Document 14
Asset Category – I&M and Faults
EPN

Asset Stewardship Report 2014

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Approved by

Approved date

Document History

Version	Date	Details	Originator	Revision Class	Section Update
1.0	12/02/ 2014	Initial Draft	Colin Bush	N/A	N/A
1.1	18/02/2014	Trees section deleted Fault volumes and I&M volumes updated in tables Preface added Appendices 3,8,9 & 10 added	Ade Olatunji	Minor Minor Minor	All sections Section 1.1 Appendices 3,8,9 &10
1.2	26/02/2014	All tables and figures edited to match correct format	Tim Taylor	Minor	All Sections
1.3	28/02/2014	Updated ED1 investment summary table and Appendix 5	Ade Olatunji	Minor	Section 1.4 and appendix 5
1.4	03/03/2014	Updated Appendix 8	Asha Kiribalasin gham	Minor	Appendix 8
1.5	04/03/2014	Updated Appendix 8	Manjula Singh	Minor	Appendix 8
1.6	07/03/2014	Updated ED1 Expenditure summary table as well as Faults Graph	Ade Olatunji	Minor	Section 1.4, Appendices 5 and 9
1.7	08/03/2014	Final amendments	Chino Atako	NA	NA
2.0	27/03/2014	Final publication	Regulation	Minor	All

Preface

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

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

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

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

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

1. **Appendix 8 - Output NAMP/ED1 RIGS reconciliation:** This section explains the 'line of sight' between the UKPN Network Asset Management Plan (NAMP) 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 – Material changes since the June 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 I&M and Faults

1.1 Scope

This document describes the inspection and maintenance (I&M) of overhead lines, underground cables, switchgear and transformers at all voltages in the EPN region of UK Power Networks. It also examines fault rates on these asset types (excluding third party damages), and the effects of trees on the network. Exceptional events have not been excluded from the analysis.

The inspection and maintenance of civils and protection and control assets are dealt with in separate documents.

This document covers the volumes for DPCR5 and the forecast for the remainder of DPCR5 and ED1 periods. It is expected that ED2 volumes will continue at a similar level to that for ED1

The inspection and maintenance cost in EPN in ED1 is £125m and is equivalent to 0.07% of the MEAV per annum.

The faults cost in EPN in ED1 is £298m and is equivalent to 0.17% of the MEAV per annum.

1.2 Strategy

The strategy for inspection and maintenance is to continue to maintain, monitor and review the performance of the assets to achieve maximum life, while keeping the risks to the network and the general public, as well as whole-life costs, as low as reasonably practical.

The approach to maintenance and inspection is described in UK Power Networks policy EMS 10-0001 – Maintenance and Inspection Overview. Inspection and maintenance frequencies are provided in EMS 10-0002 – Inspection and Maintenance Frequency Schedule.

The overall strategy for ED1 is to manage a steady state position for the majority of the asset types, with Health Indices remaining consistent across the period. This approach is based on known condition data from historic inspection and maintenance reporting and operating performance of the assets, combined with local knowledge and experience. The proposed plan manages any change in risk due to an ageing asset population or from the deployment of increasing volumes of lower maintenance equipment such as vacuum and SF_6 switchgear.

An increase in the inspection period has been recently instigated for substation sites, driven by an opportunity to create efficiency improvements that will optimise expenditure in this area during ED1.

The forecast figures for inspection and maintenance volumes have been derived from Table "O" (Volumes) from the 19th February 2014 NAMP.

Asset volumes and network statistics have been taken from the RIGS V5 return (2012) unless specified otherwise.

Fault volumes for the graphs have been derived from fault data contained in the RIGS (Regulatory Instructions and Guidance) return CV15 (2009/10 – 2011/12) and IIS (Information Incentive System) (2007/8 – 2008/9). These sources provide total fault volumes but the graphs show net faults, i.e. with third party damages excluded. Disaggregated information, such as fault cause data, e.g. Third Party Damages, Condition etc are not available from these sources and have therefore been derived from the UKPN Fault Cube in line with the other (capex) documents. Differences in the data shown between these two sources may be apparent in some graphs. This is due to differences in processing the raw data and presenting it in the appropriate format – for example see graphs in Section 8.2.

Fault repair volumes for 2010/11 and 2011/12 have been derived from the RIGS returns. In forecasting the volumes for fault rates from 2013/14 and throughout ED1, the average over the past five years (2007/8 through to 2011/12) has been used to establish a reference point from which the volumes from 2013/14 onwards were extrapolated. During the preparation of this document, figures for 2012/13 volumes were not fully available. For fault volumes, these have therefore been set equal to the 2013/14 figures.

1.3 ED1 Proposals

The rationale to developing the I&M ED1 plan for each major asset category is outlined below;

Overhead Lines: Expenditure on HV and LV overhead line inspection and maintenance activities is expected to reduce during the ED1 period because of planned improvements and efficiencies in the management, control and scope of tree-cutting and surveys, the replacement of small section conductors and the replacement of bare LV overhead conductors with aerial bundled conductors (ABC).

Cables: For cables at HV and LV, excluding underground services, fault volumes are expected to increase over the next few years. This is due to the continued extension of the asset base, the large proportion of existing assets increasing in age and degrading, and the replacement plans being limited to faulted cable sections and reactive replacement based on condition as found during other work. As can be seen from the capex interventions available, the majority of work applicable to this asset group is reactive, as it is very difficult to inspect or condition-assess buried or concealed cables.

Plant: To reflect capex interventions proposed for ED1, maintenance of oil CBs has been reduced by a total of 16% from 2016/2017 pro-rata across the period.

In summary the UKPN ED1 proposals for the EPN region are based on continued alignment with existing policies in conjunction with the following plan revisions:

- Inspection periods for Grid and Primary substation sites have been increased from four monthly to six monthly, and secondary from two to three years
- An enhanced programme of 132kV and 33kV tower painting is proposed,
- HV and LV overhead fault volumes are anticipated to decrease by 1% per annum due to undergrounding, enhanced tree management and installation of ABC,
- An improvement in efficiency for LV overhead line safety patrols by utilising tree cutting surveyors.
- HV and LV underground cable fault volumes are anticipated to increase by 1% per annum due to an increasing and ageing population,

1.4 Summary Table of ED1 investment

The proposed inspection, maintenance and faults expenditure for EPN in ED1 is £422.2. This comprises of £34.2m of Civils and £6.9m of Protection Costs. Tables 1 and 2 show the expenditure profiles with and without Civil and Protection expenditure.

This document describes all the inspection and maintenance (I&M) of overhead lines, underground cables, switchgear and transformers at all voltages in the EPN region of UK Power Networks. It also examines fault rates on these asset types (excluding third party damages), and the effects of trees on the network. Exceptional events have not been excluded from the analysis.

The inspection and maintenance of civils and protection and control assets are dealt with in the Protection Assets Stewardship Reports and Civils Asset Stewardship reports respectively.

Activity	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	Sum of DPCR5	Sum of RIIO-ED1
Faults	55.2	46.5	50.4	50.7	40.9	37.9	37.6	37.3	37.0	36.2	36.7	37.2	37.6	243.8	297.5
Inspection (I)	5.3	6.5	5.3	8.3	10	6.2	5.8	5.8	5.8	5.8	5.8	5.7	5.8	35.5	46.6
Maintenance (M)	16.3	16.6	12.6	6.9	10.6	9.9	9.7	9.7	9.7	9.6	9.8	9.9	9.8	63	78.1
I&M	21.6	23.1	17.9	15.2	20.7	16	15.4	15.6	15.5	15.4	15.6	15.6	15.6	98.5	124.7
Total	76.8	69.6	68.3	65.9	61.6	53.9	53.0	52.9	52.5	51.6	52.3	52.8	53.2	342.3	422.2

Table 1- I&M and Faults (All costs)

Sources:
Faults – CV15a and CV15b, 2014 ED1 Business Plan Submission
I&M – CV13 2014 ED1 Business Plan Submission

Activity	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	Sum of DPCR5	Sum of RIIO-ED1
Faults	55.2	46.5	50.4	50.7	40.9	37.9	37.6	37.3	37.0	36.2	36.7	37.2	37.6	243.8	297.5
Inspection (I)	5.3	6.5	5.2	8.3	10	6.2	5.8	5.8	5.8	5.8	5.8	5.7	5.7	35.4	46.6
Maintenance (M)	11.2	11.6	9.3	3.1	4.6	4.8	4.5	4.6	4.5	4.5	4.7	4.8	4.7	39.8	37.1
I&M	16.5	18.1	14.6	11.4	14.7	10.9	10.3	10.4	10.3	10.2	10.5	10.5	10.5	75.2	83.7
Total	71.7	64.6	65.0	62.1	55.6	48.8	47.9	47.7	47.3	46.4	47.2	47.7	48.1	319.0	381.2

Table 2 – I&M and Faults (Excluding Civils and Protection)

Sources:
Faults – CV15a and CV15b, 2014 ED1 Business Plan Submission
I&M – CV13 2014 ED1 Business Plan Submission

1.5 Innovation

UK Power Networks use of Reliability Centred Maintenance (RCM) assessments is a prime source of opportunity to optimise I&M activities and has been used to justify policy changes. This has recently driven changes to substation inspections and overhead plant maintenance, as well as utilising inspection techniques to change the requirement for other maintenance.

New technology also provides the chance to reconsider how we carry out activities not only more efficiently, but in a safer manner.

Innovations intended to assist in the management of faults include:

- The use of high resolution photography and locally controlled drones to identify the condition of overhead lines and fittings (2.8);
- The use of PFT to assist in fault location of fluid filled cables (4.8).

Inspection and Maintenance innovations include:

- Use of a micro-bore pressure sensing device to assess wood pole strength (3.8);
- Increased use of (remote) change of state operations to check mechanism operations and hence reduce routine inspections (3.8, 6.8, 7.8);
- Continuous (fixed) partial discharge monitoring (4.8);
- Tailoring post fault maintenance to the cumulative fault current rather than number of operations (7.8);
- Tailoring diverter maintenance to the specific transformer and tap changer types (10.8).

1.6 Risks and Opportunities

Table 3 shows a summary of the risks and opportunities associated with the investment plans proposed in this document.

	Description of similarly likely opportunities or risks arising in ED1 period	**Uncertainties**
Opportunity	Introduce condition based maintenance for tap changers	-£50k per annum
Opportunity	Introduce condition based post fault maintenance for feeder circuit breakers	-£35k per annum
Opportunity	Collate service termination condition reports (i.e. cut-out age and condition) by using supply company/meter operator/contractor installing new smart meters	+£2.3m per annum (estimate) over 5 year Smart Metering project period
Risk	Type failures of plant leading to modification programmes	+£40k per occasion
Risk	Increasing number of exceptional events	+£100k per event

Table 3 – Risks and opportunities

2.0 Towers (Broad Based) and Conductors

2.1 Asset Information

There are a total of 5,933 towers operating at 132kV and 33kV, as detailed in table 4.

Voltage	**No of Towers**	**Conductor Length (km)**
132kV	4755	2,523
EHV (33kV)	1153	515

Table 4 - Towers (Broad Based) and Conductor Asset Information (Source: 21st February ED1 RIGs)

2.2 Summary of Fault Trends, Failure Modes, and Fault Rates

132kV – The small number of faults at 132kV makes it difficult to reliably identify long-term trends. The graph below covers both steel tower and wood pole lines, although the majority of circuits are on the former. Although the trend over the past five years shows volumes increasing, a steady state position is forecast after 2013/14 for the reasons described below (refer to "Faults Plan"). The 2013/14 volumes baseline has been set using the average over the past five years (2007/8 through to 2011/12). This is illustrated in figure 1.

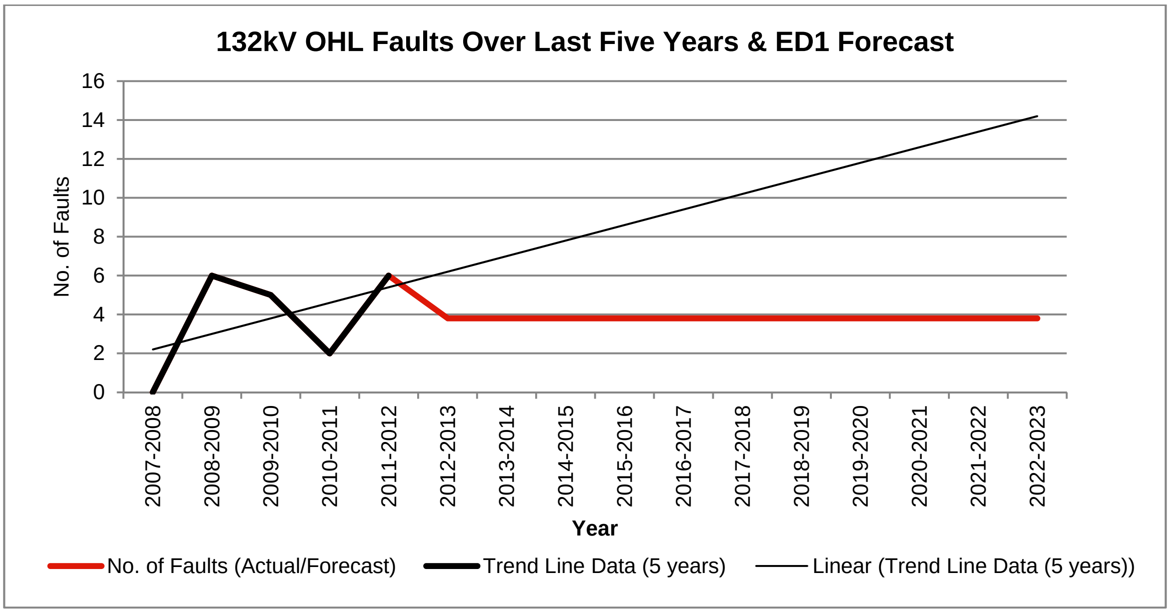

Figure 1 – 132kV OHL faults (Data Source: IIS and UKPN Fault Cube)

EHV – The small number of faults in this category makes it difficult to reliably identify long-term trends. Figure 2 covers both steel tower and wood pole lines, although the majority of circuits are on the latter.

It has been assumed that EHV on steel towers follows the same fault profile as 132kV circuits with no change over the ED1 period (and hence the downward trend should be ignored for this category).

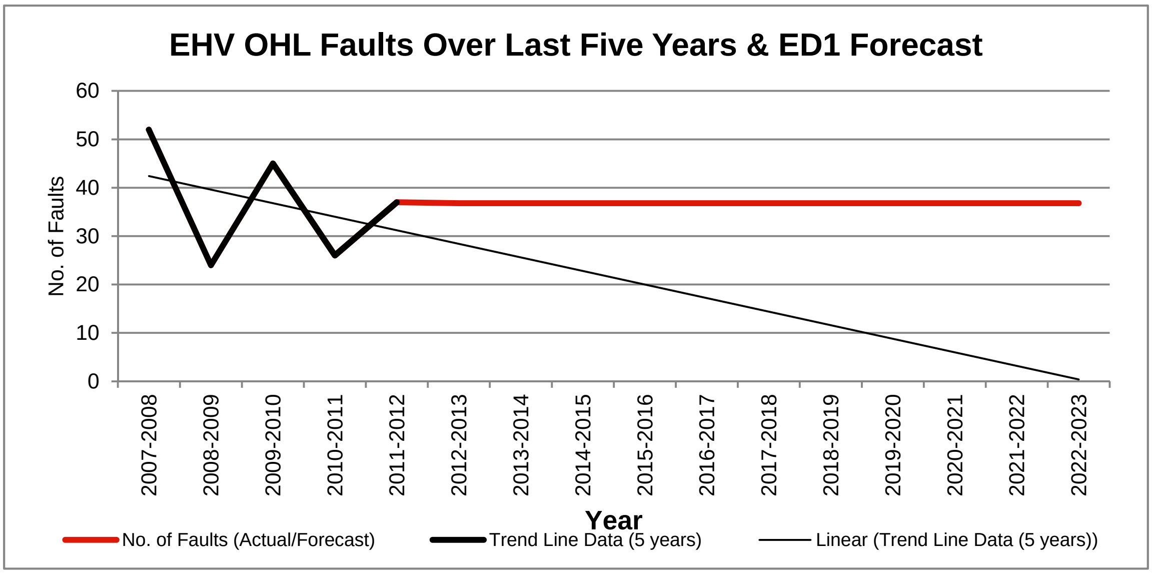

Figure 2 - *EHV OHL Faults (Source: IIS and UKPN Fault Cube)*

2.3 Faults Plan

Due to the low number of faults it is difficult to predict future fault frequency with a high degree of statistical confidence and trend lines are highly sensitive to minor fluctuations. Setting the start point from 2013/14 as the average over the past five years (2007/8 through to 2011/12), the volumes over ED1 are expected to remain fairly steady. This is due to an ongoing conductor condition-assessment programme which informs the conductor replacement programme (capex).

The presence on the network of steel core conductors, which are known to deteriorate, could affect the small volumes on a year-to-year basis. An example of this occurred in Peterborough where a single span of Lynx ACSR 132kV conductor failed unexpectedly on one phase following a lightning strike and overheating and subsequent failure of the aluminium/steel core of the conductor and the compression joint (refer to Figure 3).

As outlined in the I&M Interventions section (2.5), CORMON testing is undertaken to minimise risk of these types of failures.

EMS 10-0002 outlines the policy that at 132kV, fault patrols are carried out on an ad hoc basis where a circuit has tripped because of an unknown cause. At EHV (33kV), this is required after three successful auto-reclose sequences within a 31-day period.

Tables 5 and 6 show volumes for 132kV OHL fault repairs in ED1 and ED2. EHV OHL fault repairs are covered under the Wood Poles and Conductors section (3.0).

Description of Activity	RIGs Reference	2009 / 2010	2010 / 2011	2011 / 2012	2012 / 2013	2013 / 2014	2014 / 2015	2015 / 2016	2016 / 2017	2017 / 2018	2018 / 2019	2019 / 2020	2020 / 2021	2021 / 2022	2022 / 2023
132kV OHL fault repairs	CV15a Line 36	5	4	7	1	4	4	4	4	4	4	4	4	4	4
132kV Fault Restoration by Switching Only (OH)	CV15a Line 9	15	4	17	5	30	24	5	5	5	5	5	5	5	5
Total 132kV OHL Faults		20	8	24	6	34	28	9	9	9	9	9	9	9	9

Table 5 - DPCR4, DPCR5 & ED1 History/Forecast - Towers and Conductor Fault. (Source: 21st February 2014 RIGs Data)

ED2 Volumes	2022 /2023	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2030 /2031
132kV OHL Faults	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**

Table 6 – ED2 Forecast. Towers and Conductor Faults

Fault rates at 132kV are on average 4 per annum or approximately 0.16 per 100km.Figure 3 shows a failed compression fitting.

Figure 3 - *Failed Compression Fitting*

2.4 I&M Drivers

Operator, public and network safety are the leading drivers for an optimised inspection and maintenance regime, with ongoing monitoring of compliance to Electricity, Safety, Quality and Continuity Regulations (ESQCR), and continuing clearance of defects. Public safety is particularly pertinent to this class of asset as it is mainly to be found on private property or highways.

The condition of an asset, which determines its Health Index, is also of paramount importance in identifying the most appropriate maintenance interventions and investment strategies that provide the best value for money.

Consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is an important aspect of managing these assets utilised by UK Power Networks. Trade-off between Opex and Capex is examined and whole life cost assessment examples are provided in the Capex related narrative documents.

2.5 I&M Interventions

Towers and conductors at all voltages are inspected every year, alternating between a safety and full inspection. Where the site is determined to be high risk, this will be more frequent as required. Associated equipment is also inspected during tower line inspections. A high risk site is determined by applying the criteria in EOS 09-0061 – Assessing the Risk to the Public from Distribution Network Assets – Section 4, and may typically be a tower with cable terminations (high risk equipment) situated on arable land or a golf course (low or medium risk location), or medium risk equipment (e.g. a 132/33kV tower) at a high risk location (e.g. recreational areas or camping areas).

A random sample of tower footings are inspected once they are 40 years old, and then at 40-year intervals.

Thermal inspections of 132kV towers and conductors are carried out every two years.

CORMON testing of a 132kV or 33kV steel cored conductor starts once it is 40 years old, and then every 10 years, as outlined in table 3A of EMS 10-0002. At 132kV and 33kV, a physical inspection of fittings and supports is undertaken after 20 years of conductor life.

Tower painting has been carried out on a reactive basis over the last and current review periods to date. A planned, enhanced programme of pro-active tower painting is currently being implemented to maintain asset life and reduce the need for larger scale capex interventions (tower refurbishments) throughout ED1 and ED2.

2.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EDS 01-0003 – Refurbishment and Replacement Standard for Broad Based Towers outlines refurbishment aspects of broad-based towers, with EMS 10-0500 – Maintenance Painting for Overhead Line Steel Structures detailing the maintenance painting of these structures. Inspection of overhead lines at all voltages follows EMS 10-6001 – Inspection of Overhead Line at all Voltages, and maintenance EMS 10-0501 – Maintenance of Overhead Lines at All Voltages.

2.7 I&M Plan

Fault rate and failure mode statistics have not highlighted a need for changes in policy in the ED1 period. Apart from the enhanced tower painting programme the plan reflects consistent I&M interventions in line with the above policies. The increase in steel tower painting is in response to recent condition assessments and is designed to control the rate of degradation of the equipment where it is identified as an issue. Table 7, Table 8 and figure 4 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
132kV Full Patrol Broad Based Tower	2,163	2,400	2,378	2,378	2,378	2,378	2,378	2,378	2,378	2,378
132kV Safety Broad Based Towers Patrol	2,305	2,739	2,378	2,378	2,378	2,378	2,378	2,378	2,378	2,378
132kV Infra Red Patrol Route	576	557	548	548	548	548	548	548	548	548

132kV CORMON Testing	40	40	40	40	40	40	40	40	40	40
Climbing Inspection Broad Based Tower	72	63	39	39	39	39	39	39	39	39
132kV Inspection Total	5,156	5,799	5,383	5,383	5,383	5,383	5,383	5,383	5,383	5,383
33kV Full Patrol Broad Based Tower	540	600	577	577	577	577	577	577	577	577
33kV Safety Patrol Broad Based Tower	472	561	577	577	577	577	577	577	577	577
Spacer Checks Twin Bundles	5	20	20	20	20	20	20	20	20	20
33kV Infra Red Tower Route	124	121	121	121	121	121	121	121	121	121
33kV CORMON Testing	9	10	10	10	10	10	10	9	10	10
EHV Inspection Total	1150	1312	1305	1305	1305	1305	1305	1304	1305	1305
132kV / 66kV Tower Painting (Volume)	35	71	114	137	159	227	227	227	227	227
Maintenance Total	**35**	**71**	**114**	**137**	**159**	**227**	**227**	**227**	**227**	**227**
Includes RIGs Lines: CV13 Lines 39, 40, 41, 53, 54, 55, 67, 68, 69										

Table 7 - DPCR5 & ED1 Forecast - I&M Towers and Conductors. (Source: 19th February 2014 NAMP Table O)

ED2 Volumes	2022 /2023	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2030 /2031
132kV Inspection	**5,766**	**5,766**	**5,766**	**57,66**	**5,766**	**5,766**	**5,766**	**5,766**
EHV Inspection	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**
132kV/EHV Maintenance	**193**	**193**	**193**	**193**	**193**	**193**	**193**	**193**

Table 8 - ED2 Forecast - I&M Towers and Conductors

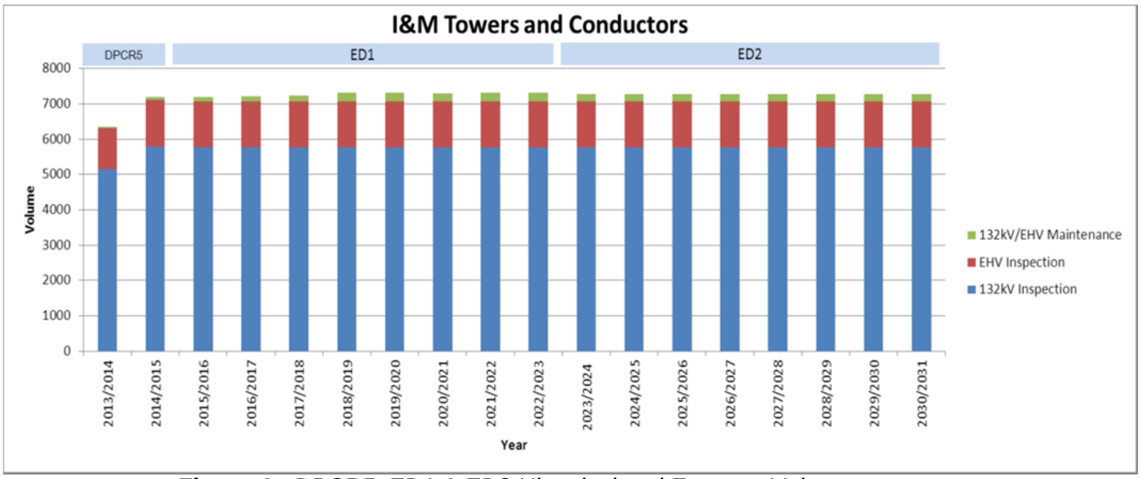

Figure 4 - *DPCR5, ED1 & ED2 Historical and Forecast Values*

2.8 Innovation

All aspects of the I&M programme are subject to continuous improvement. Improved methods of identifying tower and fitting condition (e.g. Figure 5 below), through high-resolution photography, are being investigated with the use of locally controlled drones (Figure 6). These offer the ability to carry out detailed visual condition analysis without the need for outages, or the risks from working at height, by replacing the need for climbing tower inspections. This will not only remove network and employee risk, but improve productivity in this activity.

