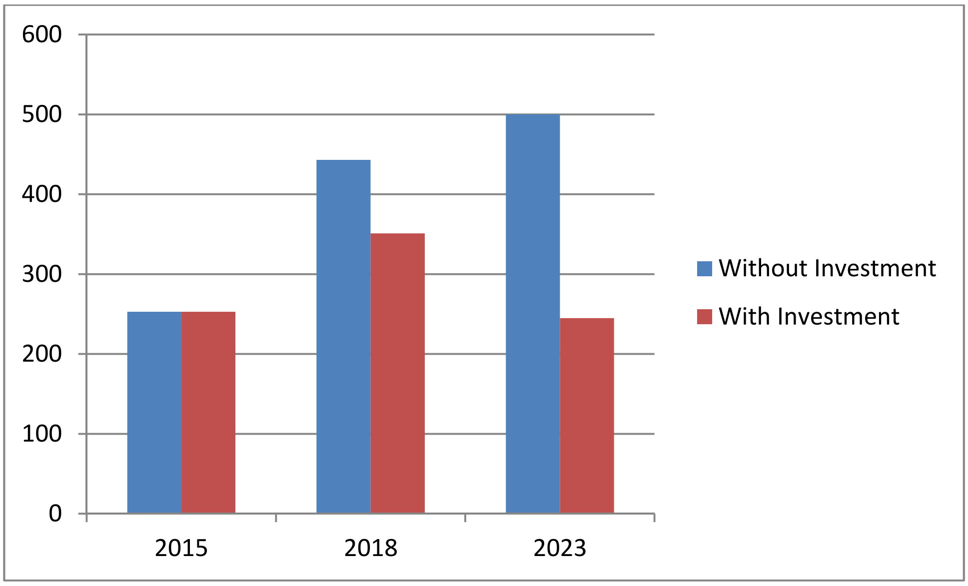


Figure 15 – Total number of HI4 and HI5s

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 at sites. If these schemes are within five years of the EHV Switchgear scheme, consideration has been given to whether cost efficiencies are possible through combining the schemes. This could mean that site establishment (CDM) costs are reduced and project administration can be combined, and there is the possibility of combining network outages.

Any LRE requirements at the 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.

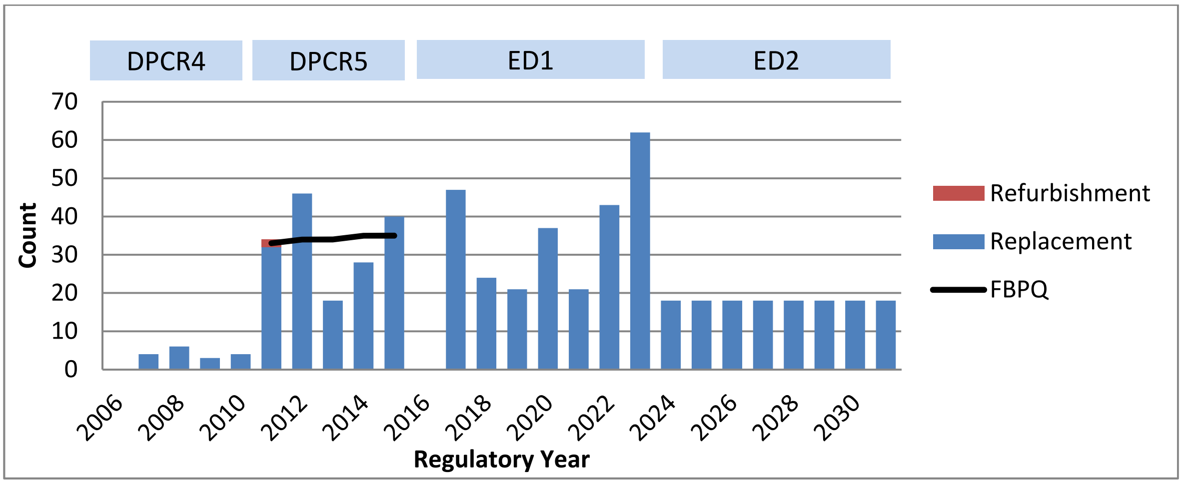


Figure 16 – Yearly EHV Switchgear interventions

Source: DPCR5 FBPQ, 2013 RIGs, 19h February 2014 S&R NAMP, and SARM Statistical Model

The volume of interventions for DPCR5 is the same as submitted in the FBPQ. Refer to Figure 18 for EHV Switchgear expenditure during DPCR4, DPCR5, ED1 and ED2.