Figure 5 - *Condition of Conductor and Fitting*

Figure 6 - *Example of Locally Controlled Drone*

3.0 Wood Poles and conductors

3.1 Asset Information

Although the reference throughout this section is to wood poles, it also includes narrow-based towers, columns and concrete structures.

This section also includes ancillary equipment such as air break switch disconnectors (ABSD), auto-reclosers, surge arresters, fusegear, and pole transformers.

Table 9 provides the pole counts and conductor lengths for the asset population.

Voltage	No of Poles	Conductor Length (km)
132kV	155	15
EHV (33kV)	35037.00	2851.12
HV (2-11kV)	214417.00	19118.31
LV	247621.00	9173.69

Table 9- Pole and Conductor Asset Information. Source: RIGs Data 2013

3.2 Summary of Fault Trends, Failure Modes, and Fault Rates

Fault rates, based on the average of the past five years (2007/8 through to 2011/12) are shown in table 10.

Voltage	Faults Per Annum	Faults Per 100 km
132kV	See "Towers"	-*
EHV	37	1.29
HV	975	5.08
LV	1211	13.1
Services	N/A	N/A

Table 10 - Fault Rates. Source: IIS and UKPN Fault Cube

*132kV – There have been no recorded faults for this very small population of assets (on wood poles) in the reporting period, and hence no data or graph is shown. The majority of OHL faults at 132kV are on tower lines and included in the "Towers" section above.

EHV (33kV) – The relatively low number of these faults makes it difficult to reliably identify long-term trends which are consequently very sensitive to minor variations. The graph below covers both steel tower and wood pole lines, although the majority of circuits are on the latter. The same graph has been included in the "Towers" section for reference.

Although the five-year trends show volumes decreasing, a steady state position is forecast from 2013/14 onwards. The 2013/14 baseline has been calculated using the average over the past five years (2007/8 through to 2011/12). This is illustrated in figure 7.

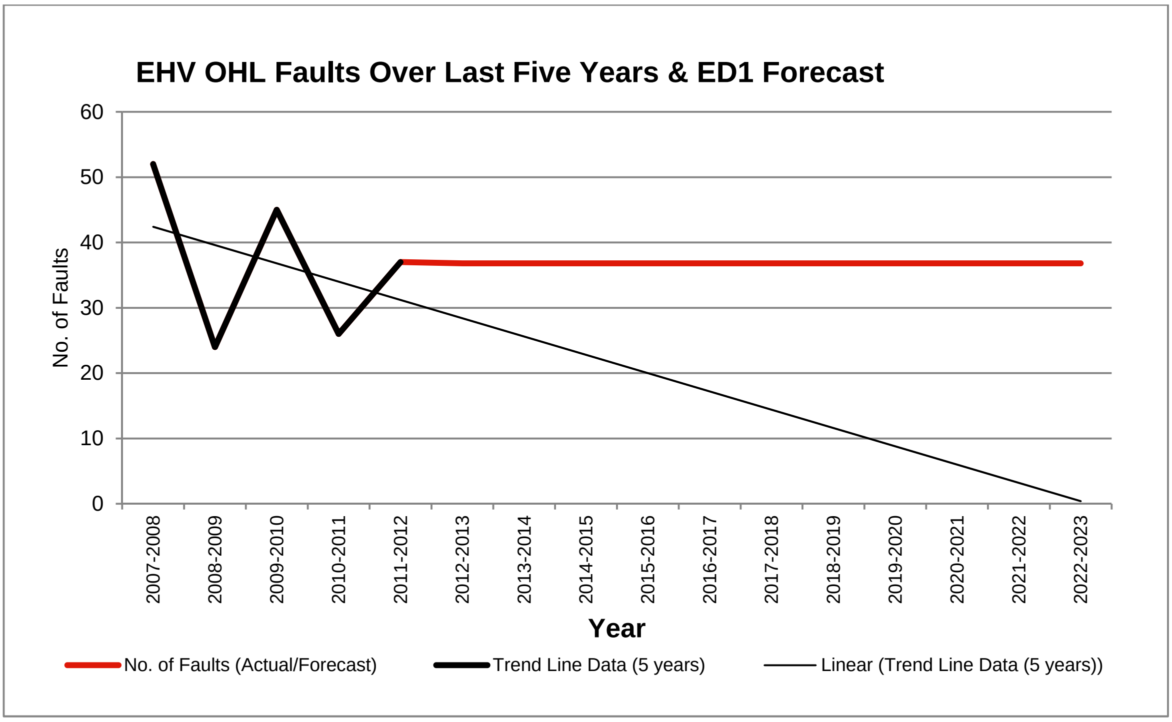

Figure 7 – *EHV OHL Faults (Source: IIS and UKPN Fault Cube)*

HV (6.6/11kV) – The fault trend is variable year on year, dependant mainly on weather conditions. The past five years shows a downward trend which aligns very closely to the forecast.

The forecast is for a 1% reduction per year, starting from a 2013/14 baseline (based on the average over the past five years (2007/8 through to 2011/12)) on the expectation that fault rates will improve. This reflects the capex investment in previous years for the replacement of small section conductors and refurbishment of overhead line feeders. This is illustrated in figure 8.

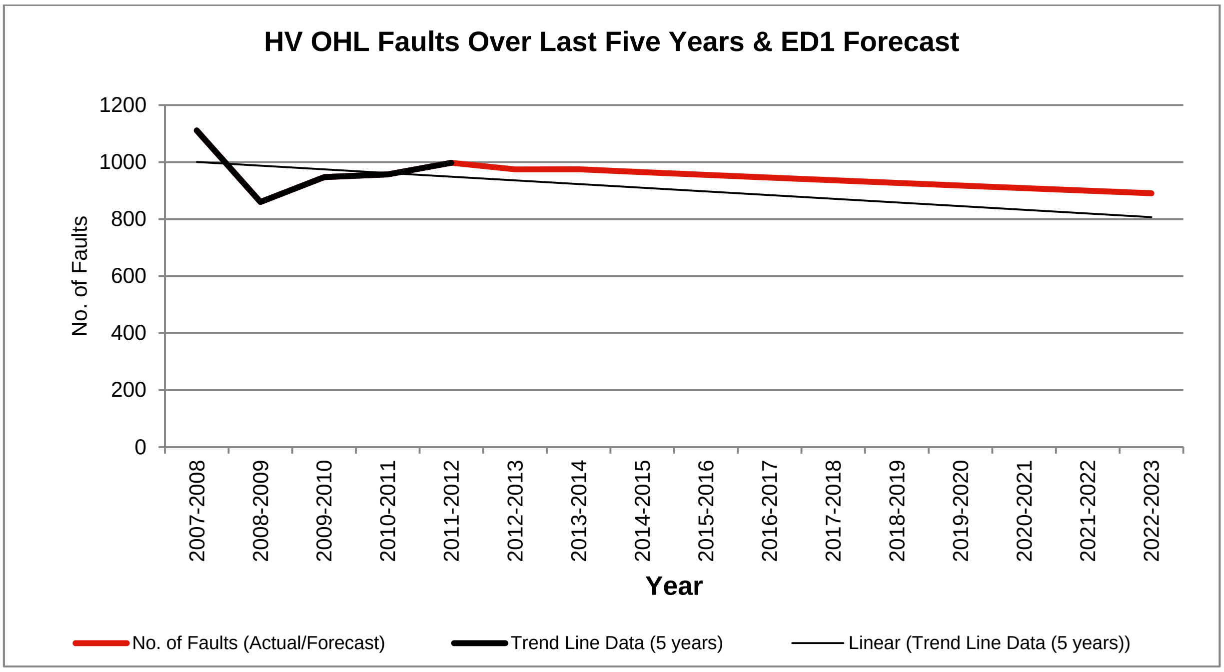

Figure 8 – *HV OHL Faults (Source: IIS and UKPN Faults Cube)*

LV – Although the fault trend over the past five years shows that the volumes are decreasing steeply, the underlying long-term trend is expected to be less severe. A reducing trend of 1% per year is forecast from 2013/14, at which volumes have been set using the average over the past five years (2007/8 through to 2011/12) as illustrated in figure 9. This reflects the change in policy with regard to the targeted investment in and installation of aerial bundled conductors (ABC) in tree-infested spans associated with climbable trees. ABC is effectively insulated LV conductor that removes the risk to the public from inadvertent contact, and improves fault performance due to interference from trees.

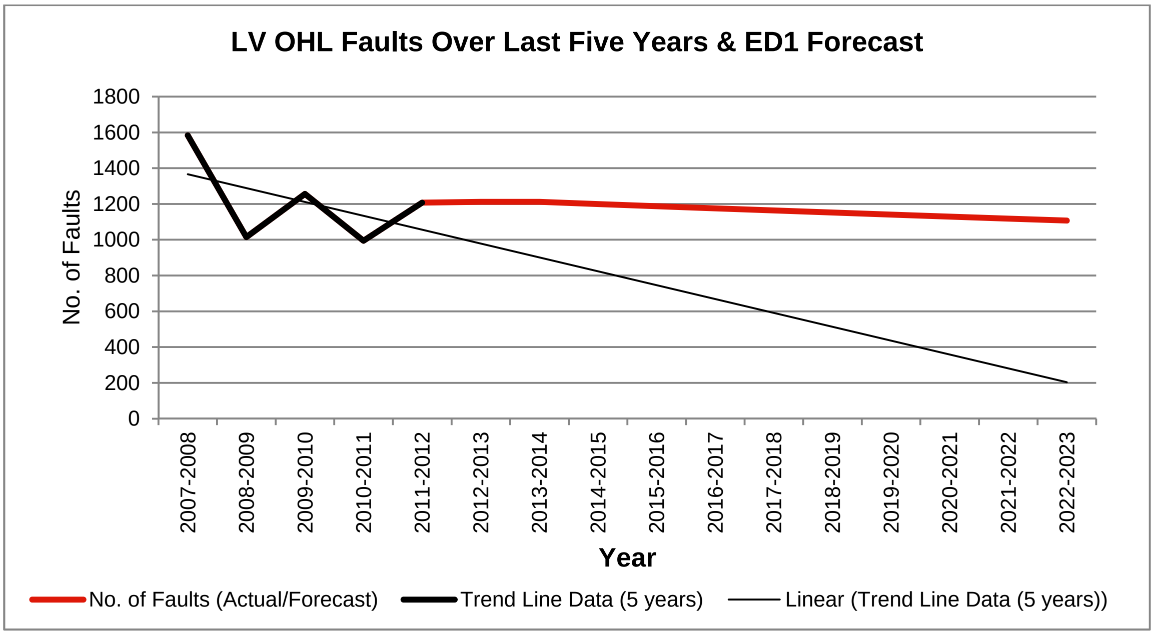

Figure 9 – *LV OHL Faults (Source: IIS and UKPN Faults Cube)*

Services – LV overhead service fault rates have decreased over the past five years, but it is expected that the trend will be less severe in the longer term. The forecast, starting from 2013/14 at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12), shows no change in volumes across the period. This is illustrated in figure 10.

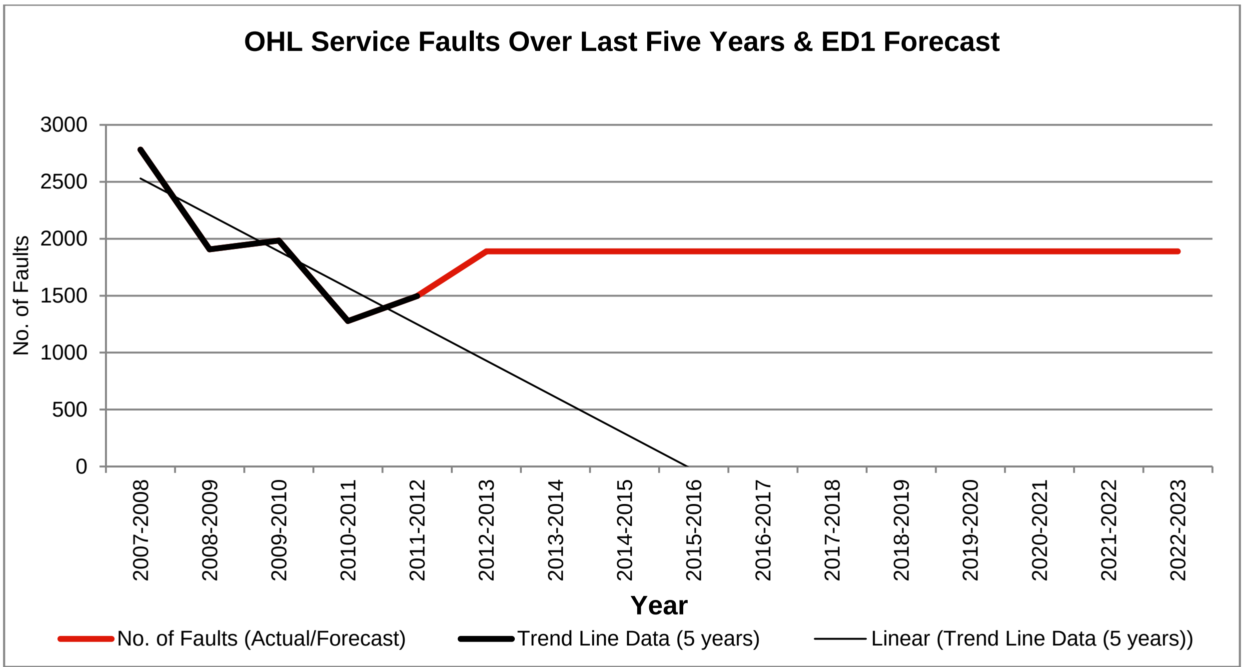

Figure 10 – *OHL Service Faults (Source: IIS and UKPN Faults Cube)*

3.3 Faults Plan

In all categories, the volumes in 2013/14 have been set using the average of the past five years (2007/8 through to 2011/12).

For HV and LV mains overhead line faults, the forecast is for the volumes to decrease in line with the effect of associated capex initiatives outlined above, and for a gradually decreasing network length where overhead spans have been replaced by underground cable lengths.

LV services are forecast to be consistent across the period as the upward trend seen in 2011/12 continues to a limited extent.

At 132kV, fault patrols are carried out on an ad hoc basis where a circuit has tripped because of an unknown cause. At 6.6/11kV and 33kV, this is after three successful auto-reclose sequences within a 31-day period.

Table 11, Table 12 and figure 11 show the volume profiles in ED1 and ED2

Description of Activity	RIGs Reference	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
33kV OHL fault repairs	CV15a Line 31	48	25	36	37	37	37	37	37	37	37	37	37	37	37
EHV supply restoration, including fault location OHL	CV15a Line 8	92	63	51	53	179	149	56	56	56	56	56	56	56	56
Total EHV OHL Faults		**140**	**88**	**87**	**90**	**216**	**186**	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**93**
11kV OHL fault repairs[1]	CV15a Line 23	1,474	1005	1083	662	962	927	917	907	898	889	881	872	864	855
HV supply restoration, including fault location OHL	CV15a Line 7	1,243	850	1,396	1332	775	775	775	775	775	775	775	775	775	775
Replacement of damaged PMT	CV15a Line 26	220	163	174	131	47	66	125	125	125	125	125	125	125	125
11kV Pole mounted Switchgear (NOT Circuit Breaker) Fault	CV15a Line 25	199	126	134	92	40	40	40	40	40	40	40	40	40	40
11kV Pole Mounted Switchgear (Circuit Breaker) Fault	CV15a Line 24	-	1	10	4	3	3	3	3	3	3	3	3	3	3
Total HV OHL Faults		**3,136**	**2145**	**2797**	**2221**	**1,905**	**1,870**	**1,860**	**1,850**	**1,841**	**1,32**	**1,824**	**1,815**	**1,807**	**1,798**
LV OHL fault repairs[2]	CV15a Line 19	1,469	1,155	1378	707	1,211	1,199	1,187	1,175	1,164	1,152	1,140	1,129	1,117	1,106
Service fault repairs overhead	CV15a Line 14	1,969	1311	1611	2248	1,889	1,889	1,889	1,889	1,889	1,889	1,889	1,889	1,889	1,889
Street lighting fault replacement – overhead	CV15b Line 7	All volumes included in UG Services				183	183	148	148	148	148	148	148	148	148
Flickering supplies[3]	CV15b Line 10	3,165	2,962	5,951	10888	6,654	6,654	6,654	6,654	6,654	6,654	6,654	6,654	6,654	6,654
Total LV OHL Faults		**6,603**	5,428	8,940	13,843	9,937	9,925	9,878	9,866	9,855	9,843	9,831	9,820	9,808	9,797

Table 11 - DPCR4, DPCR5 & ED1 History/Forecast - Wood Poles and Conductors Fault (Source: RIGs Data13th February 2014)

[1] 11kV OHL wood pole and conductor faults will reduce by 1% every year through ED1 and ED2. The other provisions for HV overhead line faults will remain constant through ED2.

[2] LV OHL wood pole and conductor faults will reduce by 1% every year through ED1 and ED2. The other provisions for HV overhead line faults will remain constant through ED2.

[3] Flickering supplies are also applicable to cables, but the majority of activity is in this (Wood Poles and Conductors) category

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Total EHV OHL Faults	93	93	93	93	93	93	93	93
Total HV OHL Faults	1,789	1,781	1,773	1,764	1,756	1,748	1,740	1,732
Total LV OHL Faults	9,786	9,775	9,764	9,753	9,743	9,732	9,722	9,712

Table 12 ED2 Forecast - Wood Poles and Conductor Faults

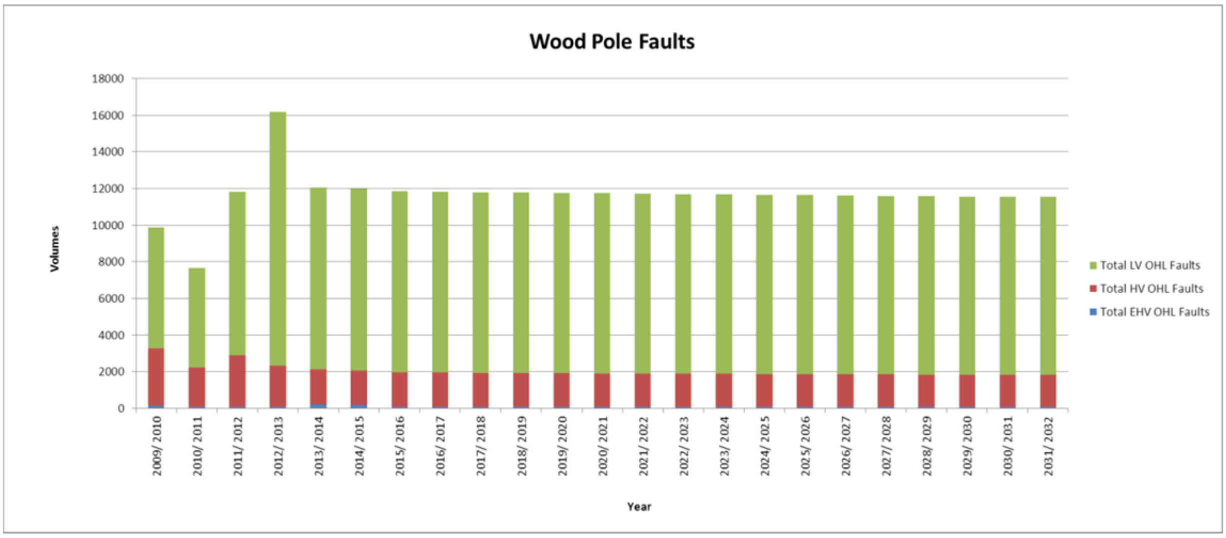

Figure 11 *- DPCR4, DPCR5, ED1 & ED2 Historical and Forecast Values*

3.4 I&M Drivers

Operator, public and network safety are the leading drivers for an optimised inspection and maintenance regime, with ongoing monitoring of compliance to Electricity, Safety, Quality and Continuity Regulations (ESQCR), and continuing clearance of defects. Public safety is particularly pertinent to this class of asset as it is mainly to be found on private property or highways.

Functional performance of air-break switched disconnectors (ABSDs) is important for restoring customers' supplies following an unplanned interruption.

The condition of an asset, which determines its Health Index, is also of paramount importance in identifying the most appropriate maintenance interventions and investment strategies that provide the best value for money.

Consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is an important aspect of managing these assets utilised by UK Power Networks. Trade-off between Opex and Capex is examined and whole life cost assessment examples are provided in the Capex related narrative documents.

3.5 I&M Interventions

In accordance with the I&M policy (see below), 132kV inspections are every year, alternating between a safety and full inspection. 6.6/11kV and 33kV and LV have a safety inspection every four years, with the third safety inspection being replaced with a full inspection (i.e. every 12 years). Associated equipment is also inspected during inspections. Inspections of high-risk 132kV sites will be more frequent as required. For sites below 132kV, the frequency will be every two years, or more frequent as required. A high risk site is determined by applying the criteria in EOS 09-0061 – Assessing the Risk to the Public from Distribution Network Assets – Section 4, and may typically be 33kV/HV Plant without an anti-climbing device (ACD) situated on arable land or a golf course (low or medium risk location), or low/medium risk equipment (e.g. LV pole insulated/bare) at a high risk location (e.g. recreational areas or camping areas).

The condition of a wood pole is assessed at the full inspection with a hammer test. Where the pole fails this test, it has traditionally been re-tested using an auger decay, or pole ultrasound rot locator (“PURL”) assessment, although a new methodology is being implemented as described in the innovation section. Following this supplementary test, the actual residual strength is assessed and the pole declared suspect (“S”) or decayed (“D”). S poles are then monitored at four-year intervals, and D poles entered in the change programme. To improve data quality, a separate re-testing regime has been implemented to provide detailed information on the extent of the decay prior to a pole change.

Tower footings are inspected on a random basis once they are 40 years old, and then at 40-year intervals.

At 132kV, a physical inspection of fittings and supports is undertaken after 20 years of conductor life.

6.6/11kV and 33kV ABSDs were previously maintained on a 12-year cycle, but a revised operation and reactive maintenance regime, as detailed in the innovation section, is to be implemented over the ED1 period.

All ancillary equipment is inspected as part of the line inspection and is subject to a visual inspection only.

3.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. Inspection of overhead line at all voltages follows EMS 10-6001, and maintenance EMS 10-0501.

3.7 I&M Plan

Fault rates and failure modes have not highlighted any particular changes that may be required to the above regime. The plan reflects consistent I&M interventions in line with the above policies. The drive to clear defects through a dedicated programme will afford a reduction in these activities through ED1. The reduction in LV safety patrol volumes reflects the costs savings of combining tree and safety patrols rather than an actual reduction in volume.