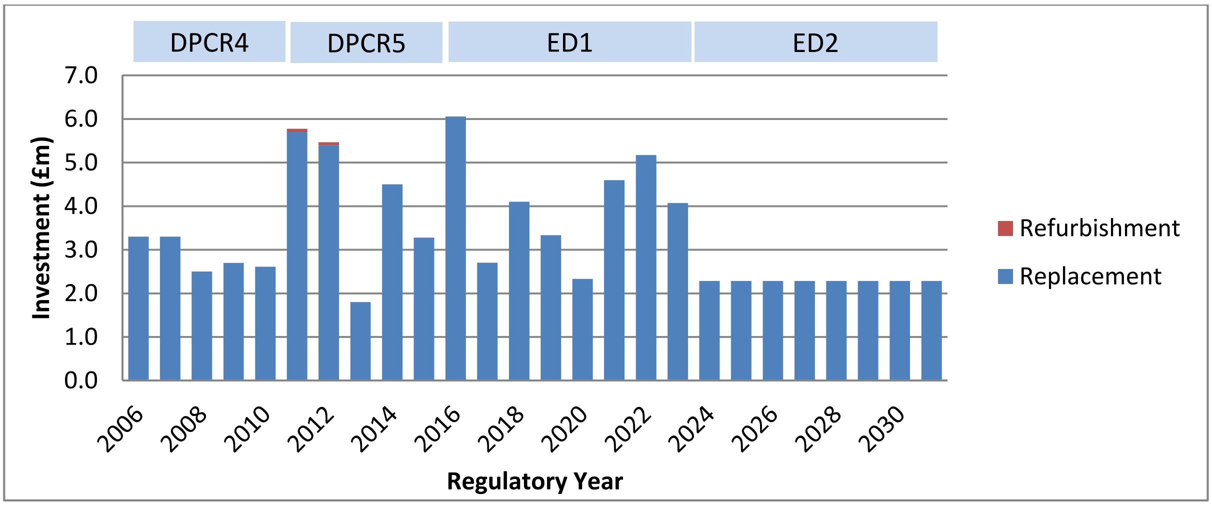


Figure 17 – EHV Switchgear yearly expenditure

Source: DPCR5 FBPQ, 2013 RIGs, 19th February 2014 S&R NAMP, and SARM Statistical Mode

The expenditure seen in 2016 is to finish projects where the volumes were delivered in 2015 and to start projects that will be delivered in 2017. Full page versions of Figure 15 and Figure 16 can be found in Appendix 5.

7.5 Commentary

The yearly average has been used to compare the number of interventions between periods. The yearly average during DPCR4 was three items of switchgear and during DPCR5 is 33, compared to a yearly average for ED1 of 32 items of switchgear. This shows a broadly consistent number of interventions per year between DPCR5 and ED1. As shown in figure 7, the fault rate of EHV Switchgear has remained broadly flat over the last years, so maintaining the same level of investment as DPCR5 should see the fault rate remain stable.

The expenditure follows a similar pattern to the number of interventions, with an increase from DPCR4 being seen in DPCR5, and ED1 remaining at a similar level.

The ED2 figures shown in 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

An independent report has been carried out by Decision Lab to understand how the Health Index profile of assets may change if the average initial life of assets does not turn out as predicted. This analysis was carried out in February 2013.

Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	41.6	25.2	14.6	15.1	3.5
-2	42.7	25.7	13.2	15.1	3.3
-1	42.9	25.8	13.1	14.9	3.2
0	43.3	26.2	12.7	14.8	3.1
1	44.0	26.3	12.0	14.9	2.8
2	45.2	26.0	11.2	14.8	2.8
4	45.7	26.1	12.1	13.6	2.5

Table 11 – 2015 sensitivity analysis

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	39.8	33.5	8.2	4.5	14.0
-2	43.3	32.9	6.6	5.3	11.9
-1	43.7	33.6	6.9	5.1	10.7
0	44.3	34.3	6.4	4.7	10.2
1	45.2	34.6	6.3	4.5	9.5
2	45.4	34.8	6.5	4.1	9.3
4	48.8	32.5	7.5	2.4	8.8

Table 12 – 2023 sensitivity analysis

Source: Decision Lab Analysis February 2013

In Table 11 and Table 12, 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.

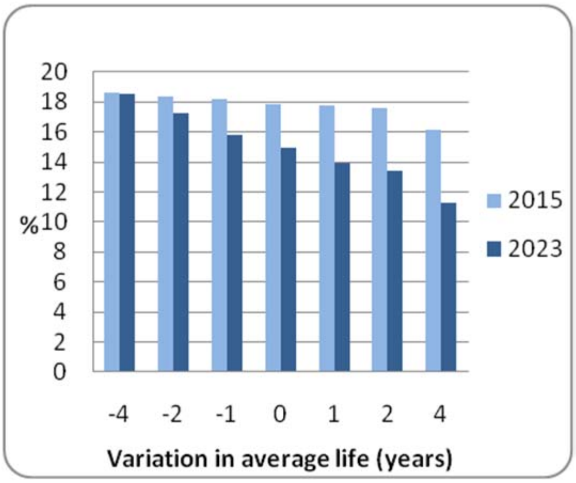


Figure 18 – Total HI4 and HI5s sensitivity analysis

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 and comparing 2015 with 2023.

The analysis shows that the model is mildly sensitive, with a difference of just 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 slightly larger difference of 7.2% in 2023, meaning that the model is more sensitive to changes in average initial life in future years.

7.7 Model Testing

The ARP model has 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 13 and Table 14 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	416	225	108	95	24	868
	Average	No. CB	139	148	49	84	17	437
	High	No. CB	29	25	10	16	2	82
	Very High	No. CB	28	33	12	14	1	88

Table 13 – 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	396	302	41	73	56	868
	Average	No. CB	193	130	42	25	68	458
	High	No. CB	25	43	0	3	11	82
	Very High	No. CB	43	27	9	8	1	88

Table 14 – 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.

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

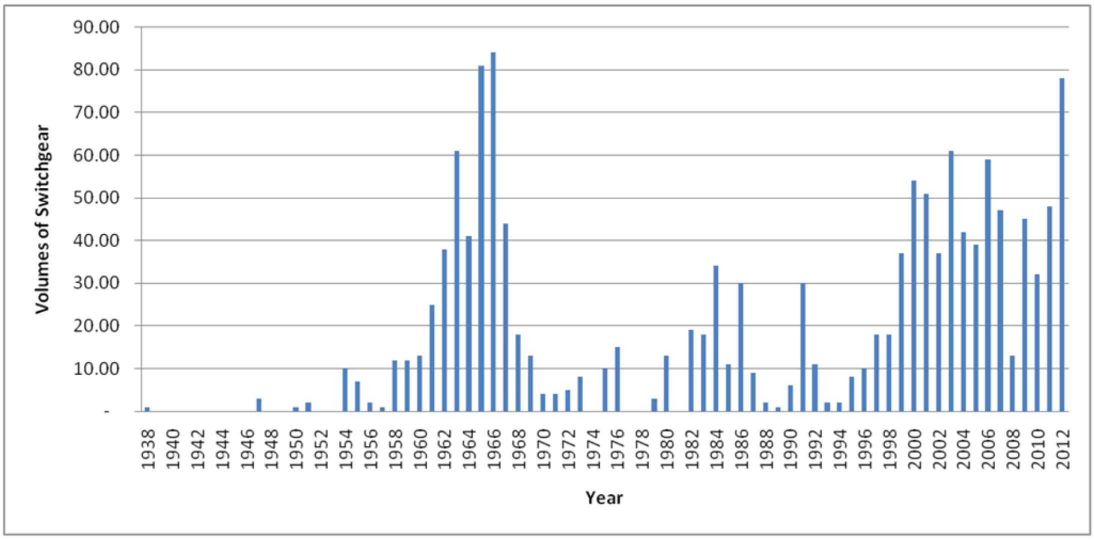


Figure 19 – EHV Switchgear age profile

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	416	225	108	95	24	868
	Average	No. CB	139	148	49	84	17	437
	High	No. CB	29	25	10	16	2	82
	Very High	No. CB	28	33	12	14	1	88

Table 2 – 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	396	302	41	73	56	868
	Average	No. CB	193	130	42	25	68	458
	High	No. CB	25	43	0	3	11	82
	Very High	No. CB	43	27	9	8	1	88

Table 16 – 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	**24**	**19**	**26**	**31**	**18**	**15**
Corrosion	0	0	0	0	0	0
Deterioration due to ageing or wear (excluding corrosion)	**10**	**10**	**9**	**13**	**8**	**5**
Deterioration due to ageing or wear (including corrosion)	10	10	9	13	8	5

	2007	2008	2009	2010	2011	2012
All faults	0.0174	0.0138	0.0188	0.0225	0.0130	0.0109
Poor condition due to age and wear	0.0072	0.0072	0.0065	0.0094	0.0058	0.0036