Table 13, Table 14 and Figure 12 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
132KV Full Patrol Wood Pole/Lattice	237	355	2,775	2,774	2,774	2,774	2,774	2,774	2,774	2,773
132KV Safety Patrol Wood Pole/Lattice - Contractors	281	212	0	0	0	0	0	0	0	0
Safety Patrol Wood Pole/Lattice 132kV	42	32	31	39	39	39	39	39	39	39
132kV Inspection Total	**560**	**599**	2806	2813	2813	2813	2813	2813	2813	2812
33KV Full Patrol Wood Pole/Lattice	3,331	4,969	4,969	4,969	4,969	4,969	4,969	4,969	4,969	4,969
Safety Patrol Wood Pole/Lattice EHV	9,743	7,226	5,868	5,868	5,868	5,868	5,868	5,868	5,868	5,868
Safety Patrol Wood Pole/Lattice EHV - Contractors	3,944	2,958	0	0	0	0	0	0	0	0
EHV Inspection Total	**17,018**	**15,153**	10,837	10,837	10,837	10,837	10,837	10,837	10,837	10,837
Follow Up - 33kV	11	45	45	46	46	48	48	49	48	49
Maintain ABSD 33kV	157	31	31	31	31	31	31	31	31	31
S poles - 33kV Structural Test after hammer test	97	149	308	308	308	308	308	308	308	308
EHV Maintenance Total	**265**	**225**	**384**	**385**	**385**	**387**	**387**	**388**	**387**	**388**
Includes RIGs Lines: CV13 Lines 36, 37, 38, 50, 51, 52, 64, 65, 66										
11KV Full Patrol Wood Pole/Lattice	20,227	30,172	17,806	17,806	17,806	17,806	17,806	17,806	17,806	17,806
Safety Patrol Wood Pole/Lattice HV - Contractors	23,947	17,961	-	-	-	-	-	-	-	-
Safety Patrol Wood Pole/Lattice HV	59,684	44,265	35,668	35,668	35,668	35,668	35,668	35,668	35,668	35,668
ESQC Inspection Wood Pole/Lattice HV	9,453	9,091	9,091	9,091	9,091	9,091	9,091	9,091	9,091	9,091
HV Inspection Total	**113,311**	**101,489**	62,565	62,565	62,565	62,565	62,565	62,565	62,565	62,565
Follow Up - 11kV	22	87	88	89	89	90	92	92	94	94
Maintain ABSD 11kV	334	181	181	181	181	181	181	181	181	181
S poles - 11kV Structural Test after hammer test	596	474	150	150	150	150	150	150	150	150
HV Maintenance Total	**952**	**742**	**419**	**420**	**420**	**421**	**423**	**423**	**425**	**425**
Includes RIGs Lines: CV13 Lines 18, 19, 20, 34, 35										
Safety Patrol Wood Pole/Lattice LV - Contractors	28,308	21,231	-	-	-	-	-	-	-	-
Safety Patrol Wood Pole/Lattice LV	73,431	50,466	40,688	40,688	40,688	40,688	40,688	40,688	40,688	41,228
Full Patrol Wood Pole/Lattice LV	16,872	20,965	20,964	20,964	20,964	20,964	20,964	20,964	20,964	20,964
LV Inspection Total	**118,611**	**92,662**	61,652	61,652	61,652	61,652	61,652	61,652	61,652	62,192
Shrouding for LV mains and Services	238	953	953	953	953	953	953	953	953	953
Shrouding for LV mains and Services - Contractors	1,970	1,359	-	-	-	-	-	-	-	-
S poles - LV Structural Test after hammer test	897	920	680	680	680	680	680	680	680	680
Follow Up - LV	50	198	200	203	204	207	209	212	213	216
LV Maintenance Total	**3,155**	**3,430**	**1,833**	**1,836**	**1,837**	**1,840**	**1,842**	**1,845**	**1,846**	**1,849**
Includes RIGs Lines: CV13 Lines 7, 8, 9										
GS6 enquiries Note 1	6,055	5,529	4,917	4,917	4,917	4,917	4,917	4,917	4,917	4,917

Table 13- DPCR5 & ED1 Forecast - I&M Wood Poles and Conductor. (Source: 19th February NAMP Table O)

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
132kV Inspection	393	393	393	393	393	393	393	393
EHV Inspection	13,592	13,592	13,592	13,592	13,592	13,592	13,592	13,592
EHV Maintenance	386	386	386	386	386	386	386	386
HV Inspection	92,085	92,085	92,085	92,085	92,085	920,85	920,85	92,085
HV Maintenance	422	422	422	422	422	422	422	422
LV Inspection	51,874	51,874	51,874	51,874	51,874	51,874	51,874	51,874
LV Maintenance	1,841	1,841	1,841	1,841	1,841	1,841	1,841	1,841

Table 14 ED1 and ED2 I&M volumes

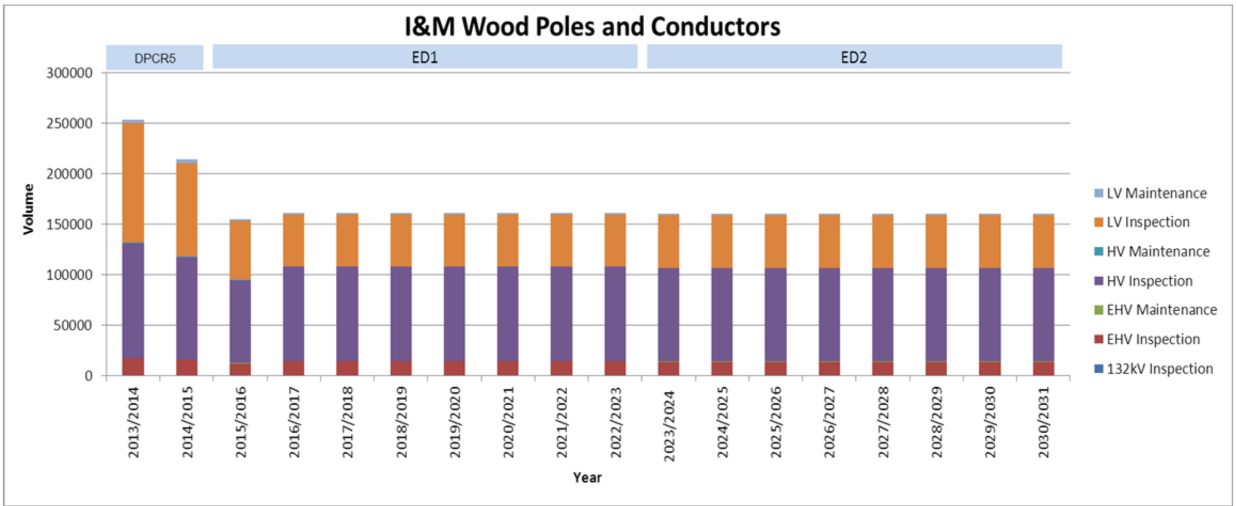

Figure 12 *DPCR5, ED1 & ED2 Historical and Forecast Values*

3.8 Innovation

All aspects of the I&M programme are subject to continuous improvement. Safety inspections of 11kV wood poles are currently under review, with the possibility of being combined with tree-cutting inspections. The former are every four years, while the latter are every three years, but despite the increased frequency, cost savings are believed to be achievable. Thus this change would improve the frequency of safety patrols while saving overall costs. This initiative is still at the trial stage. The comparative costs are shown in table 15.

	Patrol cost per pole	No of safety patrols per 12 year cycle	Cost per pole per cycle – safety patrols
Current cycle	£10	2	£20
Proposed cycle	£5	3	£15

Table 15- Inspection Costs

The two traditional methods of assessing wood pole residual strength – auger decay measurement assessment and PURL – are being superseded by a new method which adopts a similar principle to the auger method. Use of the new micro-bore pressure sensing drill device (sometimes known as a resistograph) is being implemented from 2013 (refer to Figure 13). It measures the resistance through a pole using a very small bore drill. This is far less invasive than the auger enabling more tests to be taken of the area, giving a much more accurate picture of decay within the pole and therefore an improved assessment of its residual strength (refer to Figure 14). It can also be used at ground level quite effectively without excavations being required. Coupled with this, UKPN are looking to use a software package to calculate the actual residual strength to give a more accurate picture than the current methodology, comparing areas of decay against a template. At this stage, the revised methodology is being evaluated to provide a better assessment of pole condition over existing methods and to more accurately inform the pole replacement programme (capex). In the future it is expected that the monitoring will assist in reducing or deferring the number of pole changes required.

As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities 6.6/11kV and 33kV ABSDs and 33kV line switches will undergo a change of state operation every six years, with reactive maintenance where required (i.e. following a failure to operate); this is a change from undergoing a preventative maintenance programme every 12 years. It is considered that operation of the units will, in most cases, continue to keep the mechanism in a useable state. Any operations that might achieve this during normal network activity will be captured and logged to fulfil this requirement, leaving only a few requiring purposeful operation to achieve a change of state. The numbers of inoperable ABSDs will be monitored to determine if this course of action is successful. Projected savings have been included in the I&M forecasts.

Figure 13 - *Resistograph being used to determine the extent of internal decay*

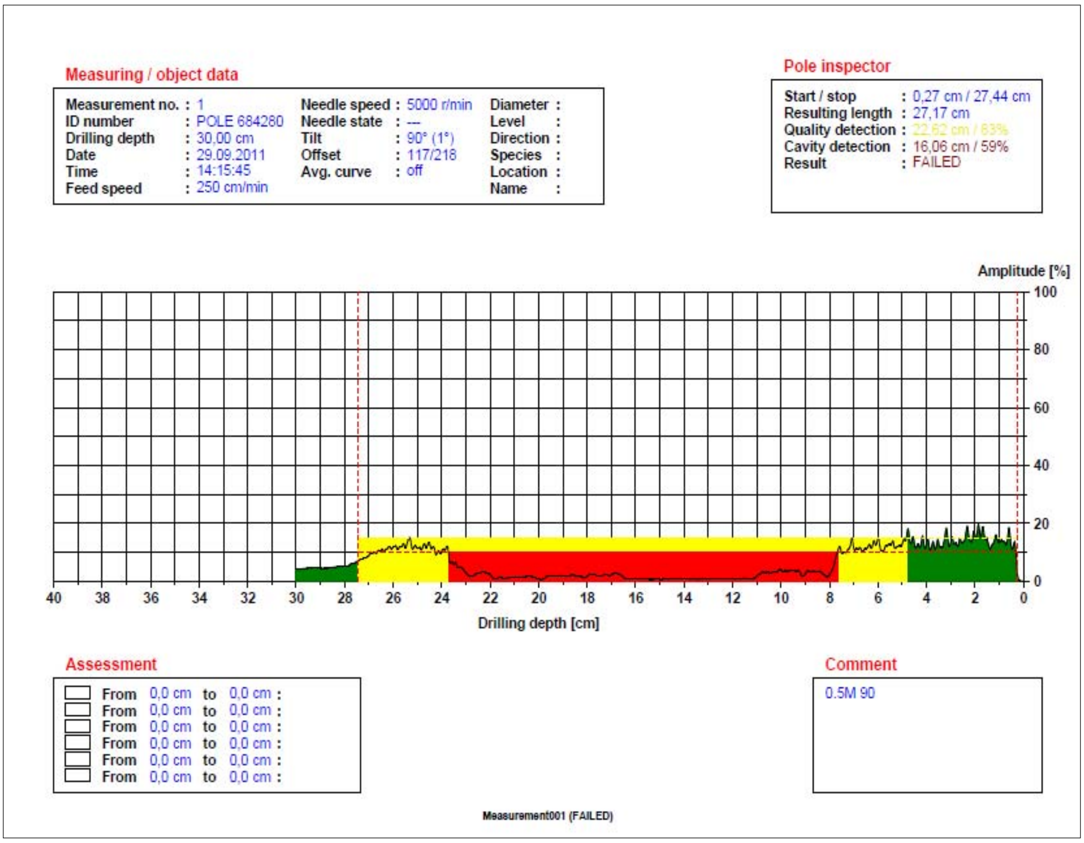

Figure 14 - *Sample Output from Resistograph*

4.0 Cables

4.1 Asset Information

The main types of underground cable on the network are given in table 19 below.

Voltage	Cable Type	Length (km)
132kV	Fluid	194
132kV	Solid	57
EHV	Fluid	611
EHV	Solid	1,816
HV (2-11kV)	Solid	19,685
LV	Solid	39,982
All (exc Services)	**All**	62,345

Table 16 - Cable Asset Information. Source: 21st February ED1 RIGs

Breakdown of LV and HV Cables:

6.6/11kV – The length 19,685km is made up of various types: mainly Paper Insulated Lead Covered (PILC), Screened Corrugated Aluminium Sheath (SCAS) and, latterly, XLPE (Triplex).

LV – The length 39,892km is made up of various types: mainly Paper Insulated Lead Covered (PILC) (26,041km), Waveconal (aluminium cores and neutral), Hybrid (aluminium cores and copper neutral) (XLPE total 13,848km), CONSAC – Concentric Neutral Solid Aluminium Conductor (3km).

4.2 Summary of Fault Trends, Failure Modes, and Fault Rates

Fault data applies only to solid insulated cable, because loss of oil or gas pressure in other cables rarely leads to electrical failure due to protection systems to detect this.

Fault rates, based on the average of the past five years (2007/8 through to 2011/12) are show in table 17 below.

Table 4.2 – Fault Rates

Voltage	Faults per annum	Faults per 100 km
132kV	5	8.77
EHV	89	5.06
HV	767	3.92
LV	2,763	6.93
LV Services	3,045	N/A

Table 17 Fault Rates. (Source: IIS and UKPN Fault Cube)

132kV – The small number of these faults makes it difficult to reliably identify long-term trends and fault rates (see figure 15). The trend over the past five years shows steeply increasing volumes, whereas it is expected that the longer-term trend will increase less sharply. The forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12), shows no increase in the rate of faults predicted across the period for the reasons described below in the Faults Plan.

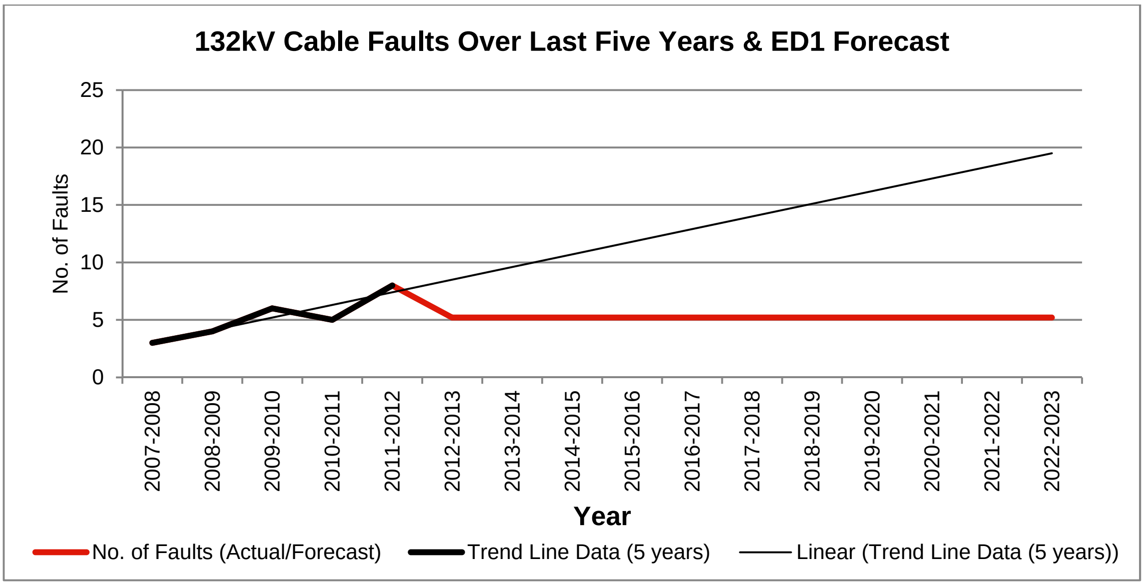

Figure 15 – *132kV Cable Faults* (**Source: IIS and UKPN Fault Cube**)

EHV – The trend over the past five years shows decreasing volumes (see Figure 16). However, the forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12), shows volumes remaining constant across the period in line with the Faults Plan below.

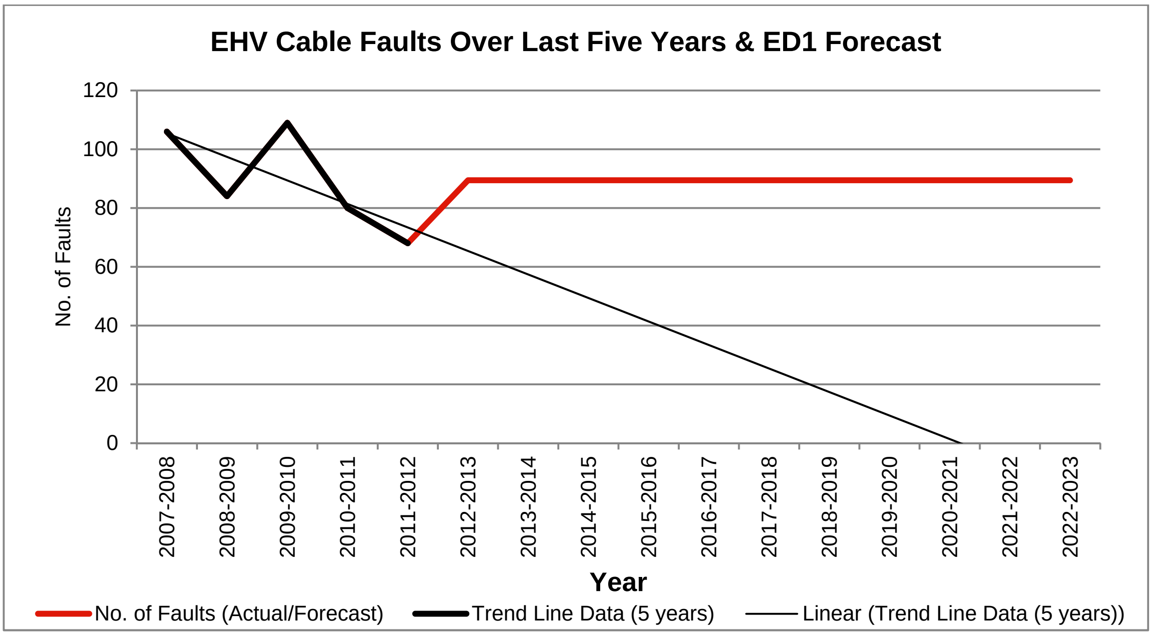

Figure 16 – *EHV Cable Faults (Source: IIS and UKPN Fault Cube)*

HV (6.6/11kV) - The fault profile shows increases in volume from 2007/8 to 2010/11 and a decrease in 2011/12. The forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12), shows volumes rising by 1% per year across the period in line with the majority of the previous period. This is illustrated in figure 17.

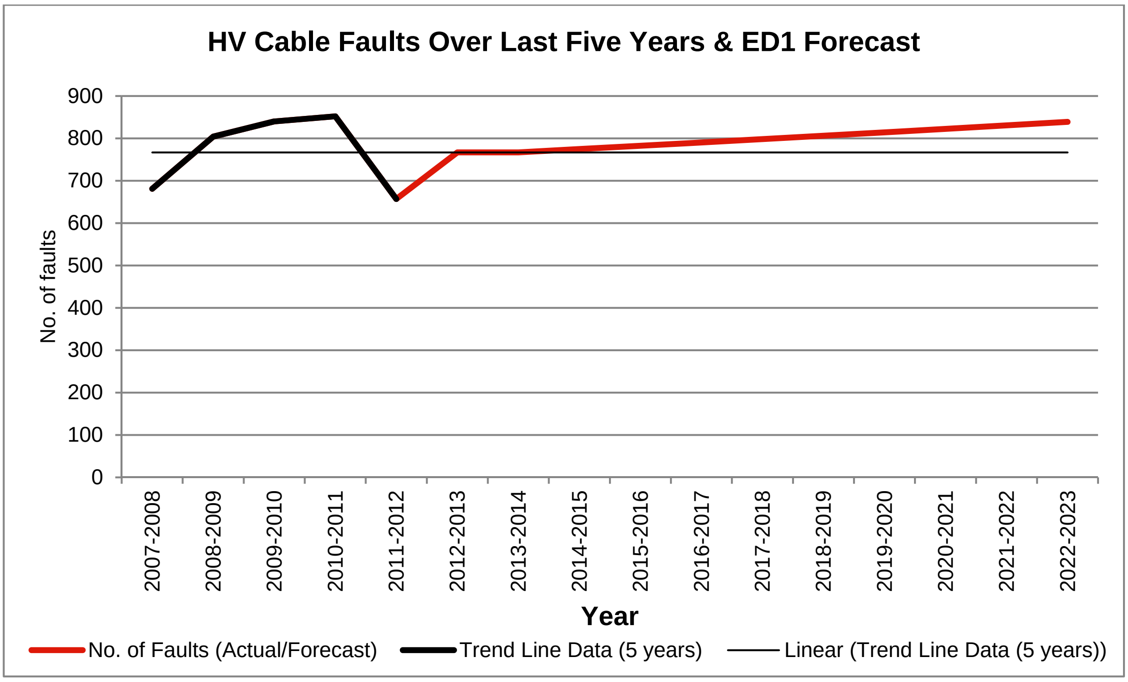

Figure 17 - *HV Cable Faults (Source: IIS and UKPN Fault Cube)*

LV - The fault trend shows an increase over the past five-year period. In line with this, the forecast, starting from 2013/14 at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12), shows volumes rising by 1% per year across the period. This is illustrated in figure 18.

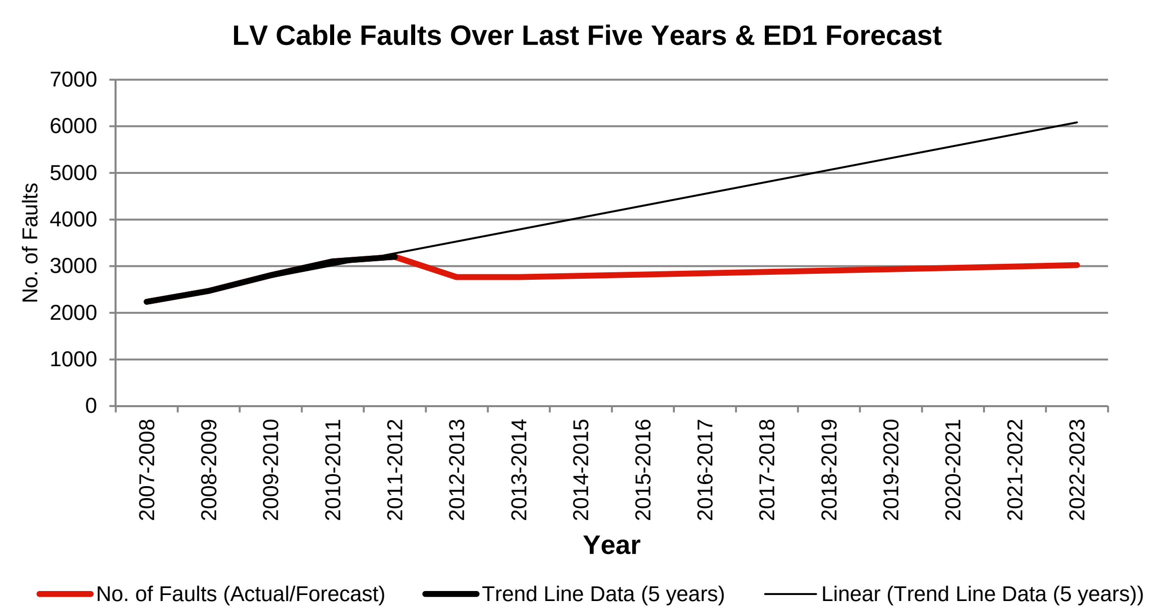

Figure 18 – *LV Cable Faults (Source: IIS and UKPN Fault Cube)*

Services – A slightly decreasing trend can be seen over the past five years. The forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12), shows volumes remaining constant across the period. See figure 19.

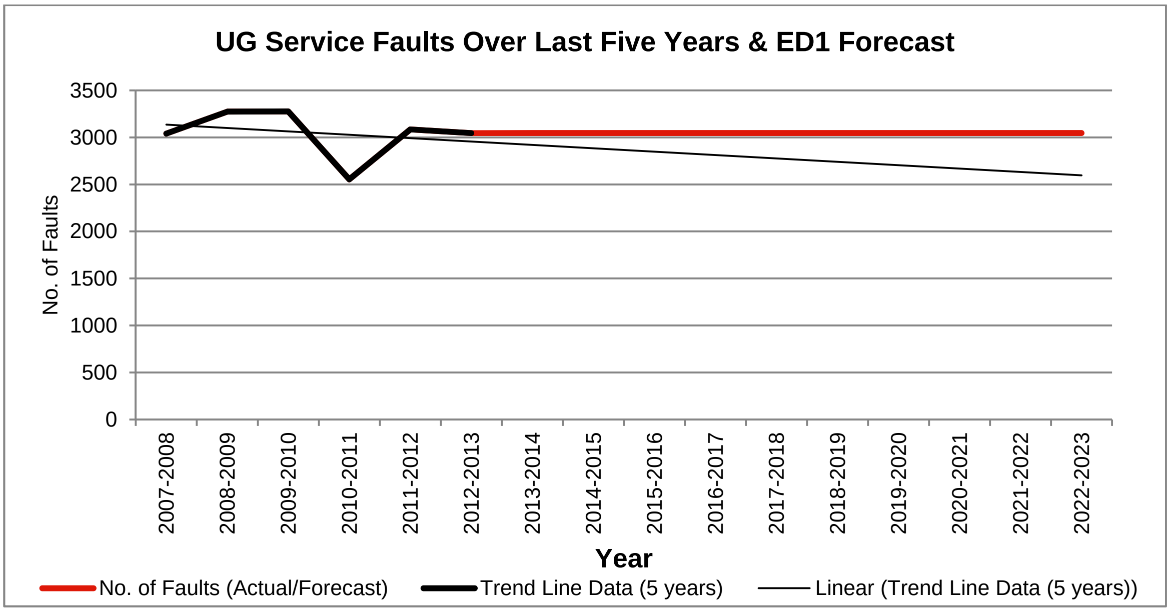

Figure 19 - UG Service faults (**Source: IIS and UKPN Fault Cube**)

4.3 Faults Plan

At 132kV, it is proposed to maintain volumes at a steady state from 2013/14 across ED1. Due to the small volumes, the figures show volatility year on year, with the historic trend varying greatly.