Table 17 – EHV Switchgear Faults data

Source: UKPN Faults cube

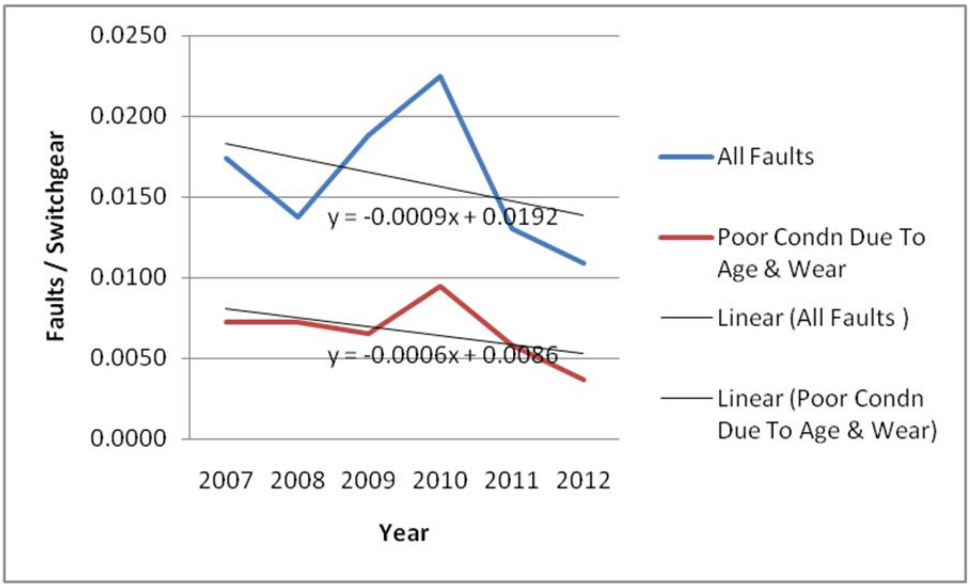


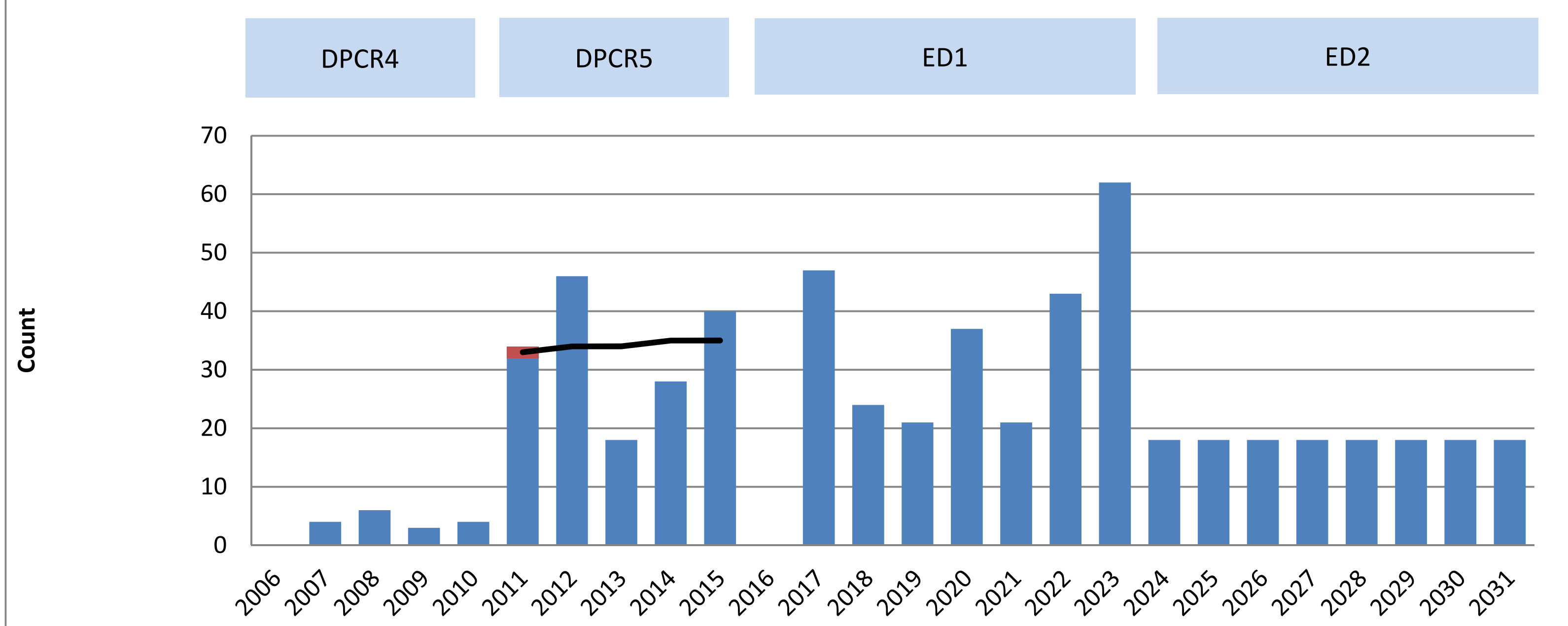
Figure 20 –Fault Rate EHV Switchgear in EPN

Source: UKPN Faults Cube

Appendix 4 – WLC Case Studies

Section not applicable.