The five-year fault rates of EHV cables showed a decreasing trend which is in contrast to the forecast. The relatively stable network lengths will not significantly increase volumes, but the ageing asset base will gradually deteriorate further over the period leading to a higher number of faults. As this activity is almost entirely reactive, the identification of cables for replacement can only be made once they have been determined as poorly performing. It is unlikely that this downward trend will continue and therefore it is proposed to maintain the forecast fault volumes at a constant level.

The fault rate of HV cables shows a rising trend over four out of the five years shown with the forecast showing a gradual increase in line with this. The network lengths are increasing each year, which in turn will increase volumes over a period, but the greater effect is the ageing asset base. Cables will deteriorate further over the period, leading to a higher number of faults. As this activity is almost entirely reactive, the identification of cables for replacement can only be made once they have been determined as poorly performing. It is therefore proposed to increase the forecast fault volumes by 1% per year.

The fault rate of LV cables shows an increasing trend over the past five years, which aligns with the forecast. The network lengths are increasing each year, which in turn will increase volumes over a period, but the greater effect is the ageing asset base. Cables will deteriorate further over the period, leading to a higher number of faults. As this activity is almost entirely reactive, the identification of cables for replacement can only be made once they have been determined as poorly performing. It is therefore proposed to increase the forecast fault volumes by 1% per year.

The fault rate of service cables shows a decreasing trend over the past five years. The number of services is increasing each year, which in turn will increase fault volumes over a period, but the greater effect is the ageing asset base. Services will deteriorate further over the period, leading to a higher number of faults. As this activity is almost entirely reactive, the identification of services for replacement can only be made once they have been determined as poorly performing. It is therefore proposed to maintain the forecast fault volumes at a steady state.

Validated data is not available for Street Lighting Faults (unmetered services) so no graph has been produced. Street Lighting faults would tend to follow the trend of LV mains cable faults as they are in similar locations. On occasions these are the result of previous third party damages which cannot be recovered as those responsible cannot be identified so long after the event. It is proposed to maintain a steady state forecast volume for this category based on an historical reducing volume from RIGs.

Where restoration of supply is achieved solely by replacement of a blown fuse it is not possible to identify the cause of the incident. There is a robust process for identifying repeat fuse operations which may then be categorised as fleeting faults or loading issues and dealt with accordingly. This category reflects both the rising volumes of LV cable faults, and reducing volumes of overhead faults giving an overall flat profile across ED1.

EHV and HV supply restoration directly relates to the total number of faults in these categories and therefore the volumes reflect the various trends shown above.

Table 18, Table 19 and figure 20 show the volume profiles in ED1 and ED2.

Description of Activity	RIGs Reference	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
132kV Cable Fault Non Pressurised	CV15a Line 35	6	5	6	2	6	6	6	6	6	6	6	6	6	6
132kV Cable Fault Pressurised	CV15a Line 34	0	0	2	0	1	1	1	1	1	1	1	1	1	1
132kV Fault Restoration by Switching Only (UG)	CV15a Line 9	Data not available				1	1	1	1	1	1	1	1	1	1
Total 132kV UG Cable Faults		**6**	**5**	**10**	**2**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**
33kV U/G Fault Pressurised	CV15a Line 29	2	6	6	12	6	6	6	6	6	6	6	6	6	6
EHV U/G Fault Non Pressurised	CV15a Line 30	113	76	62	78	76	82	82	82	82	82	82	82	82	82
EHV Fault Restoration by Switching Only (UG)	CV15a Line 8	Data not available	63	51	53	2	2	2	2	2	2	2	2	2	2
Total EHV UG Cable Faults		**115**	**145**	**119**	**145**	**84**	**90**	**90**	**90**	**90**	**90**	**90**	**90**	**90**	**90**
11kV cable fault repairs	CV15a Line 22	963	1318	792	784	767	774	782	790	798	806	814	822	830	839
HV Fault Restoration by Switching Only (UG)	CV15a Line 7	850	1396	1332	418	418	418	418	418	418	418	418	418	418	418
Total HV UG Cable Faults		**1813**	**2714**	**2124**	**1202**	**1,185**	**1,192**	**1,200**	**1,208**	**1,216**	**1,224**	**1,232**	**1,240**	**1,248**	**1,257**
LV Underground Cable Fault (Consac)	CV15a Lines 18	19	32	22	14	445	338	23	23	23	23	23	23	23	23
LV U/G Cable Fault Repairs	CV15a Line 17	3,394	3648	3741	3981	2,763	2,787	2,819	2,847	2,904	2,933	2,962	2,992	3,022	3,022
Service Fault Repairs Underground	CV15a Line 15	4,487	3,628	4187	4679	3,047	3,045	3,045	3,045	3,045	3,045	3,045	3,045	3,045	3,045
Street Lighting Fault Replacement - Underground	CV15b Line 7	9,541	7,674	6,186	7009	5,170	5,170	4,182	4,182	4,182	4,182	4,182	4,182	4,182	4,182
Blown LV Fuses at Substations	CV15a Lines All 6 (Includes OH), 17, 18, 19, 20	10,652	10,287	8538	11,156	4,486	4,486	4,486	4,486	4,486	4,486	4,486	4,486	4,486	4,486
Cut Out Fuses (Formerly CFS Costs)	CV15b Line 9	1,522	2962	2558	2771	2,729	2,593	2,593	2,593	2,593	2,593	2,593	2,593	2,593	2,593
Responding to Critical Safety Calls	CV15b Line 16	9,918	10,315	13,734	9301	10,292	10,292	10,292	10,292	10,292	10,292	10,292	10,292	10,292	10,292

Description of Activity	RIGs Reference	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Abortive Call (previously Powercare Emergency Rechargeable)	CV15b Line 14	491	263	17245	17422	11,658	11,658	9,326	6,995	4,663	2,332	583	583	583	583
Metering Fault	CV15b Line 15	424	637	520	499	502	502	401	321	257	206	206	206	206	206
Pilot Wire Failures	CV15b Line 17	All volumes included in UG Services				8	19	20	20	20	20	20	20	20	20
Total LV UG Cable Faults		**40,447**	**39,446**	**56,731**	**56,832**	41,092	40,871	37,167	34,784	32,445	30,092	28,372	28,402	28,432	28,432

Table 18 - DPCR4, DPCR5 & ED1 History/Forecast - Cable Faults (Source 21st February ED1 RIGs & NAMP Table O)

Supply restoration, blown fuses and miscellaneous faults are also applicable to overhead lines and, to some extent, switchgear, but the majority of incidents are in this cable category. Service fault repairs also include faults on risers and laterals.

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031	2031/2032
Total 132kV UG Cable Faults	8	8	8	8	8	8	8	8	8
Total EHV UG Cable Faults	923	1,015	1,117	1,228	1,351	1,486	1,635	1,798	1,978
Total HV UG Cable Faults	1,341	1,433	1,535	1,646	1,769	1,904	2,053	2,216	2,396
Total LV UG Cable Faults	28,754	29,087	29,452	29,855	30,297	30,784	31,319	31,908	32,556

Table 19 - ED2 Forecast - Cable Faults

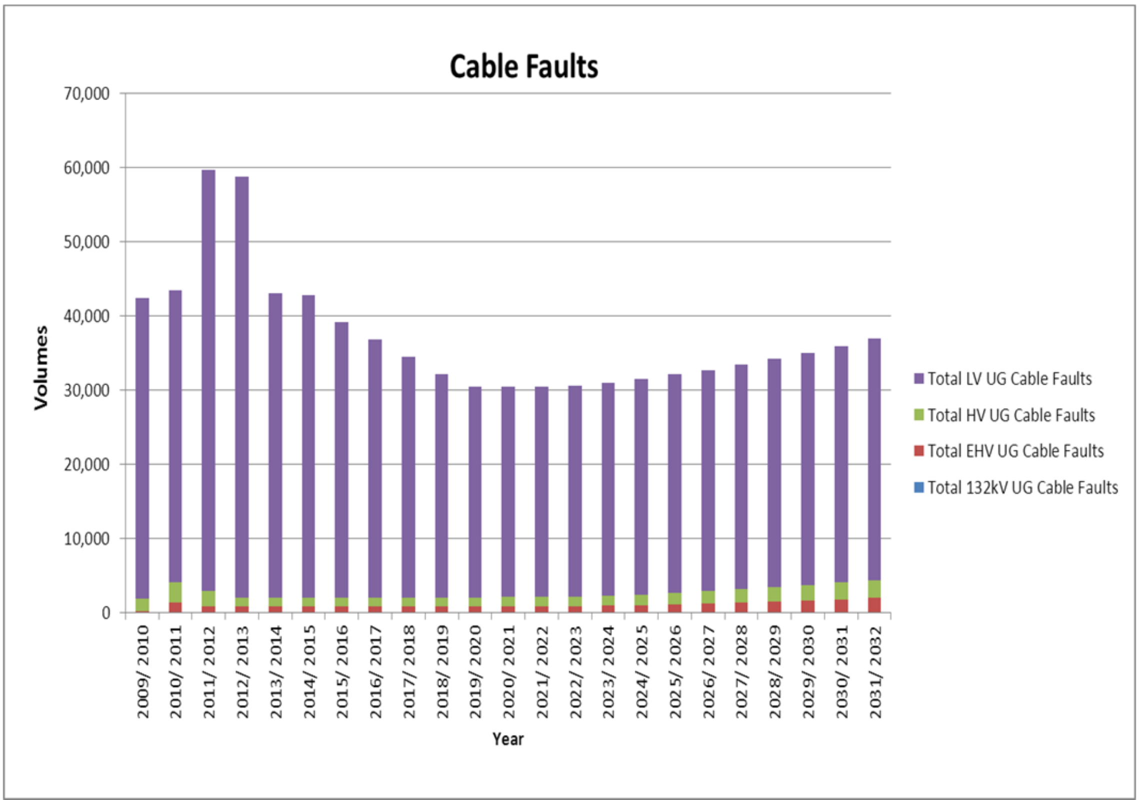

Figure 20 – *Cable Faults* ***DPCR4, DPCR5, ED1 & ED2 Historical and Forecast Values***

4.4 I&M Drivers

Operator, public and network safety are the leading drivers for an optimised inspection and maintenance regime, with ongoing monitoring of compliance to Electricity, Safety, Quality and Continuity Regulations (ESQCR), and continuing clearance of defects. Public safety is particularly pertinent to this class of asset as it is mainly to be found on private property or highways.

Identification and clearance of defects revolves mainly around fluid/gas-filled cables, ensuring the monitoring equipment is recording effectively and, where leakage is observed, the correct actions are put in place. Environmental considerations will determine when leaks are to be repaired.

Defects on other cable types may be identified due to leaking of compound or oil from cable termination boxes, or damage to overhead line terminations.

The condition of an asset, which determines its Health Index, is also of paramount importance in identifying the most appropriate maintenance interventions and investment strategies that provide the best value for money.

Consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is an important aspect of managing these assets utilised by UK Power Networks. Trade-off between Opex and Capex is examined and whole life cost assessment examples are provided in the Capex related narrative documents.

4.5 I&M Interventions

Fluid pressure gauges, with or without remote alarms, and pressure transducers, require gauge readings to be taken and checked for correct operation, accuracy and hydraulic operation. Readings vary between monthly and four years; operation between two and four years; accuracy between two and eight years; and hydraulic operation every two or eight years.

Where cables run with an insulated sheath, and it is known to be intact, a full test will be carried out every two years. Where cables run with lengths of uninsulated sheaths it is not possible to test them. Sheath voltage limiters will have a full test every two years, while cable residual gas pressure checks and dissolved gas analysis will be carried out every eight years.

While carrying out tower and wood pole inspections, ancillary equipment such as cable terminations will be checked. Inspections of grid/primary sites and secondary substations include inspections of cable terminations.

4.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EMS 10-7001 outlines the inspection and maintenance of underground cables.

4.7 I&M Plan

Fault rates and failure modes have not highlighted any particular changes that may be required to the above regime. The plan reflects consistent I&M interventions in line with the above policy.

Inspection of unmetered services is increasing during DPCR5 with the LV volumes levelling off into ED1 having re-assessed processes to comply with ESQCR obligations, and this is reflected in the total spend in this category.

Table 20, Table 21 and figure 21 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Gauges-132/33kV inspect and alarm test	491	270	270	270	270	270	270	270	270	270
Sub-standard gauge checks (tank inspection above ground)	130	113	61	61	61	61	61	61	61	61
Tank inspection (above ground)	130	130	130	130	130	130	130	130	130	97
Gauge mal function investigation	11	9	9	9	9	9	9	9	9	9

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Discharge mapping - 132-33kV	1	1	2	2	2	2	2	2	2	2
Calibrate Pressure Gauge	6	6	6	6	6	6	6	6	6	6
Inspect and Test Pressure Gauge	212	69	69	69	69	69	69	69	69	69
Check Pressure (Oil/Gas)	31	24	24	24	24	24	24	24	24	24
Test Cable Serving / Oversheath	1	2	2	2	2	2	2	2	2	2
Test Sheath Voltage Limiters (SVLs)	3	4	10	10	10	10	10	10	10	10
132/33kV Inspection Total	**1,016**	**628**	**583**	**583**	**583**	**583**	**583**	**583**	**583**	**550**
Oil top up; Pumping & Testing - 132-33kV	46	50	55	55	55	55	55	55	55	55
Repair Oil Leak	31	34	38	42	42	42	42	42	42	42
Replace minor oil plant + sheath testing	1	5	5	5	5	5	5	5	5	5
Pilot Cable Repairs	8	19	20	20	20	20	20	20	20	20
Installation & Maintenance of on-line pd monitoring	60	60	60	60	60	60	60	60	60	60
132/33kV Maintenance Total	**146**	**168**	**178**	**182**	**182**	**182**	**182**	**182**	**182**	**182**
Includes RIGs Lines: CV13 Lines 42, 43, 56, 57, 70, 71										
Partial Discharge mapping - HV	4	14	8	8	8	8	8	8	8	8
Online Partial Discharge Field Investigations	6	0	0	0	0	0	0	0	0	0
HV Inspection Total	**10**	**14**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**
Abandoned/unidentified cable location	4	18	18	18	18	18	18	18	18	18
HV maintenance Total	**4**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**
Includes RIGs Lines: CV13 Lines 21, 22										
Idle Service Inspection	9,142	9,290	9,066	9,066	9,066	9,066	9,066	9,066	9,066	9,066
Inspect service turret	144	150	159	161	161	161	161	161	161	161
LV Inspection Total	**9,286**	**9,,440**	**9,225**	**9,227**	**9,227**	**9,227**	**9,227**	**9,227**	**9,227**	**9,227**
UMS Services Inspected	5,060	6,561	10,526	10,526	10,526	10,526	10,526	10,526	10,526	10,526
LV Maintenance Total	**5,060**	**6,561**	**10,526**	**10,526**	**10,526**	**10526**	**10,526**	**10,526**	**10,526**	**10,526**
Includes RIGs Lines: CV13 Lines 13, 15, 16, 17										
General Network Enquiries										
EMF enquiries (Volume)	109	109	109	109	109	109	109	109	109	109
Voltage/load investigations	1,600	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472
Cross Voltage Total	**1,709**	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**
Included in other RIGs Lines										

Table 20: DPCR5 & ED1 Volumes Forecast – I&M Cables. (Source: 19th February 2014 NAMP, Table O)

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
132kV/EHV Inspection	**579**	**579**	**579**	**579**	**579**	**579**	**579**	**579**
132kV/EHV Maintenance	**182**	**182**	**182**	**182**	**182**	**182**	**182**	**182**
HV Inspection	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**
HV Maintenance	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**
LV Inspection	**9,227**	**9,227**	**9,227**	**9,227**	**9,227**	**9,227**	**9,227**	**9,227**
LV Maintenance	**10,526**	**10,526**	**10,526**	**10,526**	**10,526**	**10,526**	**10,526**	**10,526**
Cross Voltage	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**	**1,581**

Table 21: ED2 Forecast – I&M Cables

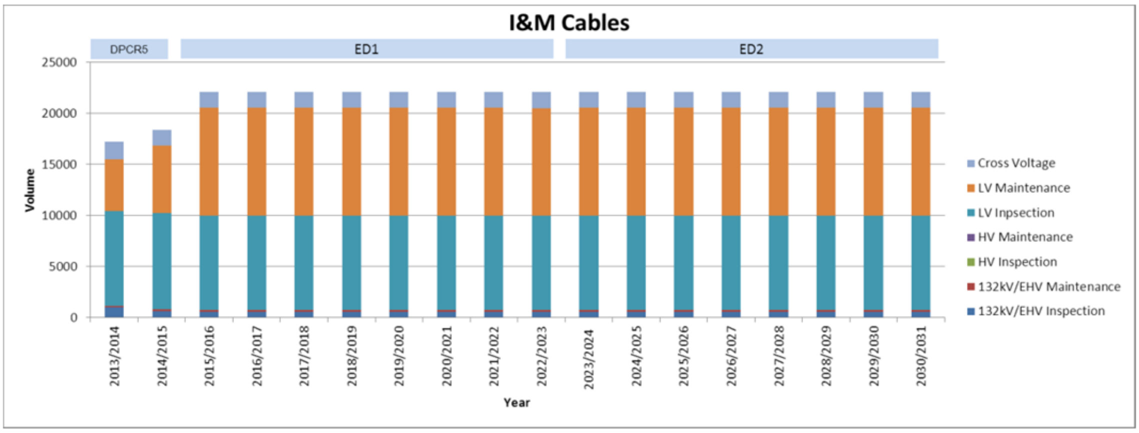

Figure 21 - *DPCR4, DPCR5, ED1 & ED2 Historical and Forecast Values*

4.8 Innovation

Online partial discharge monitoring has been introduced through an Innovation Funding Initiative (IFI) project, and has recently been adopted into "business as usual". These comprise fixed installations to monitor earth leakage current levels from source circuit breakers at primary substations. The equipment "looks" into the network as far as the first substation out on a feeder or to a maximum length of around one kilometre. Increasing levels of earth leakage current indicate a potential fault on the cable, and work is ongoing to validate the change in current levels leading to potential faults. Portable online units can be fitted further down the network to identify issues in other cable sections. Offline monitoring is also carried out where reliability of circuits may be in question and where fixed units have not been installed. This technology is still being evaluated, but its benefits are expected to be twofold:

1) Better information feeding into the cable replacement capex programme(s)
2) Quicker location of faulty feeders,

albeit realisation of any savings may only be achievable once the relationship between partial discharge and cable failures has been established. Consequently no cost benefit has been shown during ED1.

Introduction of Perfluorocarbon tracers (PFT) into fluid-filled cables with leaks is intended to reduce the number of excavations required to find the leakage point. The injection of PFT into the cable allows its detection around the leak site permitting a more accurate location than was previously the case where multiple excavations were often required to establish the site of the leak. Further analysis will be required before any savings can be shown.

5.0 132kV Switchgear

5.1 Asset Information

The total volume in this category is 291 items of plant, split into three main types of circuit breakers (CBs): air blast, bulk oil and SF_6 with associated isolators and busbars.

5.2 Summary of Fault Trends, Failure Modes, and Fault Rates

All CB types (including isolators and busbars) – The small number of these faults makes it difficult to reliably identify long-term trends and fault rates. The forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12), shows no change in volumes over the period. This is illustrated in figure 22.

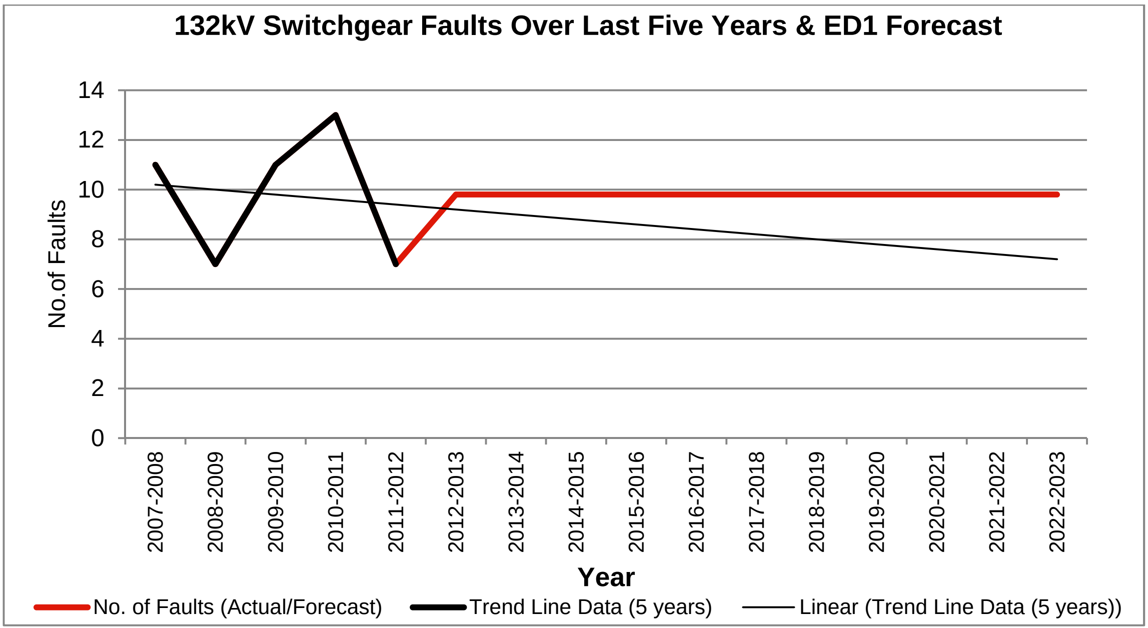

Figure 22 -*132kV switchgear faults (**Source: IIS and UKPN Fault Cube**)*

5.3 Faults Plan

The above graph shows a decreasing trend, although due to the small numbers of these faults (0.034 per asset) it is difficult to reliably forecast volumes. With the volume in 2013/14 set at the average of the past five years (2007/8 through to 2011/12), it is proposed to keep the volumes constant from then across ED1. The volumes are small leading to volatility year on year, but the trend appears to vary historically around a mean value of 10 faults per annum.

Volumes are combined with Grid & Primary 132kV transformers (10.3) in order to provide a more predictable forecast. Table 22, Table 23 and figure 23 show the volume profiles in ED1 and ED2.

Description of Activity	RIGs Reference	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
132kV Plant Fault	CV15a Line 37	30	42	30	22	17	17	17	17	17	17	17	17	17	17
Total 132kV Plant Faults		**30**	**42**	**30**	**22**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**

Table 22 - DPCR5 & ED1 History/Forecast – 132kV Plant Faults (Source: 21/02/2014 1 RIGs & NAMP Table O)

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Total 132kV Plant Faults	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**

Table 23 - DPCR4, DPCR5 & ED1 History/Forecast – ED2 Forecast - 132kV Plant Faults

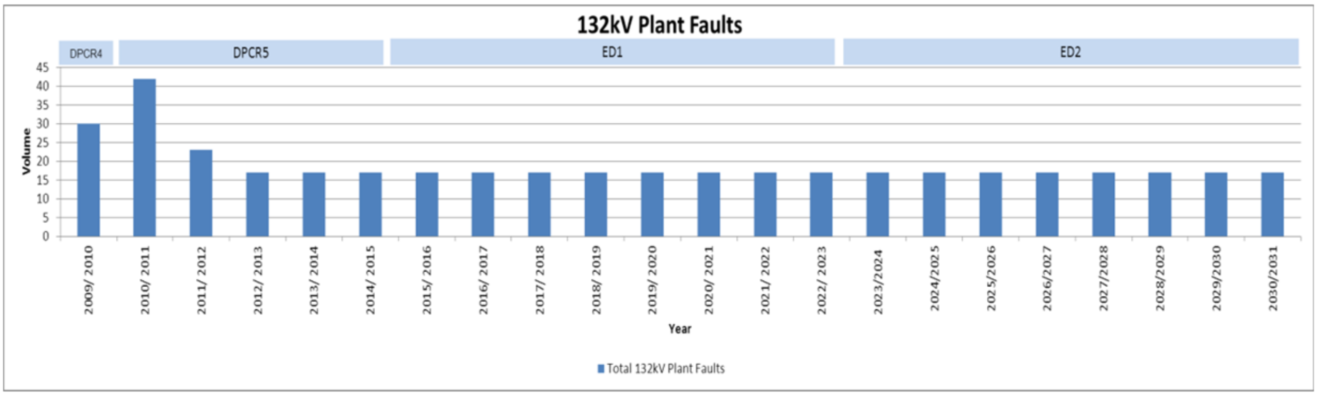

Figure 23 - *DPCR4, DPCR5, ED1 & ED2 Historical and Forecast Values*

5.4 I&M Drivers

Safety is the top priority, with ongoing monitoring of identification and clearance of defects. Information from the National Defect Reporting Scheme provides an insight into other operators' experiences and an opportunity for UK Power Networks to review its I&M regime against issues found.

Functional performance of this equipment in terms of both its protection and control, as well as the operation of the CB itself, is important for limiting the numbers of customers affected by faults.

The requirement for post-fault maintenance on oil circuit breakers must be met to maintain the operational capability.

Pressurised items of equipment are inspected and maintained in line with statutory requirements.

The condition of an asset, which determines its Health Index, is of paramount importance for identifying interventions and investment strategies that provide the best value for money.

Consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is always a factor in managing these assets

5.5 I&M Interventions

Inspections of all plant were completed every four months until the beginning of 2013 when this was amended to every six months following an RCM assessment. Alternate inspections are minor and major. Exceptions to this are detailed in the innovation section.

Air Blast CBs are operated every two years and have minor maintenance every four years and full maintenance every 12 years. Statutory inspection of the associated pressurised equipment is carried out in accordance with the individual Written Scheme of Examination. A “Written Scheme of Examination” relates to statutory inspection of pressurised vessels such as air compressors etc associated with air blast circuit breakers. This document outlines the requirements for a particular item of equipment including the frequency of inspections.

The periodic operations of the CBs are timed to identify any slow opening units.

Bulk Oil CBs are operated once a year, with maintenance every six years alternating between mechanism maintenance and full maintenance.

SF_6 CBs are operated every two years, with full maintenance every 12 years, with statutory inspections where required in line with the individual Written Scheme of Examination. Gas quality, including gas zones in GIS boards, is checked every 12 years.

Isolator operation is every six years for manual units, and every two years for motorised types. Time-based maintenance has recently been withdrawn, as explained in the innovation section, and replaced with a reactive regime.

Post-fault maintenance on 132kV oil circuit breakers is carried out after six fault trips, and is recorded as a full maintenance.

Specific makes and types may require enhanced inspection and maintenance from the norm, and these are identified in the appendices of EMS 10-0002 which sets the frequencies for I&M interventions.

5.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EI 10-1501 details maintenance requirements for 132kV to 22kV switchgear, while EMS 10-0005 details the requirements for batteries and chargers.

5.7 I&M Plan

Fault rates and failure modes have not highlighted any particular changes that may be required to the above regime. The plan reflects consistent I&M interventions in line with the above policy, but incorporates a reduction in inspection activity to reflect the change in frequency of minor site inspections which is detailed in section 12. Variances in volumes year on year are significantly affected by circuit breaker maintenance schedules.

Table 24, Table 25 and figure 24 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Inspect Air Compressor	294	233	231	232	232	232	232	232	232	232
Inspect Main Air Receiver	21	63	63	63	63	63	63	63	63	63
Insurance Insp. Air/Gas Receiver	8	15	15	15	15	15	15	15	15	15
Insurance Insp. ABCB Complete Unit	17	29	29	29	29	29	29	29	29	29
Insurance Insp. Air Panel	3	1	1	0	2	7	1	0	2	7
Inspect Flexible Earths & Rods Note 1	179	96	220	220	220	220	220	220	220	220
Infra-Red Inspection Aerial Sets/Busbars Note 2	534	535	535	535	535	535	535	535	535	535
Insurance Insp Switchgear Accumulator	4	4	4	4	4	4	4	4	4	4
Defect Repair - 132/66 kV Switchgear	22	92	92	93	94	96	96	97	98	100
Maintain Full 132/66kV Air Blast CB	9	10	4	8	15	9	6	7	12	12
Maint Full 132/66kV Oil CB	1	1	0	1	0	1	0	0	0	1
Maint FULL 132/66kV SF6 O/D CB	2	3	3	3	5	16	18	18	24	14
Maintain Mechanism 132/66kV Oil CB	0	0	0	2	3	2	1	1	0	1
Maint MECH 132/66kV SF6 O/D CB	1	4	4	4	4	4	4	4	4	4
Trip Test 132/66kV CB & op of ext isol.	212	128	6	6	6	6	6	5.1	6	4
Maintain Isolator (Manual)	38	39	39	39	39	39	39	39	39	39
Maint. Isolator (Motorised)	15	11	11	11	11	11	11	11	11	11
Maintain Earth Switch	35	39	39	39	39	39	39	39	39	39
Maintain LV AC Board	1	2	3	9	14	16	6	1	3	4
Maintain Air Compressor	29	29	29	29	29	29	29	29	29	29
Maintain Air Insulated Busbars 33/22kV	27	0	0	0	0	0	0	0	0	0
Maintain Mech 132/66kV Air Blast CB	22	9	9	10	10	9	9	9	9	9
132/66kV plant painting	2	10	10	10	10	10	10	10	10	10
Maint FULL 132/66kV SF6 GIS CB	0	4	12	16	0	0	1	10	21	3
Maint MECH 132/66kV SF6 GIS CB	9	1	1	1	1	1	1	1	1	1
Maintenance Total	**1,485**	**1,358**	**1,360**	**1,379**	**1,380**	**1,393**	**1,375**	**1,379**	**1,406**	**1,386**
Includes RIGs Lines: CV13 Lines 60, 74										

Table 24 - DPCR5 & ED1 Forecast – I&M 132kV Switchgear. Source: 13th February 2014 NAMP Table O

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
132kv Switchgear Maintenance	**1,382**	**1,382**	**1,382**	**1,382**	**1,382**	**1,382**	**1,382**	**1,382**

Table 25 - ED2 Forecast – I&M 132kV Switchgear

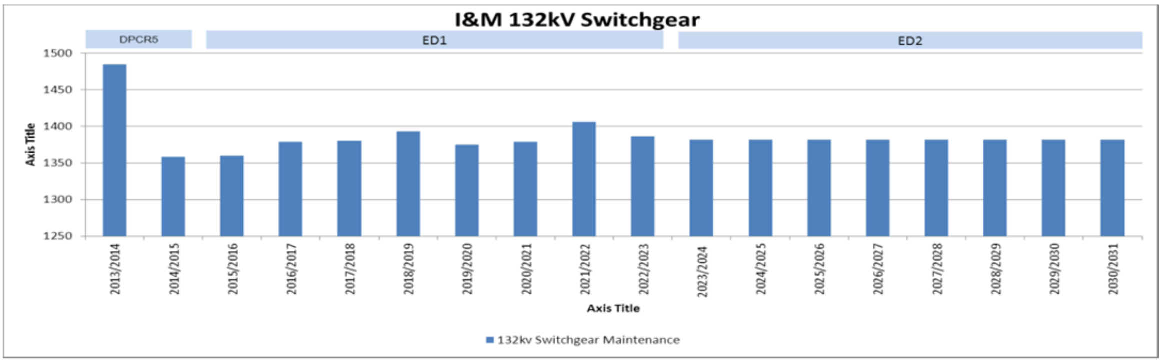

Figure 24 - *DPCR5, ED1 & ED2 Historical and Forecast Values*

5.8 Innovation

As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities the following have been changed to tailor the maintenance closer individual requirements:

The number of routine site inspections has been reduced to two per year, one minor and one major, with exceptions based on the site requirements, primarily batteries. A frequency of four months between minor inspections has been retained for sites where wet cells are installed, due to the higher level of intervention required. While on site for this, it is advantageous to carry out an extra minor inspection of plant for very little extra cost.

To evaluate this opportunity further we looked at how we gather condition data at grid sites. The assessment showed that apart from specific visits to formerly gather this information, many other visits are made for other reasons, such as vegetation management, switching etc. It is proposed to introduce methods to record such visits where it is a requirement to report any overt defects that may affect site security or present a safety or environmental hazard.

Mechanism maintenance for vacuum and SF_6 CBs has been withdrawn, as the correct operation of the units is checked every year by remotely opening and closing them, with a full service every 12 years. Often, manufacturers' of these units designate them as being lubricated for life, reducing what could be achieved from this type of action. Oil CBs were not aligned as there are generally of older designs requiring a higher level of intervention to maintain functionality.

Inspection and maintenance of busbars is fairly limited without large outages that introduce heightened network risk and customer outages. For air-insulated busbars, the annual thermal inspection will identify potential failure points; and for metal-clad busbars, monitoring of discharge on inspections will again identify issues. Time-based busbar maintenance has been withdrawn on this basis.

Isolator maintenance was set at every 12 years, which often involved large-scale outages creating increased network risk. The RCM assessment judged that the combination of thermal and visual inspections, along with the revised operation regime, will allow detection of problems with units before it would impact their functional capabilities.

6.0 EHV Switchgear

6.1 Asset Information

The total volume in this category is 1,380, split into 3 main types of circuit breakers (CB) – oil, SF_6 and vacuum – with associated isolators and busbars.

6.2 Summary of Fault Trends, Failure Modes, and Fault Rates

All CB types (including isolators and busbars) – The small number of these faults makes it difficult to reliably identify long-term trends and fault rates. The forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12) (22 per annum), shows no change in anticipated volumes over the period. This is illustrated in figure 25.

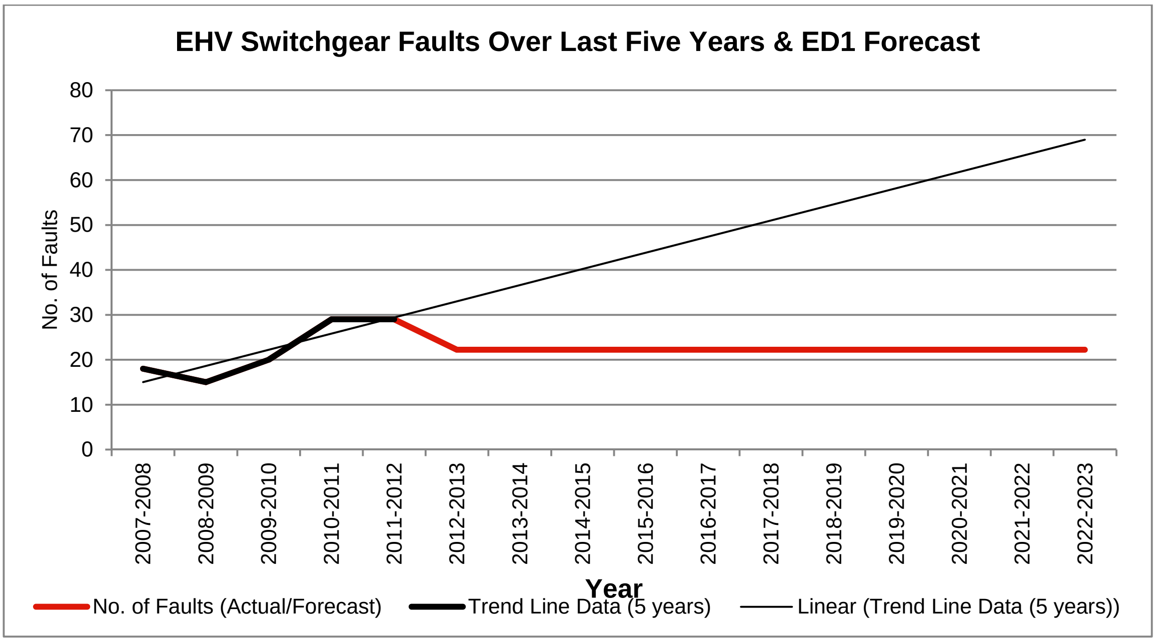

Figure 25 – *EHV Switchgear Faults (Data Source: IIS and UKPN Fault Cube)*

6.3 Faults Plan

Due to the small numbers of faults in figure 9 (0.016 per asset) it is difficult to reliably forecast volumes based on the trend. With the volume in 2013/14 set at the average over the past five years (2007/8 through to 2011/12), it is proposed to keep it constant from then across ED1. The volumes are small, leading to volatility year on year, with the historic trend shown varying greatly. EHV switchgear volumes are combined with Grid & Primary EHV transformers (10.3) in order to provide a more predictable EHV Plant forecast. Table 26, table 27 and figure 26 show the volume profiles in ED1 and ED2.

Description of Activity	RIGs Reference	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
EHV Plant Fault	CV15a Line 32	83	137	82	54	47	42	42	42	42	42	42	42	42	42
Total EHV Plant Faults		**83**	**137**	**82**	**54**	**47**	**42**	**42**	**42**	**42**	**42**	**42**	**42**	**42**	**42**

Table 26 DPCR4, DPCR5 & ED1 History/Forecast – EHV Plant Faults. Source: 21st February 2014 ED1 RIGs & NAMP Table O

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Total EHV Plant Faults	**42**	**42**	**42**	**42**	**42**	**42**	**42**	**42**

Table 27 - ED2 Forecast – EHV Plant Faults

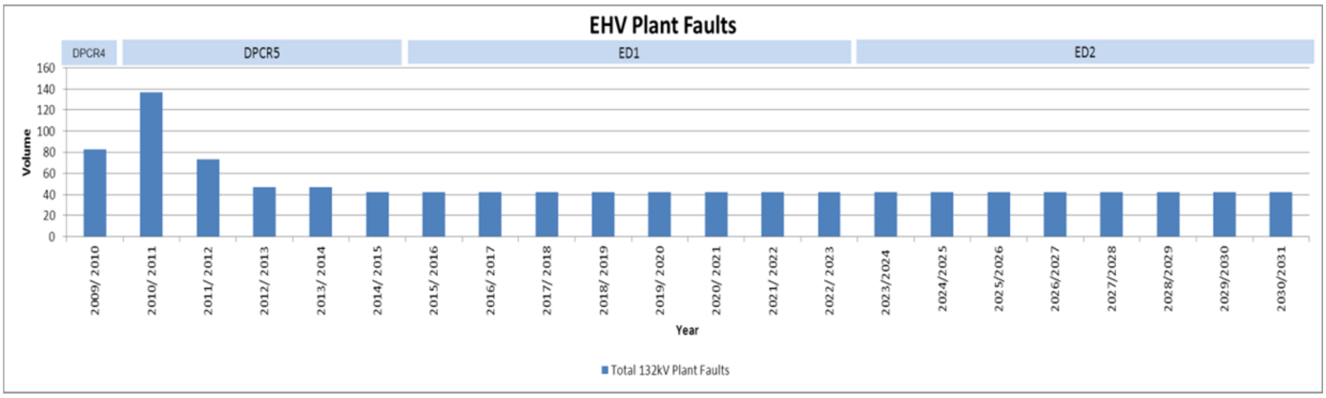

Figure 26 ***- DPCR4, DPCR5, ED1 & ED2 Historical and Forecast Values***

6.4 I&M Drivers

Safety is the top priority, with ongoing monitoring of identification and clearance of defects. Information from the National Defect Reporting Scheme provides an insight into other operators' experiences and an opportunity for UK Power Networks to review its I&M regime against issues found.

Functional performance of this equipment in terms of both its protection and control, as well as the operation of the CB itself, is important to limit the numbers of customers affected by faults.

The requirement for post-fault maintenance on oil circuit breakers must be met to maintain the operational capability.

Pressurised items of equipment are inspected and maintained in line with statutory requirements.

The condition of assets, which determines their Health Indices, is of paramount importance for identifying interventions and investment strategies that provide the best value for money.

Consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is always a factor in managing these assets.

6.5 I&M Interventions

Inspections of all plant were completed every four months until the beginning of 2013, when this was amended to every six months. Alternate inspections are minor and major. Exceptions to this are detailed in the innovation section.

Transformer and bus-section/coupler CBs are operated every year and feeder CBs every two years. The CBs are timed to identify any slow opening units. Oil CBs are maintained every six years alternating between mechanism maintenance and full maintenance. Figure 27 shows an insulation test on switchgear.

Post-fault maintenance on EHV oil circuit breakers is carried out after three fault trips on underground circuits and six fault trips on overhead ones, and is recorded as a full maintenance.

Specific makes and types may require enhanced inspection and maintenance from the norm, and these are identified in the appendices of EMS 10-0002 which sets the frequencies for I&M interventions.

Statutory inspections of pressurised equipment are scheduled in line with the individual Written Scheme of Examination.

Figure 27 - *Insulation testing of switchgear is important to understand its condition*

6.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EI 10-1501 details maintenance requirements for 132kV to 22kV switchgear, while EMS 10-0005 details the requirements for batteries and chargers.

6.7 I&M Plan

Fault rates and failure modes have not highlighted any particular changes that may be required to the above regime. The plan reflects consistent I&M interventions in line with the above policy, but incorporates a reduction in inspection activity to reflect the change in frequency of minor site inspections which is detailed in section 12.0. The fluctuating volumes reflect the variance in activity levels associated with the periodic operation and maintenance of circuit breakers. Table 28, Table 29 and figure 28 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Defect Repair - 33/22 kV Switchgear (Volume)	27	107	108	110	112	112	113	114	117	117
33kV OCB Painting (Volume)	13	12	13	12	13	12	13	12	12	12
Strategic Spares Provision (Volume) Note 1	45	54	75	75	75	75	75	75	75	75
Maintain Batteries and Charger (Volume)	136	307	472	472	472	472	472	472	472	472
Maintain 33/22kV Oil CB (Volume)	94	93	24	32	29	24	28	28	29	52
Maint FULL 33/22kV Vac/SF6 O/D CB (Volume)	12	23	14	6	11	18	20	31	20	20
Maint FULL 33/22kV Vac/SF6 F/P & GIS CB (Volume)	50	47	25	28	36	44	58	47	45	77
Maintain Mechanism 33/22kV Oil CB (Volume)	40	37	34	52	51	54	73	66	40	52
Maint MECH 33/22kV Vac/SF6 O/D CB (Volume)	13	4	4	5	5	4	4	4	4	4
Maint MECH 33/22kV Vac/SF6 F/P & GIS CB (Volume)	3	11	12	12	12	12	12	12	13	12
Trip Test 33/22kV CB inc op of Isolators (Volume)	1,081	956	949	970	949	970	949	970	891	747
Maint FULL 33/22kV Vac/SF6 W/D CB (Volume)	2	0	0	0	3	1	2	8	7	3
Maint MECH 33/22kV Vac/SF6 W/D CB (Volume)	1	1	1	1	1	1	1	1	1	1
Maintenance Total	**1,517**	**1,652**	**1,731**	**1,775**	**1,769**	**1,99**	**1,820**	**1,840**	**1,726**	**16,44**
Includes RIGs Lines: CV13 Lines 46, 49, 63, 77										

Table 28 – ED1 & ED1 Forecast – I&M EHV Switchgear. Source: 13th February 2014 NAMP Table O

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
EHV Switchgear Maintenance	**1,763**	**1,763**	**1,763**	**1,763**	**1,763**	**1,763**	**1,763**	**1,763**

Table 29- ED2 Forecast – I&M EHV Switchgear

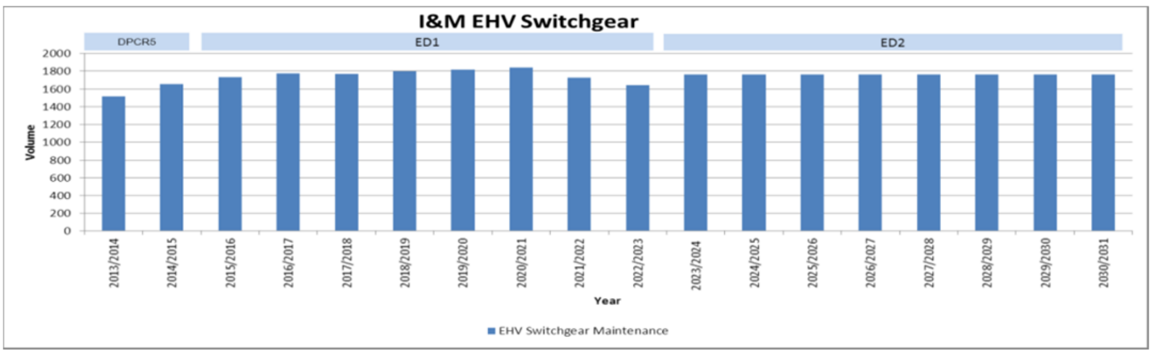

Figure 28 - *DPCR4, DPCR5, ED1 & ED2 Historical and Forecast Value*

6.8 Innovation

As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities the following have been changed to tailor the requirements closer to individual site and plant needs:

The number of routine site inspections has been reduced to two per year, one minor and one major, with exceptions based on the site requirements, primarily batteries. A frequency of four months between minor inspections has been retained for sites where wet cells are installed, due to the higher level of intervention required. While on site for this, it is advantageous to carry out an extra minor inspection of plant for very little extra cost.

To evaluate this opportunity further we looked at how we gather condition data at grid sites. The assessment showed that apart from specific visits to formerly gather this information, many other visits are made for other reasons, such as vegetation management, switching etc. It is proposed to introduce methods to record such visits where it is a requirement to report any overt defects that may affect site security or present a safety or environmental hazard.

Mechanism maintenance for vacuum and SF_6 CBs has been withdrawn, as the correct operation of the units is checked every year by remotely opening and closing them, with a full service every 12 years. Often, manufacturers' of these units designate them as being lubricated for life, reducing what could be achieved from this type of action. Oil CBs were not aligned as there are generally of older designs requiring a higher level of intervention to maintain functionality.

Inspection and maintenance of busbars is fairly limited without large outages that introduce heightened network risk and customer outages. For air-insulated busbars, the annual thermal inspection will identify potential failure points; and for metal-clad busbars, the monitoring of discharge on inspections will also identify issues. Time-based busbar maintenance has been withdrawn on this basis.

Isolator maintenance was set at every 12 years, which often involved large-scale outages creating increased network risk. It is considered that the combination of thermal and visual inspections, along with the current operation regime, will allow units to be maintained when they show initial signs of problems.

7.0 Primary Switchgear

7.1 Asset Information

The total volume in this category is 5,123, located specifically at primary substations. There are three main types of circuit breakers (CBs) – oil, SF_6 and vacuum with associated isolators and busbars. These units operate at 11/6.6kV and control the downstream side of transformers and outgoing feeders at primary sites.

7.2 Summary of Fault Trends, Failure Modes, and Fault Rates

All CB types (including isolators and busbars) – The volumes for this category are included under HV switchgear in section 8.3, as primary switchgear represents only a small proportion of the total volumes at this voltage. Table 30 shows the mechanism performance for all CBs and instances where CBs have failed to trip correctly for a fault over the past nine years. It is included in this section as it is mainly primary feeder CBs that suffer from stiction problems.

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
No of stuck CBs	5	4	11	3	12	5	12	13	5	5

Table 30 - Stuck CBs. Source: Major network investigation reports

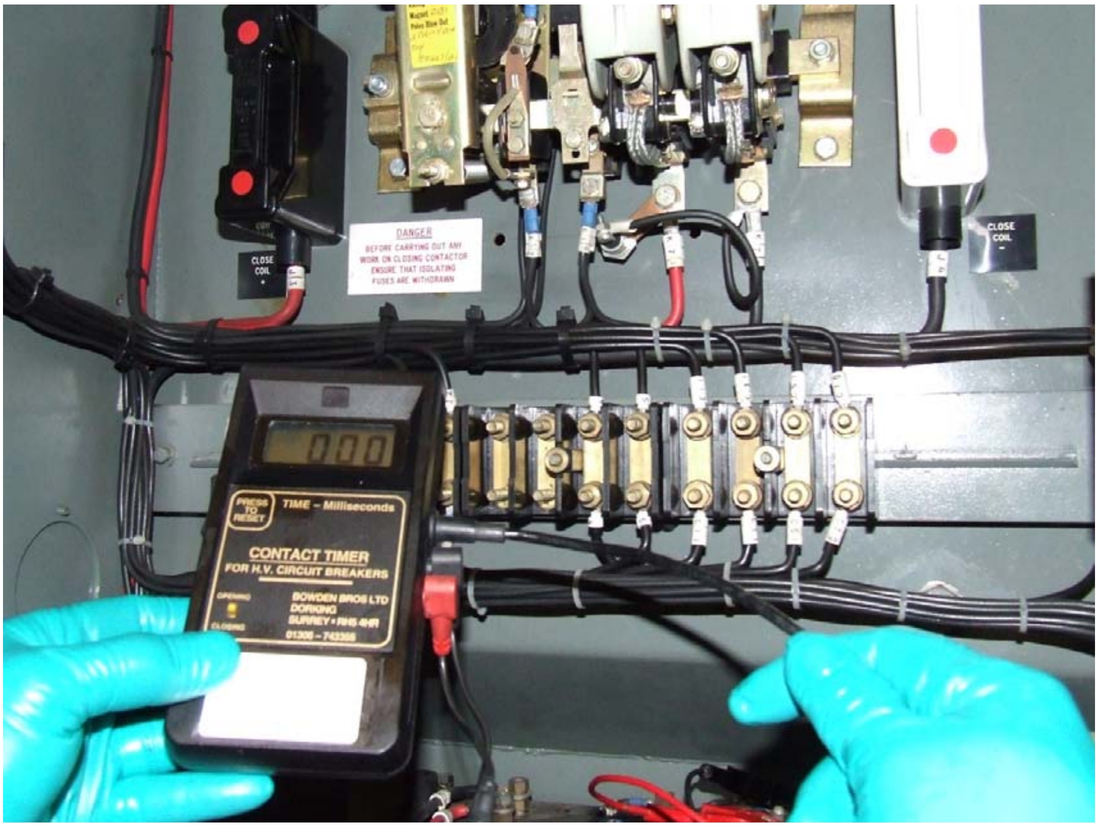

Figure 29 - *Circuit breaker timing tests are important to ensure continued operability*

7.3 Faults Plan

There is no separate analysis of this category due to the small number of faults, which makes it difficult to reliably forecast volumes. Fault data for this activity are included in the HV switchgear section 8.0, as it covers the larger population of switchgear operating at 11/6.6kV.

7.4 I&M Drivers

Safety is the top priority, with ongoing monitoring of identification and clearance of defects. Information from the National Defect Reporting Scheme provides an insight into other operators' experiences and an opportunity for UK Power Networks to review its I&M regime against issues found.

The requirement for post-fault maintenance on oil circuit breakers must be met to maintain the operating capability.

For this class of switchgear, specific attention is paid to functionality performance and, in particular, instances where CBs have failed to trip for a fault, as this can significantly increase the number of customers affected.

The condition of assets, which is used to determine their Health Indices, is of paramount importance for identifying interventions and investment strategies that provide the best value for money.

Consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is always a factor in managing these assets.

7.5 I&M Interventions

Inspections of all plant were completed every four months until the beginning of 2013, when this was amended to every six months. Alternate inspections are minor and major. Exceptions to this are detailed in the innovation section.

Transformer and automatic bus-section/coupler CBs are operated every year; and feeder, plus all non-remote control CBs, every two years. They are timed to identify any slow opening units.

Oil CBs are maintained every six years alternating between mechanism maintenance and full maintenance. This is kept under continual review in relation to instances of

CBs failing to trip for a fault. Figure 28 shows mechanism maintenance being carried out on an oil circuit breaker.

Post-fault maintenance on primary oil circuit breakers is carried out after three fault trips where the primary fault level is 150MVA or greater, and six fault trips where it is less than 150MVA, and is recorded as full maintenance.

Specific makes and types may require enhanced inspection and maintenance from the norm, and these are identified in the appendices of EMS 10-0002 which sets the frequencies for I&M interventions.

Figure 28 - *Carrying out mechanism maintenance on an oil circuit breaker*

7.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions, while EMS 10-0005 details the requirements for batteries and chargers.

7.7 I&M Plan

Fault rates and failure modes have not highlighted any particular changes that may be required to the above regime. Generally, the plan reflects consistent I&M interventions in line with the above policy, but incorporates a reduction in inspection activity to reflect the change in frequency of minor site inspections which is detailed in section 12. To reflect capex interventions proposed for ED1 (where oil CBs are replaced by vacuum or SF_6 CBs), maintenance of oil CBs has been reduced by a total of 16% from 2016/2017 pro-rata across the period. Table 31, Table 32 and figure 29 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Partial Discharge test of switchboard Note 1	435	441	441	441	441	441	441	441	441	441
Record EPR & Identification of Hot Sites	57	57	57	57	57	57	57	57	57	57
Inspection and testing of lifting equipment	4	4	4	4	4	3	4	3	4	3
Defect Repair - 11kV Circuit Breakers	48	196	197	200	201	204	205	206	208	212
Maint FULL 11/6.6kV SF6/Vac CB W/B Feed	104	132	106	156	134	139	237	167	80	179
Maint FULL 11/6.6kV SF6/Vac CB F/B Feed	126	113	58	88	116	98	128	119	126	108
Maint MECH 11/6.6kV OCB Feeder	95	80	84	95	83	32	38	75	100	92
Maint MECH 11/6.6kV SF6/Vac CB W/B Feed	16	65	65	65	65	65	65	65	65	65
Maint MECH 11/6.6kV SF6/Vac CB F/B Feed	16	5	5	5	5	5	5	5	5	5
Trip Test 11/6.6KV CB Feeder	2,762	0	0	0	0	0	0	0	0	0
Maint FULL 11/6.6kV OCB Feeder	35	66	97	97	79	57	75	75	83	120
Maint FULL 11/6.6kV OCB TSC	44	71	81	66	52	60	67	63	77	91
Maint FULL 11/6.6kV SF6/Vac CB W/B TSC	21	32	24	24	28	16	19	18	12	23
Maint FULL 11/6.6kV SF6/Vac CB F/B TSC	56	60	36	41	48	37	43	33	29	37
Maint MECH 11/6.6kV OCB TSC	52	55	70	89	76	35	39	49	78	69
Maint MECH 11/6.6kV SF6/Vac CB W/B TSC	5	3	3	3	3	3	3	3	3	3
Maint MECH 11/6.6kV SF6/Vac CB F/B TSC	6	3	3	3	3	3	3	3	3	3
Trip Test 11/6.6KV CB TSC	1170	242	242	242	242	242	242	242	242	242
Maint metal clad busbars at Grid/Primary	6	0	0	0	0	0	0	0	0	0
Maintenance Total	**5058**	**1625**	**1,573**	**1,676**	**1,637**	**1,497**	**1,671**	**1,624**	**1,613**	**1,750**
Includes RIGs Lines: CV13 Lines 27										

Table 31 - DPCR5 & ED1 Forecast – I&M Primary Switchgear. Source: NAMP 19th February 2014

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Primary Switchgear Maintenance	**1,630**	**1,637**	**1,632**	**1,632**	**1,649**	**1,646**	**1,649**	**1,653**

Table 1 - ED2 Forecast – I&M Primary Switchgear

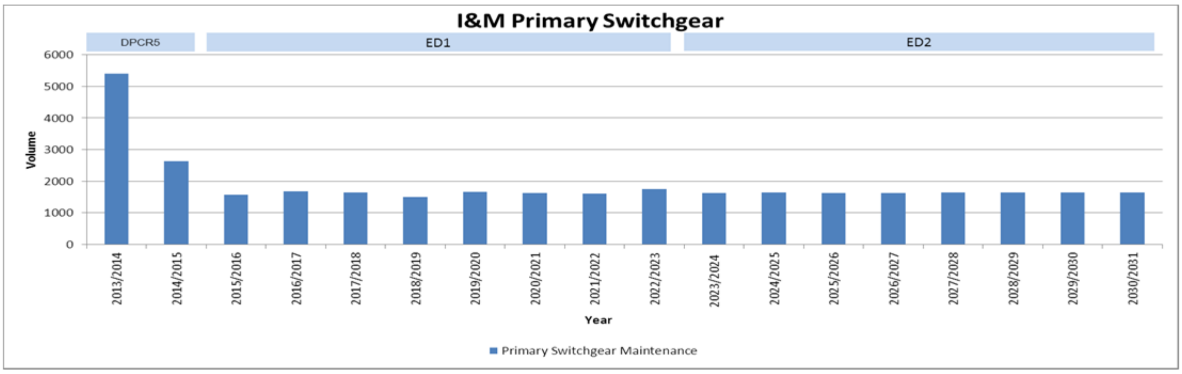

Figure 29 - *DPCR5, ED1 & ED2 Historical and Forecast Values*

7.8 Innovation

As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities the following have been changed to tailor the requirements closer to individual site and plant needs: The number of routine site inspections have been reduced to two per year, one minor and one major, with exceptions based on the site requirements, primarily batteries. A frequency of four months between minor inspections has been retained for sites where wet cells are installed, due to the higher level of intervention required. While on site for this, it is advantageous to carry out an extra minor inspection of plant for very little extra cost.

To evaluate this opportunity further we looked at how we gather condition data at primary sites. The assessment showed that apart from specific visits to formerly gather this information, many other visits are made for other reasons, such as vegetation management, switching etc. It is proposed to introduce methods to record such visits where it is a requirement to report any overt defects that may affect site security or present a safety or environmental hazard.

Mechanism maintenance for vacuum and SF_6 CBs has been withdrawn, as the correct operation of the units is checked every one/two years by remotely opening and closing them, with a full service every 12 years. Often, manufacturers' of these units designate them as being lubricated for life, reducing what could be achieved from this type of action. Oil CBs were not aligned as there are generally of older designs requiring a higher level of intervention to maintain functionality.

Inspection and maintenance of busbars is fairly limited without large outages that introduce heightened network risk and customer outages. For air-insulated busbars, the annual thermal inspection will identify potential failure points; and for metal-clad busbars, monitoring of discharge on inspections will also identify issues. Time-based busbar maintenance has been withdrawn on this basis.

Techniques are being investigated to tailor post-fault maintenance to the cumulative value of fault current broken on a particular unit rather than linking it to the number of fault operations. At present CBs is maintained following operation due to a fault (post fault) on the basis of a fixed number of operations dependent on the site fault level. Wear on the CB and carbonisation of the oil is a function of the magnitude of fault current it has broken, which can be measured on each occasion. If this is aggregated it provides a profile of the condition of the CB and once correlation has been established between the cumulative current and CB condition, the maintenance intervals can be driven more accurately leading to better timed interventions, often of a reduced frequency. This will be the subject of an IFI project that will be required to investigate the methodology for collecting the data and the profiles for different types of CB for values of current broken.

8.0 HV Switchgear and LV Plant

8.1 Asset Information

There are three main types of HV switchgear – oil, SF_6 and vacuum – which can be found as extensible switchgear (EXT), ring main units (RMU), and circuit breakers (CBs). The total volume in this category is 29,794 items of plant split as follows:

EXT – 5,684 units
RMU – 20,993 units
CB – 3,117 units

There are eight main types of LV Plant, Substation Pillars, Free Standing Pillars, Fuse Cabinets, Indoor Boards, Circuit Breakers, Link Boxes, Regulators and Balancers. The total volume in this category is 66,370 items of plant split as follows:

Substation Pillars/Fuse Cabinets/Boards – 28,930
Circuit Breakers - 537
Link Boxes/Free Standing Pillars – 36,882
Regulators/Balancers – 21
Data Source: RIGS Return (2012)

8.2 Summary of Fault Trends, Failure Modes, and Fault Rates

Based on the average faults over the past five years (2007/8 through to 2011/12), the fault rates for switchgear are as shown in table 33.

Voltage	Faults per Annum	Fault Rate per Asset
132kV (inc for comparison)	10	0.034
EHV (inc for comparison)	22	0.0146
HV	117	0.0039
LV	600	0.0090

Table 33 - Fault Rates. Source: IIS and UKPN Faults Cube

HV Switchgear All Types – The fault trend has been rising over the past five years as the number of assets approaching their life expectancy continues to increase. The forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12) (117 per annum), shows no change in volumes over the period. See figure 30. It is anticipated that the fault rate will remain the same (0.009 per asset) reflecting improving techniques, the latest being ARP modelling, to identify life-expired plant before it fails in service.

This is supported by a further breakdown of fault causes, which shows an increasing trend in condition-based faults (e.g. due to age or wear) representing about 50% of the total number of faults over the past three years. This is evident in figure 31. This will be monitored over the period – the probable increase in condition-based faults being offset by the installation of new switchgear.

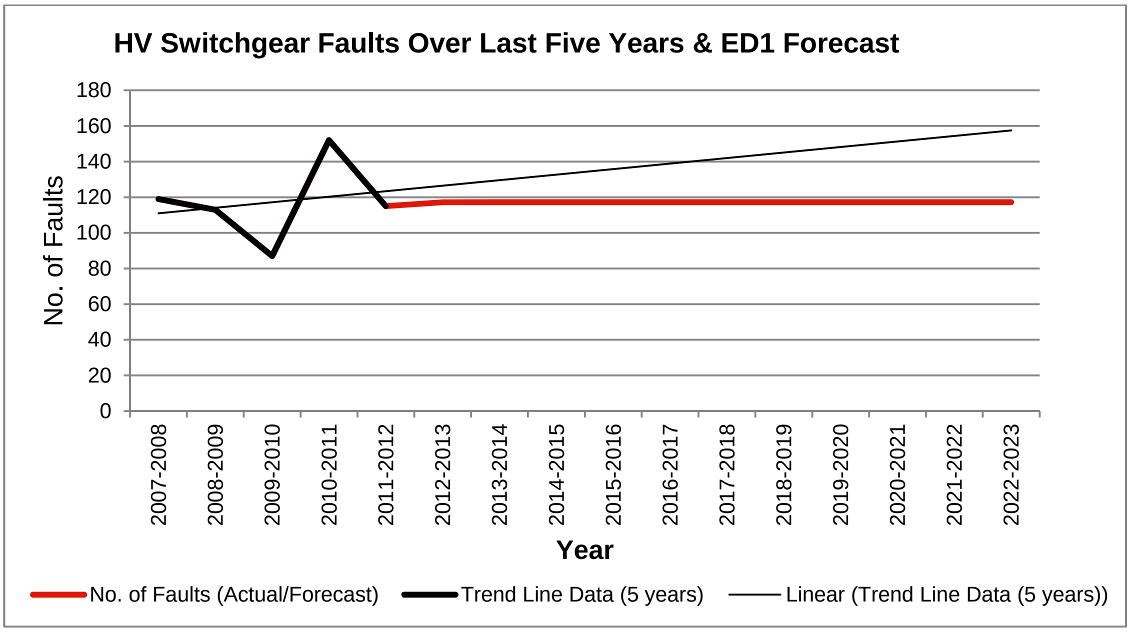

Figure 30 – *HV switchgear Fault (Source: IIS and UKPN Fault Cube)*

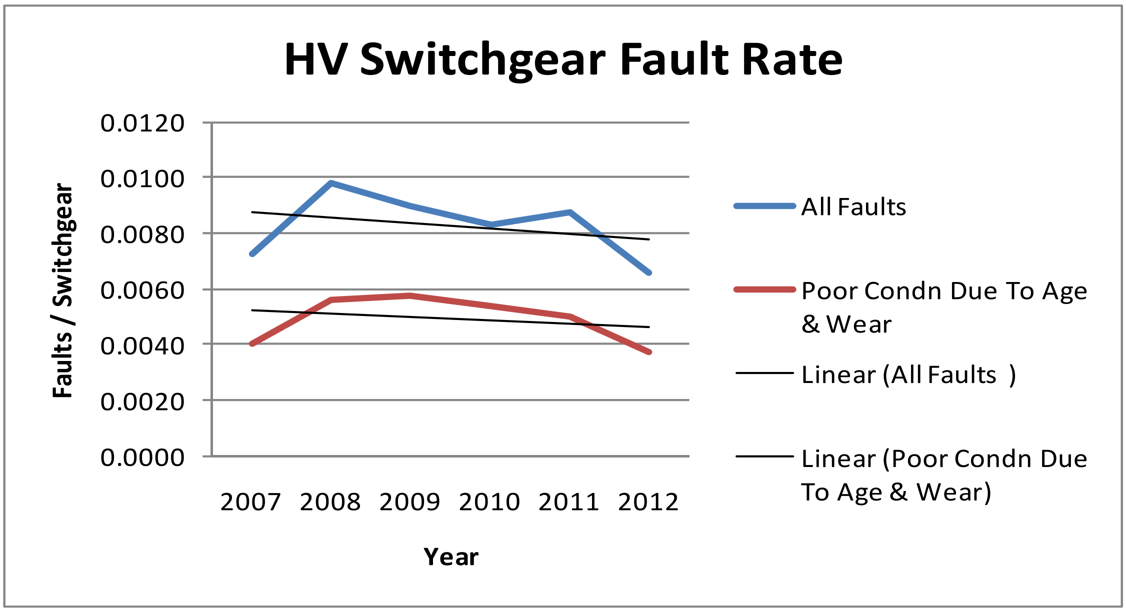

Figure 31 – HV switchgear Fault rate (Source: UKPN Fault Cube)

LV Plant All Types – The fault trend is shown as falling over the past five years mainly due to the abnormally high volumes in 2009/10 and reduced fault rate in 2011/12. The forecast, starting from 2013/14, at which volumes have been set using the average over the past five years (2007/8 through to 2011/12) (600 per annum), shows no change in volumes over the period. This is shown in figure 32 This equates to a fault rate of 0.009 per asset.

From a separate analysis (see figure 33), it is evident that the number of condition-based faults (e.g. due to age and wear) is a consistently high contributor as a percentage of the total number of faults; for LV switchgear, this represents just under

90% of fault causes over the past two years. An enhanced capital investment programme is proposed to offset a proportion of the condition-based faults, resulting in a level forward projection for all LV faults. Further details may be found in the HV Switchgear and LV Plant capex document (No 8).

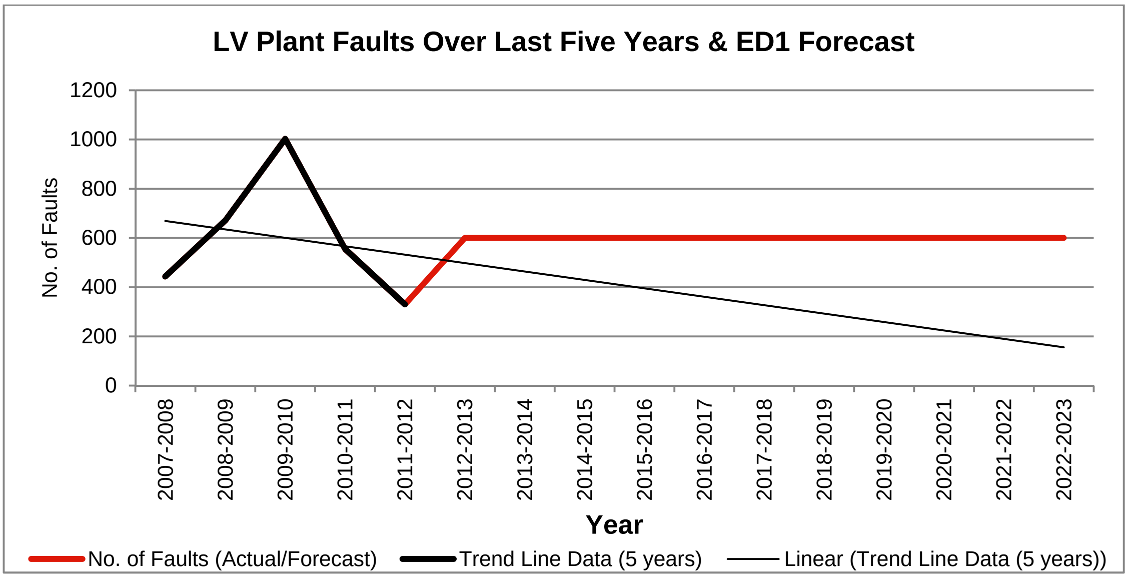

Figure 32 – *LV Plant Faults (Source: IIS and UKPN Fault Cube)*

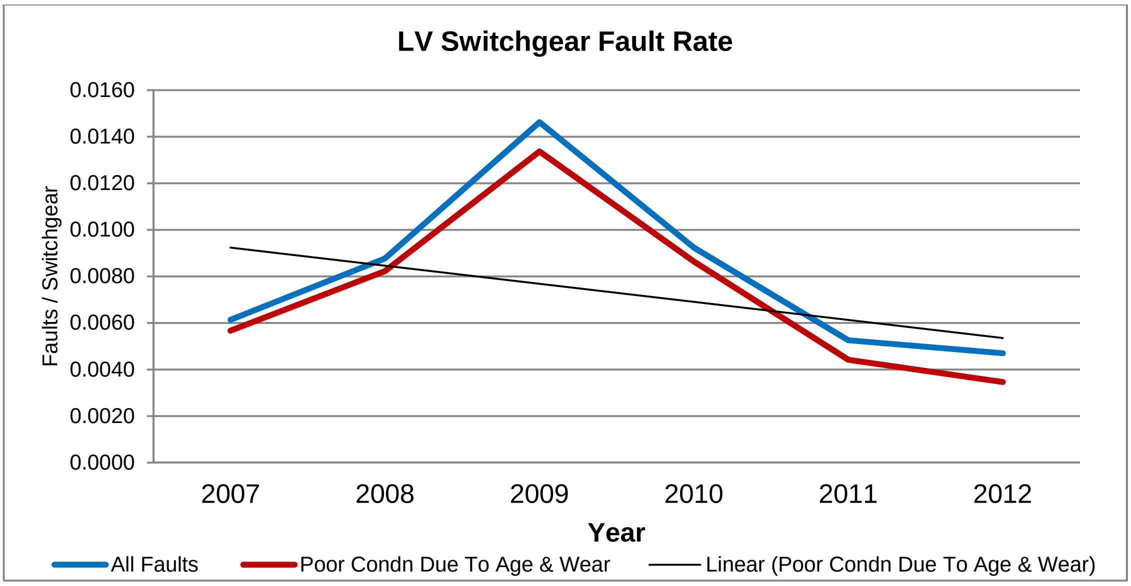

Figure 33 LV plant fault rate (*Source: UKPN Fault Cube)*

8.3 Faults Plan

Generally, failure of this equipment leads to wholesale replacement as the most cost-effective solution, although repair is always considered as an initial option, especially where a component within the unit is involved. This decision process is also affected by the availability of spares, which can be a problem with older equipment.

HV – The above graph shows an increasing trend. With the volume in 2013/14 set at the average over the past five years (2007/8 through to 2011/12) (273 per annum), it is proposed to keep the volumes constant from then across ED1. Opex spend on activities following switchgear faults will continue at a constant level. Improving techniques, the latest being ARP modelling, to identify life-expired plant before it fails in service should help to reduce the volumes of failures, leading to a flat volume profile.

Volumes for HV switchgear are aggregated with HV transformers (section 11.3) as the volumes for both are relatively low, and the numbers of each can vary year to year giving a broader statistical base on which to forecast.

LV – The above graph shows a decreasing trend due to abnormally high volumes in 2009/10. The expected underlying trend, enhanced by the high proportion of condition-based faults at LV, fluctuates around a mean value. With the volume in 2013/14 set at the average over the past five years (2007/8 through to 2011/12), it is proposed to keep the volumes constant from then across ED1.

Table 34, Table 35 and figure 34 show the volume profiles in ED1 and ED2.

Description of Activity	RIGs Reference	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
HV Other Plant Faults (volume)	CV15a Line 27	176	238	188	170	170	170	170	170	170	170	170	170	170	170
Total HV Plant Faults		**176**	**238**	**188**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**
Other plant (LV etc)	CV15a Line 20	977	512	255	600	600	600	600	600	600	600	600	600	600	600
Flooding Burst Water Main	CV15b Line16	Included in "Responding to Safety Critical Calls"				816	816	816	816	816	816	816	816	816	816
Total LV Plant Faults		**977**	**512**	**255**	**600**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**

Table 34 -DPCR4, DPCR5 & ED1 History/Forecast – HV Switchgear & LV Plant Faults. Source: UKPN Faults Cube and 13th February 2014 NAMP.

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Total HV Plant Faults	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**
Total LV Plant Faults	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**	**1,416**

Table 35 - ED2 Forecast – HV Switchgear & LV Plant Faults

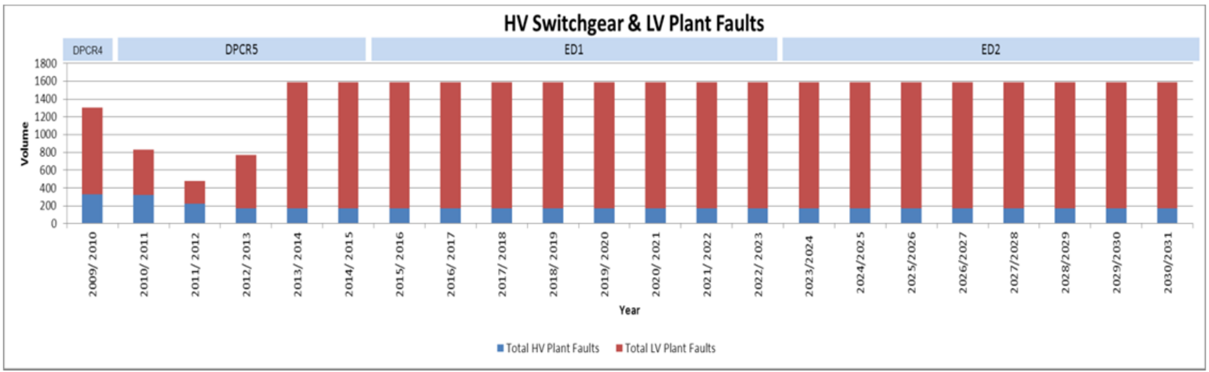

Figure 34 - DPCR4, DPCR5, ED1 & ED2 Historical and Forecast Values

8.4 I&M Drivers

Safety is the top priority, with ongoing monitoring of identification and clearance of defects. Information from the National Defect Reporting Scheme provides an insight into other operators' experiences and an opportunity for UK Power Networks to review its I&M regime against issues found.

The requirement for post-fault maintenance on oil circuit breakers must be met to maintain operating capability.

Due to the large volumes of this type of plant, and the large numbers of manual operations carried out on them with the operator close to the equipment, inspection and maintenance regimes need to quickly reflect issues that could affect operator safety.

Public safety is particularly pertinent to this category of plant, as often it is situated close to domestic properties or in public thoroughfares, in some areas with high numbers of passing pedestrians.

Maintenance of functionality is a prime consideration for this class of equipment, as this often directly affects the ability to restore customers' supplies following an unplanned outage.

The condition of assets, which determine their Health Indices, is of paramount importance for identifying interventions and investment strategies that provide the best value for money.

Consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is always a factor in managing these assets.

8.5 I&M Interventions

Plant at secondary substations was inspected every two years up to the end of 2012, with a more targeted approach starting in 2013, as outlined in the innovation section below.

Inspection of network pillars and link boxes takes place every four or eight years depending on their site risk rating.