Appendix 5 – NLRE Expenditure Plan

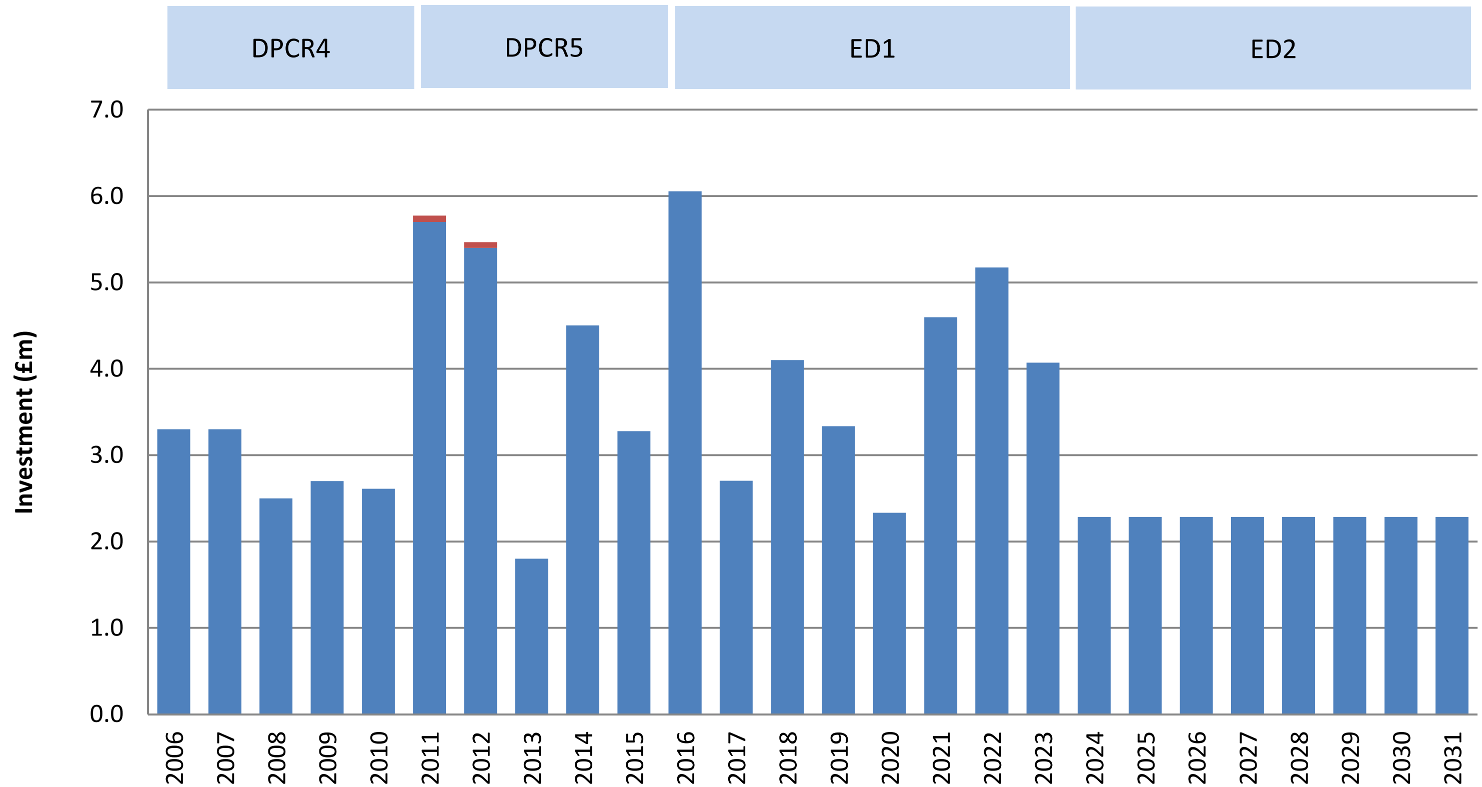


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Refurbishment	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Replacement	0	4	6	3	4	32	46	18	28	40	0	47	24	21	37	21	43	62	18	18	18	18	18	18	18	18
FBPQ						33	34	34	35	35																

Regulatory Year

Figure 21 – 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	0.1	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	0.0	0.0	0.0	0.0
Replacement	3.3	3.3	2.5	2.7	2.6	5.7	5.4	1.8	4.5	3.3	6.1	2.7	4.1	3.3	2.3	4.6	5.2	4.1	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3

Figure 22 - EHV Switchgear yearly expenditure

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

Appendix 6 – Sensitivity Analysis

Sensitivity Analysis:

Asset Risk and Prioritisation Model for EPN EHV 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 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 25 to 55 years. In 2012, the current average life values of the population had a mean of 45.6 years. This study covered the full population of EPN 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.

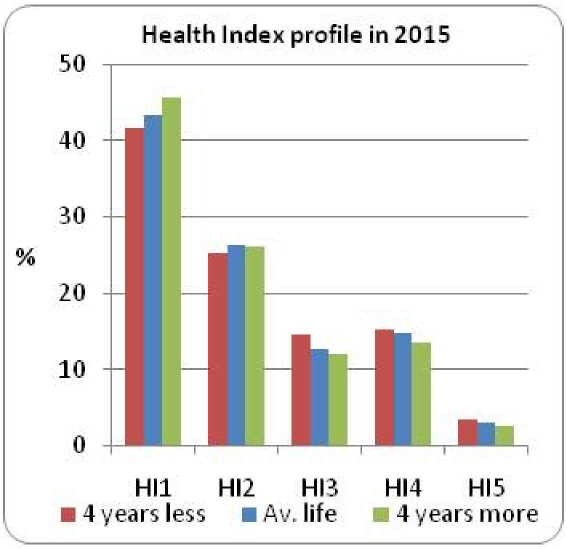
All results are shown below as the percentages of the population.

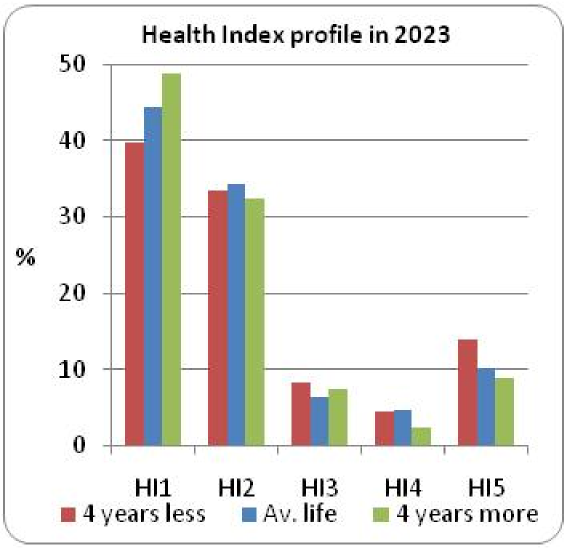
Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	41.6	25.2	14.6	15.1	3.5
-2	42.7	25.7	13.2	15.1	3.3
-1	42.9	25.8	13.1	14.9	3.2
0	43.3	26.2	12.7	14.8	3.1
1	44.0	26.3	12.0	14.9	2.8
2	45.2	26.0	11.2	14.8	2.8
4	45.7	26.1	12.1	13.6	2.5

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	39.8	33.5	8.2	4.5	14.0
-2	43.3	32.9	6.6	5.3	11.9
-1	43.7	33.6	6.9	5.1	10.7
0	44.3	34.3	6.4	4.7	10.2
1	45.2	34.6	6.3	4.5	9.5
2	45.4	34.8	6.5	4.1	9.3
4	48.8	32.5	7.5	2.4	8.8

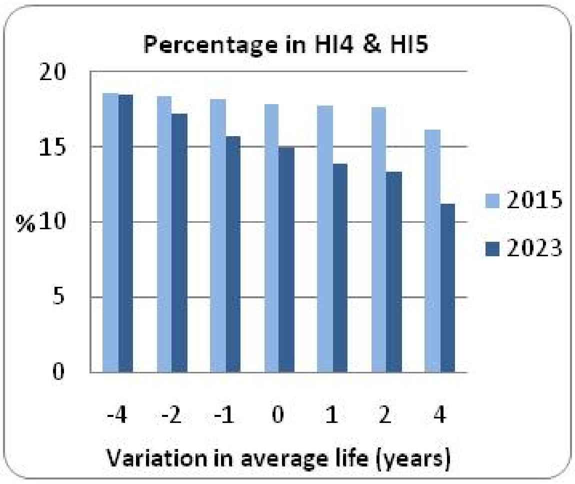
As the percentages above are rounded, the sum of a row may be 0.2% above or below 100%.

The upper, 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 17.9% to 16.1%; if four years shorter, it will increase to 18.6%.
- In 2023 if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 14.9% to 11.2%; if four years shorter, it will increase to 18.5%.

Conclusion

The ED1 replacement plan for EPN EHV Switchgear is mildly sensitive to a variation in average asset life of up to four years.

Appendix 7 – Named Schemes

GWP	Ref	Project ID	DNO	Description	Switchgear manufacturer and model	Volume	Scheme Paper
1.48	1.48.11.2059	2059	EPN	Crowlands 132/33kV Grid Substation – Replace 33kV Switchgear	Switchgear and Cowans K30	15	No
1.48	1.48.02.2099	2099	EPN	Abberton 132/33kV Grid – Replace 33kV Switchgear	English Electric OKM4	6	No
1.48	1.48.02.2199	2199	EPN	Turret Lane 33/11kV Primary Substation – Replace 33kV Switchgear	Switchgear and Cowans RK30	5	No
1.48	1.48.11.2249	2249	EPN	Barnet 132/33kV Grid Substation – Replace 33kV Switchgear	Crompton and Parkinson OE5	12	No
1.48	1.48.11.2348	2348	EPN	Welwyn 132/33kV Grid Substation – replace 33kV switchgear (2000A)	Crompton and Parkinson OE5 and AEI JB424	15	No
1.48	1.48.02.2390	2390	EPN	Walsoken 132/33kV Grid Substation – Replace 33kV Switchgear	English Electric OKM4	7	No
1.48	1.48.02.2399	2399	EPN	Wealdstone 33/11kV Primary Substation – Replace 33kV Switchgear	Yorkshire Hive	2	No
1.48	1.48.11.2431	2431	EPN	Purfleet 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear EO1	17	No
1.48	1.48.02.2507	2507	EPN	Lye Green 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear EO1	13	No
1.48	1.48.11.3388	3388	EPN	Shenfield 132/33kV Grid Substation – Replace 33kV Switchgear	GEC OBA07	12	No
1.48	1.48.02.7604	7604	EPN	Stody 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear EO1	1	No