All HV switchgear has a full maintenance at 18 years, with mechanism maintenance performed every nine years on all oil-insulated equipment that has relay protection and other specific types (Figure 35).

Post-fault maintenance on oil circuit breakers is carried out after three fault trips where the primary fault level is 150MVA or greater, and six fault trips where it is less than 150MVA, and is recorded as full maintenance.

Specific makes and types may require enhanced inspection and maintenance from the norm, and these are identified in the appendices of EMS 10-0002 which sets the frequencies for I&M interventions.

Painting provides an opportunity to restore the condition of the external housing of plant where it is seen to be deteriorating quicker than would be expected. This contributes to maintaining the health index of the equipment in line with the predicted rate of degradation within the ARP model, and therefore keeps the forecast replacement date in line.

Figure 35 - *Secondary substation maintenance oil handling facilities*

8.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EI 10-1502 details the requirements for secondary substation maintenance.

8.7 I&M Plan

Fault rates and failure modes have not highlighted any particular changes that may be required to the above regime. The plan reflects consistent I&M interventions in line with the above policy, but incorporates a reduction in inspection activity to reflect the change in frequency of minor site inspections which is detailed in section 12.0. A revised programme of preventative maintenance in the form of painting HV switchgear, and LV pillars has been implemented and will continue over the ED1 period in order to control the rate of degradation of the equipment housing(s) where it is identified as an issue.

The variations in volumes across the ED1 period are linked to variations in HV switchgear maintenance which are driven by fixed time periods for maintenance. High volumes of link box inspections in 2013/2014 are due to a backlog, and condition data quality improvement.

Table 36, Table 37 and figure 36 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
VMX Discharge Testing	38	160	177	177	177	177	177	177	177	177
Defect Repair - 11kV Secondary G/M S/S Equipment	172	174	175	147	78	150	183	184	187	188
Forensic testing of Network Equipment	17	17	17	17	17	17	17	17	17	17
Maintain Non-Isolatable Oil Switch	38	9	5	4	13	18	10	13	26	17
Maintain Non-Isolatable Gas/Vac.Switch	12	8	7	6	7	3	4	4	4	4
Maintain Non-Isolatable RMU (Oil) - Contractor	0	12	44	26	31	27	35	63	60	26
Maintain Non-Isolatable RMU (Oil)	660	378	366	11	25	31	46	42	108	158
Maintain Non-Isolatable RMU (Gas/Vacuum)	6	9	13	17	25	14	18	10	10	16
Maintain Isolatable Oil Switch	5	3	5	9	14	19	2	10	11	16
Maintain Switch Fuse - Contractors	89	89	0	0	0	0	0	0	0	0
Maintain Switch Fuse	293	232	0	3	16	44	13	37	66	106
Maintain HV Metering Unit	58	24	0	0	0	0	1	1	0	3
Maintain Fused End Box	127	136	176	265	245	136	143	227	189	155
Maint FULL 11/6.6kV OCB at S/SUB	136	33	17	39	88	73	51	89	84	104
Maint FULL 11/6.6kV SF6/Vac CB F/P S/SUB	24	25	26	40	51	36	29	40	46	56
Maint FULL 11/6.6kV SF6/Vac CB W/D S/SUB	7	11	6	5	6	1	7	10	4	13
Maint MECH 11/6.6kV OCB at S/SUB	102	149	87	31	26	12	24	64	37	31
Maint MECH 11/6.6kV SF6/Vac CB F/P S/SUB	18	54	5	12	12	5	4	2	0	0
Maint MECH 11/6.6kV SF6/Vac CB W/D S/SUB	2	11	10	6	4	1	5	1	3	0
Trip Test 11/6.6Kv CB at S/SUB	1	1	0	0	0	0	0	0	0	0
Maint Busbars (inc VT"s) at S/SUB	1	1	0	0	0	0	0	0	0	0
HV Maintenance Sub-Total	**1,806**	**1,536**	**1,136**	**815**	**835**	**764**	**769**	**991**	**1,029**	**1,087**
Plant Paint 11kV & below	198	408	694	857	1,029	1,179	1,179	1,179	1,179	1,179
HV Maintenance Total	**2,033**	**1,944**	**1,830**	**1,672**	**1,864**	**1,943**	**1,948**	**2,170**	**2,208**	**2,266**
Includes RIGs Lines: CV13 Lines 28, 29, 30, 33										
Inspect LV Link Box	26,725	4,598	4,262	4,262	4,262	4,262	4,262	4,262	4,262	4,262
Inspect Network LV Pillar	98	232	229	229	229	229	229	229	229	229
Network Pillar inspection	51	122	122	122	122	122	122	122	122	122
Reserve Sub Station Inspection	651	652	652	652	652	652	652	652	652	652
LV Inspection Total	**27,525**	**5,604**	**5,65**	**5,265**	**5,265**	**5,265**	**5,265**	**5,265**	**5,265**	**5,265**
Defect Repair - LV G/M S/S Equipment	16	65	65	66	63	53	54	55	56	60
Maintain LV Dist.Board (Pillar/TOC)	2,389	1,312	719	1,137	1,005	567	580	1,233	1,645	1,369
Maintain LV ACB	98	17	30	30	30	30	30	30	30	30
Trip Test LV ACB	0	2	7	4	7	4	7	4	7	2
LV Maintenance Total	**2,503**	**1,396**	**821**	**1,237**	**1,105**	**654**	**671**	**1,322**	**1,738**	**1,461**
Includes RIGs Lines: CV13 Lines 10, 11										

Table 36 - PCR5 & ED1 Forecast – I&M HV Switchgear & LV Plant. Source: 13th February 2014 NAMP Table O

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
HV Switchgear Maintenance	**1,988**	**1,988**	**1,988**	**1,988**	**1,988**	**1,988**	**1,988**	**1,988**
LV Plant Inspection	**5,265**	**5,265**	**5,265**	**5,265**	**5,265**	**5,265**	**5,265**	**5,265**
LV Plant Maintenance	**1,126**	**1,126**	**1,126**	**1,126**	**1,126**	**1,126**	**11,26**	**1,126**

Table 37 - ED2 Forecast – I&M HV Switchgear & LV Plant

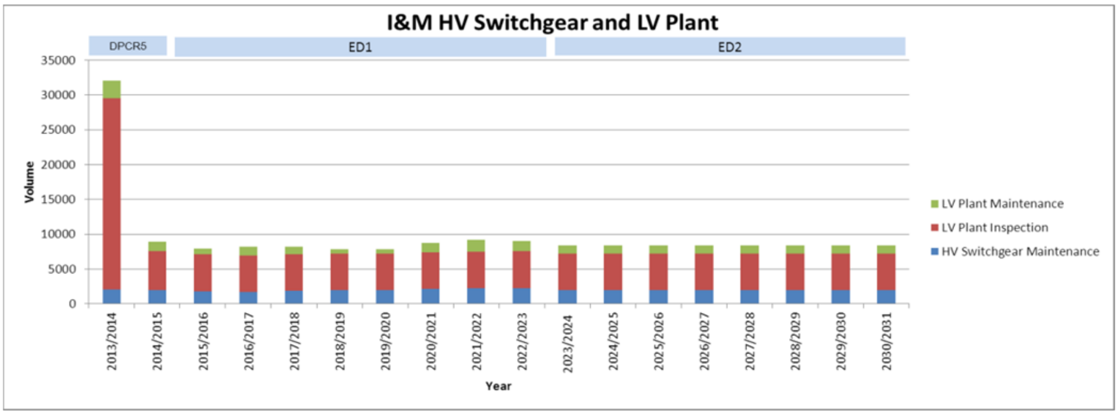

Figure 36 - *DPCR5, ED1 & ED2 Historical and Forecast Values*

8.8 Innovation

Plant inspections were reviewed in 2012 and a more targeted approach is being used from 2013. As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities the following have been changed to provide a more targeted approach:

For plant at secondary substations, the general inspection frequency has been decreased from two to three years. Exceptions are where protection schemes and batteries are on site.

To evaluate this opportunity further we looked at how we gather condition data at secondary sites. The assessment showed that apart from specific visits to formerly gather this information, many other visits are made for other reasons, such as vegetation management, switching etc. It is proposed to introduce methods to record such visits where it is a requirement to report any overt defects that may affect site security or present a safety or environmental hazard.

9.0 Service Terminations, Cut-outs, and Risers and Laterals

9.1 Asset Information

This equipment covers many different types, depending on the customer's individual requirements, and required capacity.

In the main, services up to 300kVA are supplied through a cut-out, and those larger either into the customer's own switchgear or a termination cubicle.

Multi-occupancy buildings may have one central intake distributed by the owner to individual properties, or have the DNO's network installed through risers and laterals within the building.

Engineering Recommendation G87, issued by the Energy Networks Association (ENA), provides a structure for installation and inspection and maintenance for new installations that has been implemented within UK Power Networks through document EDS 08-0118. This is effective from 1st June 2013. This document also gives some guidance on existing installations.

9.2 Summary of Fault Trends, Failure Modes, and Fault Rates

Currently there is no validated fault data available for this category, but potential improvements into the reporting and extraction of data in this area will be investigated.

9.3 Faults Plan

Generally, wholesale replacement is the most cost-effective solution to failure of this equipment, although repair is always considered as an initial option, especially where a component within a larger unit is involved. This decision process is also affected by the availability of spares, which can be a problem with older or bespoke equipment. It is proposed to keep the volumes constant from 2013/14 and across ED1 based on an estimate of the expected volumes which are likely to reduce with the smart meter roll out. Fault volumes for risers and laterals are included under (service) cables – section 4.3.

Table 38, Table 39 and figure 37 show the volume profiles in ED1 and ED2

Description of Activity	RIGs Reference	2009/ 2010	2010/ 2011	2011/ 2012	2012/ 2013	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Service Terminations, Cut-outs, Risers and Laterals	CV15b Line 8	514	3,012	3,039	3395	5,359	5,359	4,019	2,680	2,680	2,680	2,680	2,680	4,161	4,161
Emergency Disconnections	CV15b Line 6	Included in "Responding to Safety Critical Calls"				1,075	1,075	1,075	1,075	1,075	1,075	1,075	1,075	1,075	1,075
Total Service Termination Faults		**514**	**3,012**	**3,039**	**3395**	**6,434**	**6,434**	**5,094**	**3,755**	**3,755**	**3,755**	**3,755**	**3,755**	**5,236**	**5,236**

Table 38 - DPCR5 & ED1 History/Forecast – Service Termination Faults. Source: RIGs Data and 19th February 2014 NAMP Table O.

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Total Service Termination Faults	**4,293**	**4,293**	**4,293**	**4,293**	**4,293**	**4,293**	**4,293**	**4,293**

Table 39 - ED2 Forecast – Service Termination Faults

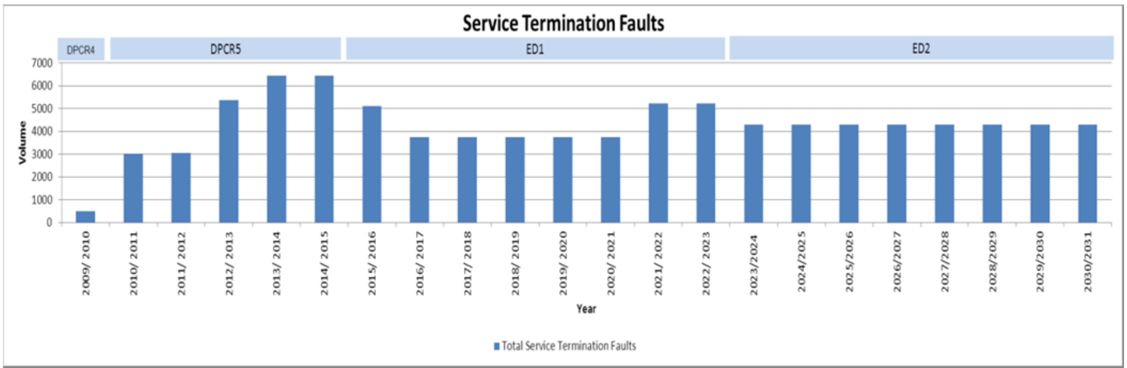

Figure 37 - *DPCR4, DPCR5, ED1 & ED2 Historical and Forecast Values*

9.4 I&M Drivers

Safety is the top priority, with ongoing monitoring of identification and clearance of reported defects. Where applicable, information from the National Defect Reporting Scheme provides an insight into other operators' experiences and an opportunity for UK Power Networks to review its I&M regime against issues found.

The large volumes of this equipment and the location within private residences and premises present particular challenges in assuring safe operation.

Maintenance of operational and safety integrity is a prime consideration for this class of equipment as customers and meter operators may come in very close proximity.

Where this equipment is housed in vacant properties, with the supply de-energised, the ongoing hazard it represents needs to be monitored and action taken where required to minimise the risk to the public.

The condition of assets is of paramount importance for identifying interventions and investment strategies that provide the best value for money.

9.5 I&M Interventions

The inspection of cut-outs is carried out by suppliers when meter readings are taken.

Where the service terminates in a customer's switchgear, the customer monitors the overall condition and reports exceptions that may affect our incoming supply.

Following a review of the inspection process for risers and laterals, a new process was put in place in 2012 to identify record and condition-assess this equipment over a 10 year period.

The inspection of idle and unmetered services is required either as identified or on a specified basis.

Maintenance is reactive following the reporting of an issue through the various channels stated above.

9.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EMP 10-0100 covers Idle Services Inspections, and EMP 10-0012 Unmetered Services, whilst the recently introduced policy EMS 10-7005 describes the inspection of Risers and Laterals (R&Ls) in Multi-Occupancy Premises.

9.7 I&M Plan

No changes from the above policy regimes have been identified and the plan reflects consistent I&M interventions in line with the above policies.

Table 40, Table 41 and figure 38 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Inspection of R&Ls	14,610	20,892	23,571	23,571	23,571	23,571	23,571	23,571	23,571	23,571
Inspection Total	14,610	20,892	23,571	23,571	23,571	23,571	23,571	23,571	23,571	23,571
Includes RIGs Lines: CV13 Line 12, 14										

Table 40 - DPCR5 & ED1 Forecast – I&M Service Terminations. Source 19th February 2014 NAMP

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Service Terminations, Cut-outs, Risers & Laterals Inspection	**23,571**	**23,571**	**23,571**	**23,571**	**23,571**	**23,571**	**23,571**	**23,571**

Table 41- ED2 Forecast – I&M Service Terminations

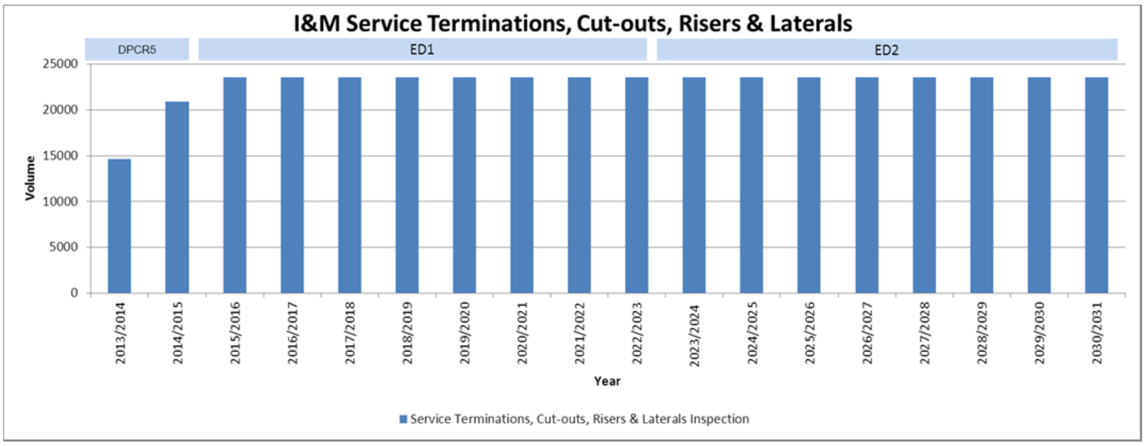

Figure 38 - *DPCR5, ED1 & ED2 Historical and Forecast Values*

9.8 Innovation

No particular innovation initiatives have been identified, although the introduction of smart metering will provide a platform to re-evaluate our processes.
An opportunity may arise through the smart metering initiative for the supplier/meter operator/contractor to carry out service termination/cut-out inspections at the same time as the new meters are installed

10.0 Grid and Primary Transformers

10.1 Asset Information

There are 255 transformers with a primary winding voltage of 132kV and ratings between 7.5MVA and 90MVA. There are 895 EHV transformers with ratings between 3MVA and 30MVA.

There are various tap-changer types, including: high-speed or slow-speed diverters in separate tanks to the selector; diverter/selector in a combined tank; Jansen/Reinhaussen; and Vacutap.

Any ancillary equipment, such as auxiliary/earthing transformers, neutral earthing resistors/reactors, arc suppression coils, fault-throwing switches, voltage transformers and surge diverters, are included in this section.

10.2 Summary of Fault Trends, Failure Modes, and Fault Rates

Fault rates based on the average of the past five years (2007/8 through to 2011/12) are shown in table 42.

Transformer Primary	Faults Per Annum	Fault Rate per Asset
132kV	9	0.035
EHV	19	0.021
HV (See next section)	53	0.002

Table 42 - Fault Rates. Source: IIS and UKPN Faults Cube

All types (132kV & EHV) – The small numbers of these faults make it difficult to reliably identify long-term trends and fault rates. The forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12), shows no change in volumes over the period. This is illustrated in figure 39.

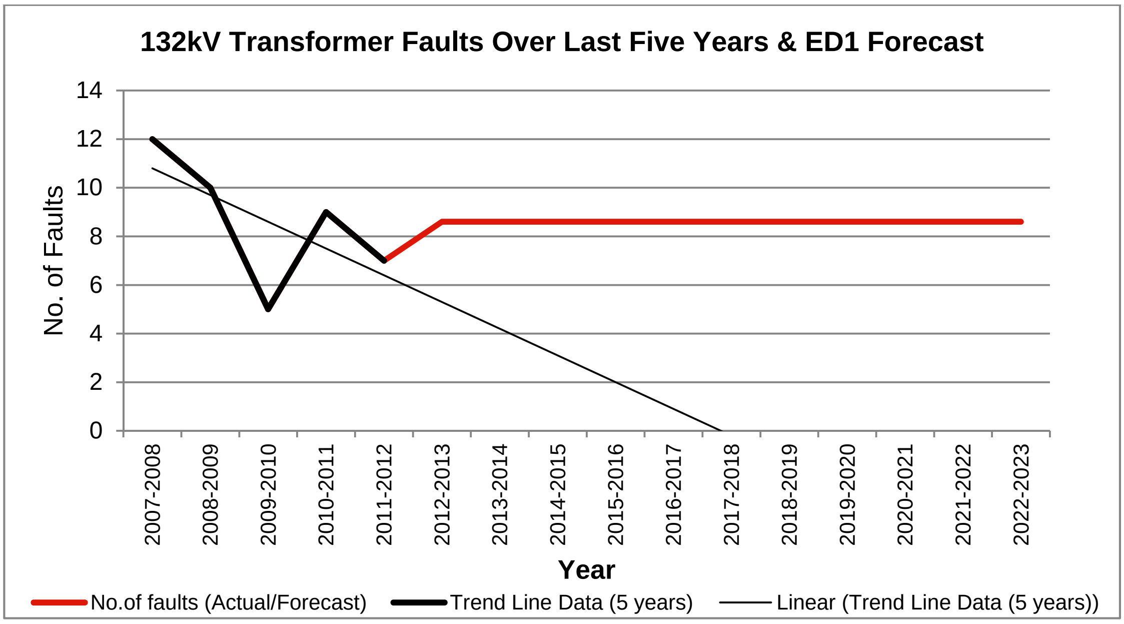

Figure 39 – *132kV Transformer faults (Source: IIS and UKPN Faults Cube*

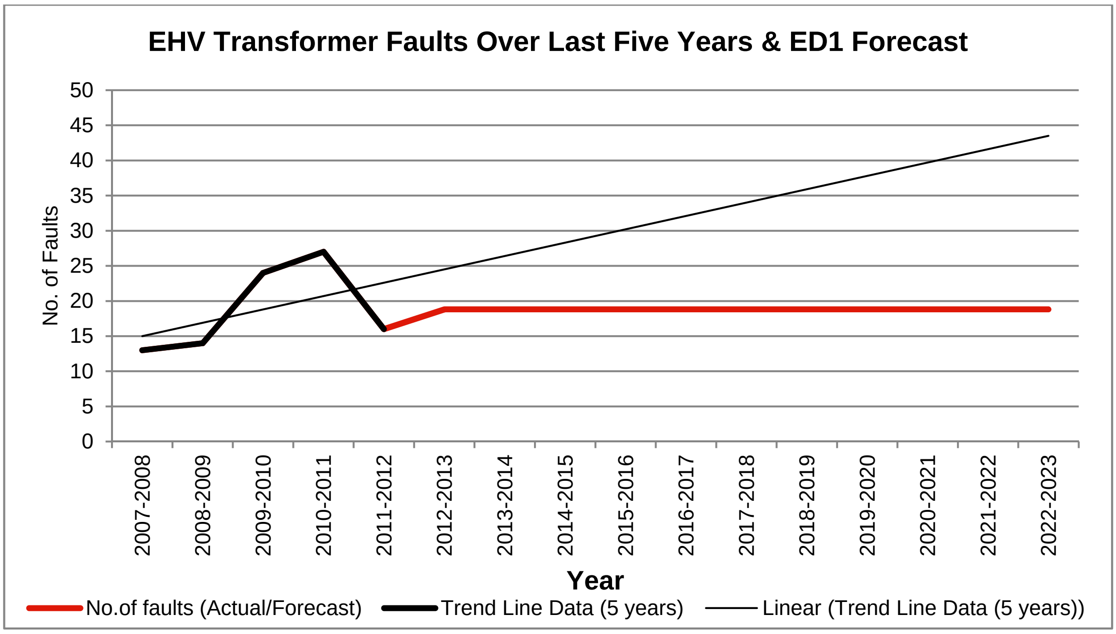

Figure 40 – *EHV transformer Fault Rates (Source: IIS and UKPN Faults Cub)*

10.3 Faults Plan

Figures 39 and 40 show contrasting trends over a five year period, although due to the small numbers of these faults it is difficult to reliably forecast volumes. The underlying long-term trend in both cases is expected to be constant or a gradual increase due to the ageing asset base continuing to deteriorate over time. With both volumes in 2013/14 set at the average over the past five years (2007/8 through to 2011/12), it is proposed to keep the volumes constant from then across ED1.

Overall volumes for 132kV Grid Transformers and Switchgear, and EHV Primary Transformers and Switchgear are shown in Tables 25 and 6.3 respectively.

10.4 I&M Drivers

Mitigation of any safety and environmental factors are the leading priorities for this asset class, with ongoing monitoring of identification and clearance of defects. Information from the National Defect Reporting Scheme provides an insight into other operators' experiences and an opportunity for UK Power Networks to review its I&M regime against issues found.

Issues, such as whether PCBs are present in the oil, are important to understand and redress to ensure a safe working environment.

Functional performance of the tap-changers is a prime consideration to ensure voltage is maintained within statutory limits.

The condition of assets, used to determine their Health Indices, is of paramount importance for identifying interventions and investment strategies that provide the best value for money. Due to the value and criticality of these assets, a more definitive view than visual and thermal inspection is required.

Consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is an important aspect of managing these assets utilised by UK Power Networks. Trade-off between Opex and Capex is examined and whole life cost assessment examples are provided in the Capex related narrative documents.

10.5 I&M Interventions

Inspections of plant were completed every four months until the beginning of 2013, when this was amended to every six months. Alternate inspections are minor and major. Exceptions to this are detailed in the innovation section. Inspections include thermal imaging and discharge monitoring.

Transformers regularly have oil samples analysed for moisture, acidity, electric strength and dissolved gases. At 132kV, this is carried out every year with the lower primary voltages every four years. Every four years, additional FFA tests for Furans (e.g. furfuraldehyde) are run on all transformers, and PCB checks are made on 132kV units only.

Generally, slow-speed tap-changers are maintained every four years and high-speed tap-changers are maintained every eight years. There are exceptions to both where the particular make and type need a higher frequency. The maintenance frequencies of transformers, where the general frequency has been found to be too long due to loading and frequency of tap changes, are modified on an individual basis.

Maintenance of combined diverter/selector units has a frequency of two or eight years according to make and type. Figure 41 shows diverter braids which are in poor condition.

Jansen/Reinhausen units are maintained every four or eight years, depending on the primary winding configuration, and require specialist training. Although the maintenance unit cost is higher than for other units the frequency is generally lower than other types. The latest types of tap changer being installed require less maintenance, but there is no replacement programme planned for these units based on the cost of maintenance.

Vacutap units require little maintenance, only an oil sample and mechanism check every eight years.

The maintenance of selectors in separate tanks is scheduled every 16 years.

Painting provides an opportunity to restore the condition of the external housing of plant where it is seen to be deteriorating quicker than would be expected. This contributes to maintaining the health index of the equipment in line with the predicted rate of degradation within the ARP model, and therefore keeps the forecast replacement date in line.