1.48	1.48.02.7605	7605	EPN	Lakenheath 132/33kV Grid Substation – Replace 33kV Switchgear	English Electric OKM4	2	No
1.48	1.48.11.7606	7606	EPN	Aylesbury East 132/33kV Grid Substation – Replace 33kV Switchgear	Crompton and Parkinson OE5	13	No
1.48	1.48.11.7608	7608	EPN	Southend 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear UE1	8	No
1.48	1.48.11.7609	7609	EPN	Ilmer 132/33kV Grid Substation – Replace 33kV Switchgear	Switchgear and Cowans K30	12	No
1.48	1.48.11.7610	7610	EPN	Stevenage 132/33kV Grid Substation – Replace 33kV Switchgear	Switchgear and Cowans K30	12	No
1.48	1.48.02.7611	7611	EPN	Bourn 33/11kV Primary Substation – Replace 33kV Switchgear	Crompton and Parkinson OE5	1	No
1.48	1.48.02.7612	7612	EPN	Knebworth 33/11kV Primary Substation – Replace 33kV Switchgear	Ferguson and Palin ROP32	1	No
1.48	1.48.02.7613	7613	EPN	Laxfield 33/11kV Primary Substation – Replace 33kV Switchgear	English Electric OKM4	1	No
1.48	1.48.02.7614	7614	EPN	UK Pipelines 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear EO1	2	No
1.48	1.48.11.7615	7615	EPN	Harlow West 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear EO1	10	No
1.48	1.48.11.7616	7616	EPN	Epping 132/33kV Grid Substation – Replace 33kV Switchgear	Switchgear and Cowans K30	8	No
1.48	1.48.02.7617	7617	EPN	Lawford 132/33kV Grid Substation – Replace 33kV Switchgear	English Electric OKM4	9	No
1.48	1.48.11.7618	7618	EPN	Bishops Stortford 132/33kV Grid Substation – Replace 33kV Switchgear	Switchgear and Cowans K30	11	No

1.48	1.48.02.7619	7619	EPN	Bury St 33/11kV Primary Substation – Replace 33kV Switchgear	South Wales Switchgear UE1	4	No
1.48	1.48.02.7620	7620	EPN	LS & E 33/11kV Primary Substation – Replace 33kV Switchgear	South Wales Switchgear EO1	2	No
1.48	1.48.11.7621	7621	EPN	Lowestoft 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear ET	8	No
1.48	1.48.11.7622	7622	EPN	Coryton 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear ET	9	No
1.48	1.48.02.7623	7623	EPN	Long Rd 33/11kV Primary Substation – Replace 33kV Switchgear	South Wales Switchgear ET	2	No
1.48	1.48.11.7624	7624	EPN	Palmers Green 132/33kV Grid Substation - Replace 33kV Switchgear	South Wales Switchgear ET	11	No
1.48	1.48.11.7625	7625	EPN	Cell Barnes 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear ET	11	No
1.48	1.48.11.7626	7626	EPN	Houghton Regis 132/33kV Grid Substation – Replace 33kV Switchgear	South Wales Switchgear ET	13	Yes

Table 3 – EHV Switchgear Named Schemes

Source: 19th February NAMP 2014 Table J Less Indirect

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**	RIGs Table	RIGs Row	2015 /16	2016 /17	2017 /18	2018 /19	2019 /20	2020 /21	2021 /22	2022 /23	**Total**
EHV Switchgear Removals		0	47	24	21	37	21	43	62	255	CV3	197	0	0	0	0	0	0	0	0	**0**
											CV3	198	0	47	24	21	37	21	43	62	**255**
	1.48.02										CV3	199	0	0	0	0	0	0	0	0	**0**
	1.48.11										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	0	0	0	0	0	0	**0**
											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**	**47**	**24**	**21**	**37**	**21**	**43**	**62**	**255**			**0**	**47**	**24**	**21**	**37**	**21**	**43**	**62**	**255**

Table 4 - 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

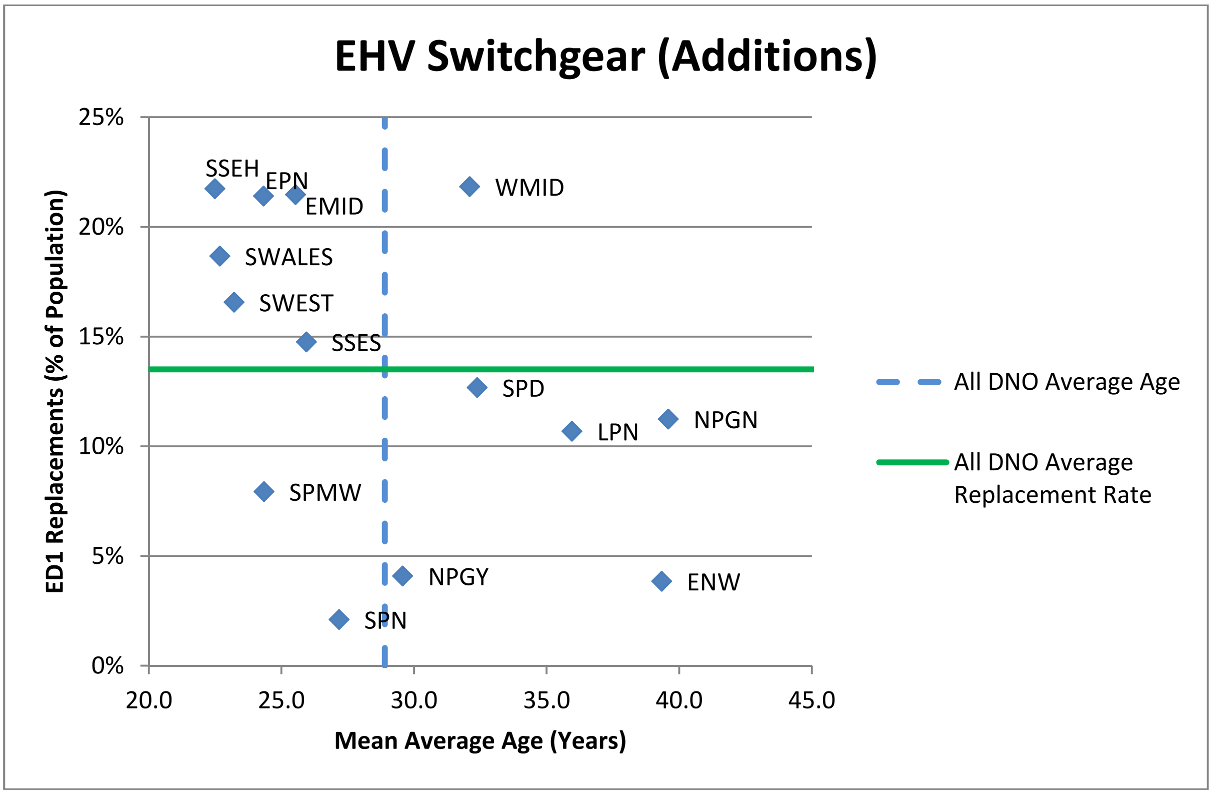


Figure 23 – Efficiency Benchmarking

Source: DNO Datashare_2013

The graph above shows that EPN has younger than average age but a higher than average percentage replacement rate. This is mainly due to the fact that the plan has been put together using condition of assets rather than age. This is outlined in section 3 of this document which includes specific type issues on certain models of switchgear.

It is also partly due to the switchgear age profile in EPN, as found in section 2. The population has two peaks in investments, the 1960s and the late 1990s to early 2000s. This means that although the average age is relatively young, there is still a lot of old switchgear on the network but this is being masked by the 1990s/2000s peak.

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 Switch (GM)	Replace	Volumes (Additions)	43	4	(39)	Volumes moved to 33kV Switchgear (Other) line
		Volumes (Removals)	0	0	0	
		Investment (£m)	0.58	0.08	(0.5)	
		UCI (£k)	13.4	19.9	6.5	
33kV Switchgear (Other)	Replace	Volumes (Additions)	160	199	39	Volumes moved from 33kV Switch (GM) line and removal volumes added
		Volumes (Removals)	160	199	39	
		Investment (£m)	0.57	1.18	0.61	
		UCI (£k)	3.5	6.0	2.5	

Table 5 - 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 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 Ph1-148 were moved to the 33kV Switchgear (other) line. As part of this question removal volumes were also added. The costs have also increased on the 33kV Switchgear (other) line because in the July 13 submission there were cost savings expected as part of partial discharge monitoring mapped to the line as negative values. However, as part of Ofgem questions Ph1-82 and Ph1-84 this was moved to the 6.6/11kV Transformer (GM) line. The following Ofgem questions were answered relating to EHV Switchgear:

- Ph1-14
- Ph1-82
- Ph1-84
- Ph1-148