Specific makes and types may require enhanced inspection and maintenance from the norm, and these are identified in the appendices of EMS 10-0002 which sets the frequencies for I&M interventions.

Figure 41 - *Recording the condition of diverter braids in tap changers improves how we understand wear and maintenance requirements*

10.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EMS 10-1001 Maintenance of Power Transformers details maintenance requirements for power transformers.

10.7 I&M Plan

Fault rates and failure modes have not highlighted any particular changes that may be required to the above regime. The plan reflects consistent I&M interventions in line with the above policy, but incorporates a reduction in inspection activity to reflect the change in frequency of minor site inspections which is detailed in section 12.0.

A revised programme of preventative maintenance in the form of painting transformer radiators/cooling systems has been implemented and will continue over the ED1 period in order to control the rate of degradation of the equipment where it is identified as an issue.

Table 43, Table 44 and figure 42 show the volume profiles in ED1 and ED2

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
EHV Transformer / Cooler Painting	9	16	28	33	33	33	33	33	33	33
Defect Repair - Grid Transformers/Tapchangers	61	62	62	63	64	64	65	65	66	67
Defect Repair - Primary Transformers/Tapchangers	118	120	120	122	123	124	125	127	128	129
Maintain Power TX	142	153	151	154	134	156	128	116	149	155
Oil Sample Power TX	503	502	495	484	533	502	495	484	533	502
Maintain Auxiliary/Earthing Tx	39	48	49	36	33	33	29	37	38	43
Maintain Neutral Earthing Reactor	97	69	0	0	0	0	0	0	0	0
Maintain Neutral Earthing Resistor	20	22	25	28	24	32	24	15	17	23
Maintain Arc Suppression Coil	9	11	11	14	18	14	8	9	9	8
Maintain Fault Throwing Switches	44	47	65	66	51	56	48	39	45	42
Maintain VT Isolatable	26	24	27	27	27	27	27	27	25	15
Maintain VT Non-Isolatable	35	55	43	53	58	84	87	98	106	75
Maintain CT	3	0	0	0	0	0	0	0	0	0
Maintain CVT (Volume)	28	5	22	23	16	7	12	2	6	3
Oil Sample Selector	235	234	230	235	234	238	229	235	234	240
Oil Sample NEX	109	110	148	176	165	161	148	177	165	166
Oil Sample ASC	8	11	7	5	6	7	10	12	13	14
Oil Sample Regulator/Balancer	0	0	0	0	0	1	2	0	0	0
Maintain Tapchanger single tank (incl TX)	81	83	94	106	87	83	60	73	85	87
Maintain Tapchanger Diverter - Contractors	35	27	0	0	0	0	0	0	0	0
Maintain Tapchanger Diverter	110	68	64	74	82	96	68	76	86	100
Maintain Tapchanger Selector - Contractors	48	36	0	0	0	0	0	0	0	0
Maintain Tapchanger Selector	51	36	18	10	12	21	22	26	43	45
Oil Sample Vacutap	0	0	3	5	5	6	3	5	5	7
Maintain Tapchanger Vacutap	0	1	3	5	4	6	0	0	1	0
Oil Sample VT	9	10	5	0	0	0	0	0	0	0
Oil Sample CT	14	25	15	0	0	0	0	0	0	0
Oil Sample F/Breathing Barrier Bushings	10	8	6	26	26	26	26	26	26	26
Maintain Series / Shunt Reactor	1	3	3	0	0	0	0	0	0	0
Maintain Capacitors	0	1	0	0	0	0	0	0	0	0
Maintenance Total	**1,845**	**1,788**	**1,694**	**1,745**	**1,734**	**1,777**	**1,649**	**1,682**	**1,813**	**1,780**
Includes RIGs Lines: CV13 Lines 48, 62, 76										

Table 43 - DPCR5 & ED1 Forecast – I&M Grid & Primary Transformers. Source: 13th February NAMP Table O.

ED2 Volumes	2022 /2023	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2030 /2031
Grid and Primary Transformers Maintenance	1,734	1,734	1,734	1,734	1,734	1,734	1,734	1,734

Table 44 ED2 Forecast – I&M Grid & Primary Transformers. Source: 13th February 2014 NAMP Table O.

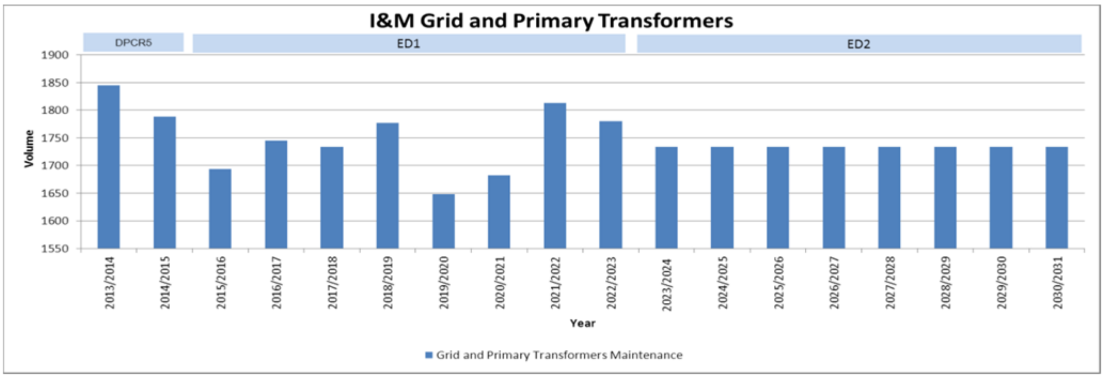

Figure 42 *DPCR5, ED1 & ED2 Historical and Forecast Values*

10.8 Innovation

As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities the following have been changed to tailor the requirements closer to individual site needs:

Inspections have been amended to every six months, alternating between minor and major, based on the site requirements, primarily for batteries. A frequency of four months has been retained for sites with wet cells, due to a higher level of intervention being required. While on site for this, it is advantageous to carry out an extra minor inspection of plant for very little extra cost.

To evaluate this opportunity further we looked at how we gather condition data at grid and primary sites. The assessment showed that apart from specific visits to formerly gather this information, many other visits are made for other reasons, such as vegetation management, switching etc. It is proposed to introduce methods to record such visits where it is a requirement to report any overt defects that may affect site security or present a safety or environmental hazard.

To improve the reliability of tap-changers, maintenance kits have been supplied by the manufacturers for high-volume units. Although marginally increasing the unit cost, this ensures the quality and availability of replacement parts ensuring good performance from the units throughout the maintenance period.

Potential avenues are being pursued to tailor diverter maintenance regimes more closely to the requirements of a particular transformer and to record its load and tap-changer operations, so as to set an individual limit on the number of operations, given the type installed. Reliability of SCADA information and an understanding of the limitations and needs of different types of tap-changers are a part of this. This has been suggested as being the subject of an IFI project to initiate the research required.

11.0 Distribution Transformers

11.1 Asset Information

There are 31,597 ground-mounted distribution transformers, with the majority complying with a T1 specification (HV RMU and LV Pillar/Board connected via cable to HV and LV cable boxes on different sides of the transformer) or of a unit substation design (HV RMU and LV Fuse cabinet directly coupled to the transformer). Most are oil-filled, and all have offload tap-changers with a primary voltage of 6.6/11kV. Low voltage output is a standard 230/400volts with some single phase transformers delivering 230/460 volts.

11.2 Summary of Fault Trends, Failure Modes, and Fault Rates

The fault rates shows a downward trend over a five-year period. The forecast, starting from 2013/14, at which point volumes have been set using the average over the past five years (2007/8 through to 2011/12) (53 per annum), shows no change in volumes over the period. This is shown in figure 43.

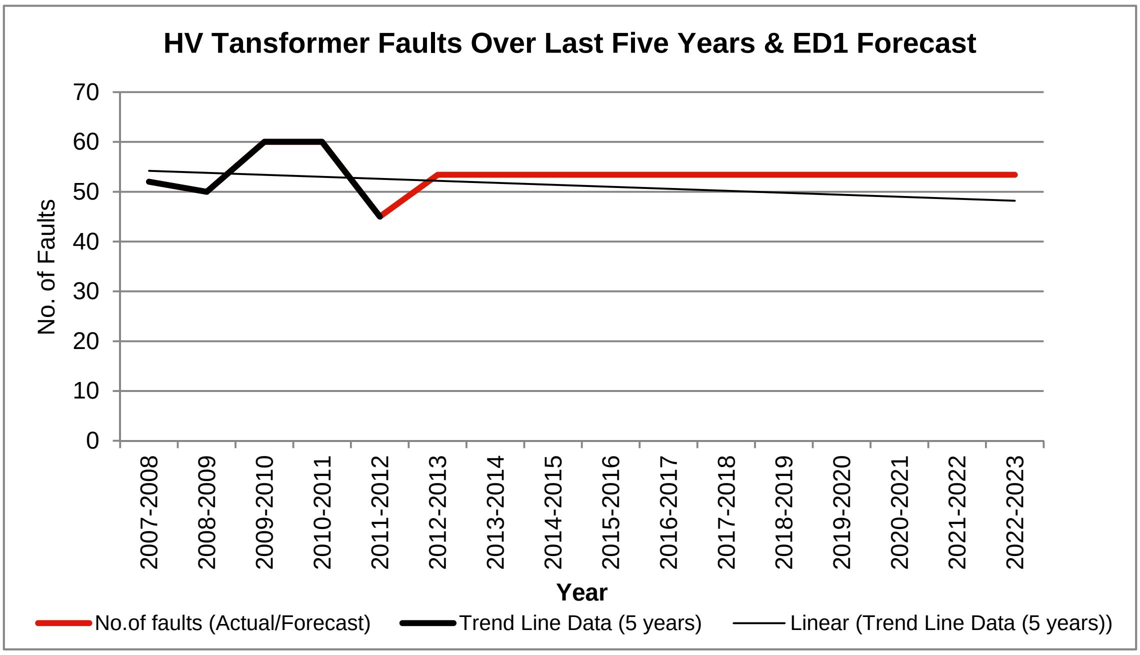

Figure 43 - *Source: IIS and UKPN Fault Cube*

11.3 Faults Plan

Generally, failure of this equipment leads to wholesale replacement as the most cost-effective solution, although repair is always considered as an initial option, especially where a component within the unit is involved. This decision process is also affected by the availability of spares, which can be a problem with older equipment.

The above graph shows a decreasing trend. With the volume in 2013/14 set at the average over the past five years (2007/8 through to 2011/12), it is proposed to keep the volumes constant from then across ED1. Opex spend on activities following transformer faults will continue at a constant level.

Volumes for HV transformers are aggregated with HV switchgear (section 8.3) as the volumes for both are relatively low, and the numbers of each can vary year to year giving a broader statistical base on which to forecast. Volumes are shown in section 8.3.

11.4 I&M Drivers

Safety is the top priority, with ongoing monitoring of identification and clearance of defects. Information from the National Defect Reporting Scheme provides an insight into other operators' experiences and an opportunity for UK Power Networks to review its I&M regime against issues found.

Issues, such as whether PCBs are present in the oil, are important to understand and redress to ensure a safe working environment.

Public safety is particularly pertinent to this category of plant as it is often sited close to domestic properties or in public thoroughfares – in some areas with high numbers of passing pedestrians.

The condition of assets, which determines their Health Indices, is of paramount importance for identifying interventions and investment strategies that provide the best value for money.

11.5 I&M Interventions

Plant at secondary substations was inspected every two years up to the end of 2012, with a more targeted approach starting in 2013 as outlined in the innovation section below.

All distribution transformers have a full maintenance at 18 years, in line with the HV switchgear frequency.

Specific makes and types may require enhanced inspection and maintenance from the norm, and these are identified in the appendices of EMS 10-0002 which sets the frequencies for I&M interventions.

Painting provides an opportunity to restore the condition of the external housing of plant where it is seen to be deteriorating quicker than would be expected. This contributes to maintaining the health index of the equipment in line with the predicted rate of degradation within the ARP model, and therefore keeps the forecast replacement date in line.

11.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EI 10-1502 details the requirements for secondary substation maintenance.

11.7 I&M Plan

Fault rates and failure modes have not highlighted any particular changes that may be required to the above regime. The plan reflects consistent I&M interventions in line with the above policies, with a reduction starting in 2013/14, compared to previous years, to reflect the change in frequency of site inspections which is included in section 12.0.

Also a programme of preventative maintenance in the form of painting transformers has been implemented (volumes are for complete distribution substations and are included in table 45) and will continue over the ED1 period in order to manage the rate of degradation of the equipment where it is identified as an issue.

Table 45, Table 46 and figure 44 show the volume profiles in ED1 and ED2.

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Maintain Distribution Tx	1,763	1,395	813	1,280	1,137	697	687	1,283	1,414	1,543
Oil Sample Dist Tx	269	335	412	412	412	412	412	412	412	412
Noise complaint investigations by Operations Note 1	0	2	2	2	2	2	2	2	2	2
Maintenance Total	**2,032**	**1,730**	**1,225**	**1,692**	**1,549**	**1,109**	**1,099**	**1,695**	**1,826**	**1,955**
Includes RIGs Lines: CV13 Lines 32										

Table 45 - DPCR5 & ED1 Forecast – I&M Distribution Transformers. Source 13th February 2014 NAMP Table O

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Distribution Transformers Maintenance	**1,955**	**1,519**	**1,519**	**1,519**	**1,519**	**1,519**	**1,519**	**1,519**

Table 46 - ED2 Forecast – I&M Distribution Transformers

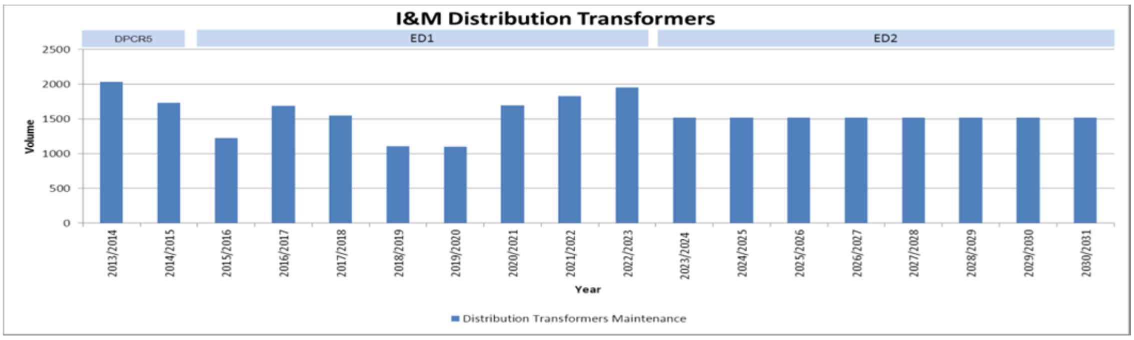

Figure 44 - *DPCR5, ED1 & ED2 Historical and Forecast Values*

11.8 Innovation

As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities the following have been changed to provide a more targeted approach:

For plant at secondary substations, the general frequency has been decreased from two to three years. Exceptions are where protection schemes and batteries are on site.

To evaluate this opportunity further we looked at how we gather condition data at secondary sites. The assessment showed that apart from specific visits to formerly gather this information, many other visits are made for other reasons, such as vegetation management, switching etc. It is proposed to introduce methods to record such visits where it is a requirement to report any overt defects that may affect site security or present a safety or environmental hazard.

12.0 Sites Housing Electrical Equipment

12.1 Asset Information

This section deals with periodic inspection of sites with ground mounted plant and the factors that are taken into account in their frequency. Remedial action is dealt with in the Civils document.

There are 32,312 substation sites split into 613 Grids and Primaries, and 31,699 Secondary sites. There are also 2,090 reserved substation sites

Electricity Safety Quality Continuity Regulations (ESQCR) risk ratings are established using EOS 09-0061 and are shown in table 47.

ESQCR Risk Rating	Grids & Primaries	Secondary
Very High	92	38
High	122	2,779
Medium	341	17,361
Low	58	11,521

Table 2 - *ESQCR Ratings. Source: Ellipse Register*

12.2 ESQCR Issues

Sites where trespassing has been identified as an issue automatically rise to a high-risk category. For secondary sites, this instigates four additional inspections at a 90-day frequency. For grids and primaries, this instigates four additional inspections: two at a 15-day frequency, followed by two at a 30-day frequency. If after this inspection cycle there are no further signs of trespassing, the frequency returns to normal. If evidence persists, the cycle is repeated.

Theft of metal, either earthing or decommissioned plant left on site, is an ongoing problem. A new standard for above-ground earthing to be aluminium has been issued to discourage theft, and an ongoing project to fully identify decommissioned plant is under way to better manage and provide security for such items.

Breaches of ESQCR for sites with ground mounted equipment generally relate to site security and housekeeping, and signage

12.3 Security Regimes

Apart from routine and trespass inspections, security patrols may be used to provide random checking for unauthorised entry.

A capex programme is due to be completed in 2014 to change operational locks at grid and primary sites. This change will remove boundary and building door locks, which have keys that have found their way into general circulation, and replace them with an intelligent locking system. The keys require regular re-authorisation to be kept active, and any lost or stolen keys will only remain authorised for a limited time. The keys also download information from locks into the central database system to provide details of entry into sites.

The security of sites that are particularly vulnerable to trespassing have been reviewed and extra security measures taken where appropriate. This aspect of capex work is covered by the Civils document.

12.4 I&M Drivers

Safety is the dominant priority, with ongoing monitoring of identification and clearance of security defects.

Public safety is particularly pertinent, as these sites can often be close to domestic properties.

In particular, where a substation or supply is no longer required, a risk assessment needs to be completed to identify if it is safe to leave energised.

The consideration of the whole-life asset cost, through the identification of complementary investment and maintenance strategies to maximise asset life, is always a factor in managing security of sites.

12.5 I&M Interventions

As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities the following have been changed to provide a more targeted approach:

For secondary substation sites, the general inspection frequency has been decreased from two to three years. Exceptions are where protection schemes and batteries are on site. Figure 45 shows a portable device used to record condition assessment results and to update the asset register.

Grid & Primary site inspections have been amended to every six months, alternating between minor and major, based on the site requirements, primarily for batteries. A frequency of four months has been retained for sites with wet cells, due to a higher level of intervention being required. While on site for this, it is advantageous to carry out an extra minor inspection of plant for very little extra cost.

Other visits are undertaken for vegetation management and water testing at some grids and primaries, while some operational visits are made to carry out switching or perform maintenance. On each occasion, any security issues can be raised.

Figure 45- *Recording equipment condition on a portable device for automatic updating of the asset register*

12.6 I&M Policies

The I&M frequency schedule (EMS 10-0002) details the timescales for interventions. EMP 10-0100 covers Idle Service Inspections and EMP 10-0012 Idle Site Inspections. EMS 10-5001 details grid and primary substation inspections, while EMS 10-5501 is for secondary sites.

12.7 I&M Plan

The overall plan of grid and primary site inspections and ad hoc visits provides a pro-active regime to identify sites where trespassing may have occurred. Due to the number of secondary sites, there would always be a significant time lapse between trespass and identification, unless by chance it had just happened, so it is not envisaged that a change to increase frequencies would be cost effective. Taking into account measures being put in place to reduce metal theft in particular, the plan reflects consistent I&M interventions in line with the above policies throughout the period, with a reduction starting in 2013/14, compared to previous years, to reflect the change in frequency of grid and primary minor, and secondary site inspections.

Site inspections cover all plant on the site. At grids and primaries, a minor inspection looks for easily identifiable defects, while major inspections look at items of plant in detail for defects.

Table 48, Table 49 and figure 46 show the volume profiles in ED1 and ED2

Description of Activity	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Inspect Grid/Primary Site (Minor)	1,168	749	749	749	749	749	749	749	749	749
Inspect Grid/Primary Site (Major)	679	705	705	705	705	705	705	705	705	705
Inspect ESQC Grid/Primary Site High Risk	9,912	7796	5959	4588	4588	4588	4588	4588	4588	4588
Grid and primary earthing inspection	571	676	676	676	676	676	676	676	676	676
Inspect Secondary Substation	11,940	13,002	10,764	11,673	12,986	10,780	11,658	13,001	10,765	11,672
Inspect ESQC Secondary Substation High Risk	4,450	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300
Inspection Total	**28,720**	**27,228**	**23,153**	**22,691**	**24004**	**21798**	**22676**	**24019**	**21783**	**22690**
Includes RIGs Lines: CV13 Line 23, 24, 44, 58, 72										

Table 48 - DPCR5 & ED1 Forecast – I&M Distribution Sites. Source: 13th February NAMP Table O

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
Sites Housing Electrical Equipment Inspection	**22,851**	**22,851**	**22,851**	**22,851**	**22,851**	**22,851**	**22,851**	**22,851**

Table 49 - ED2 Forecast – I&M Distribution Sites

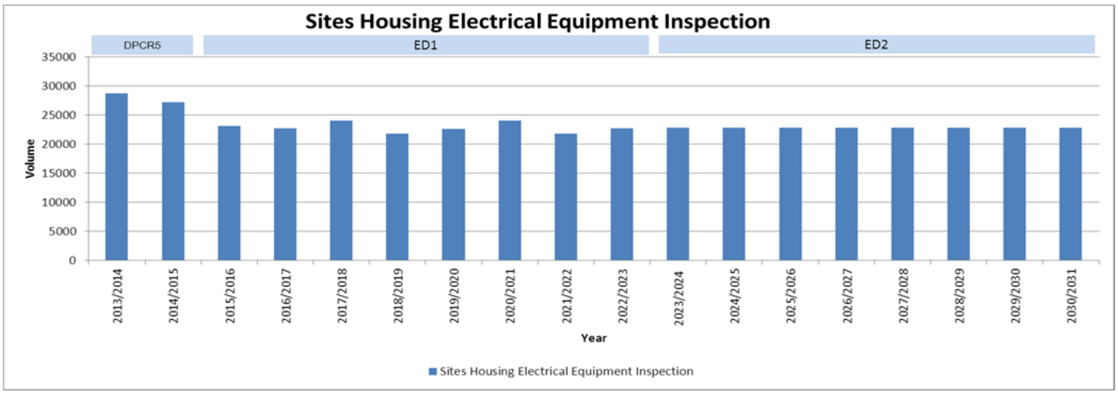

Figure 46 DPCR5*, ED1 & ED2 Historical and Forecast Values*

12.8 Innovation

One of the biggest problems currently faced by UK Power Networks is metal theft, often in the form of copper earthing straps or cables, and on occasions batteries. Although the government are proposing to tackle the issue by removing the opportunity for cash transactions, there will always be a market for such items. In order to address this, security measures, such as reducing the attractiveness of theft by using aluminium earthing conductor above ground, or building earthing into structures, have been introduced to reduce the draw to such activity in the long term.

As part of ongoing Reliability Centred Maintenance (RCM) assessments to optimise I&M activities the following have been changed to provide a more targeted approach:

For plant at secondary substations, the general frequency has been decreased from two to three years. Exceptions are where protection schemes and batteries are on site.

The frequency of inspections at Grid and Primary sites has been generally decreased to two per year (one minor and one major inspection) except where other plant on site requires a higher level such as wet cell batteries.

To evaluate this opportunity further we looked at how we gather condition data at all sites. The assessment showed that apart from specific visits to formerly gather this information, many other visits are made for other reasons, such as vegetation management, switching etc. It is proposed to introduce methods to record such visits where it is a requirement to report any overt defects that may affect site security or present a safety or environmental hazard.

13.0 Third Party Damage

This category of work has been excluded from the fault volumes included in the asset sections above as the costs are recoverable from third parties.

Table 50, Table 51 and figure 47 show the volume profiles in ED1 and ED2.

Description	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
LV Cable Damages	739	746	754	761	769	777	685	792	800	808
LV Cable Damage (Consac)	1	1	1	1	1	1	1	1	1	1
LV Overhead Network Damage	205	202	200	198	196	194	193	191	189	187
11kV Overhead Damage	93	92	89	90	89	88	88	87	86	85
11kV Cable Damage	164	126	128	169	169	173	134	176	178	180
EHV Cable Damage Non Pressurised	1	0	0	0	0	0	0	0	0	0
33kV Overhead Line Damage	1	1	1	1	1	1	1	1	1	1
Services - LV Cable Damage	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160
132kV Cable Damage Non Pressurised	1	0	0	0	0	0	0	0	0	0

Table 50 - Third Party Damage Information in DPCR5 and ED1. Source: 19th February 2014 NAMP Table O.

ED2 Volumes	2023 /2024	2024 /2025	2025 /2026	2026 /2027	2027 /2028	2028 /2029	2029 /2030	2030 /2031
LV Cable Damages	768	768	768	768	768	768	768	768
LV Cable Damage (Consac)	1	1	1	1	1	1	1	1
LV Overhead Network Damage	194	194	194	194	194	194	194	194
11kV Overhead Damage	88	88	88	88	88	88	88	88

Table 51 - Third Party Damage Information in ED2. Source: 19th February 2014 NAMP Table O.

11kV Cable Damage	163	163	163	163	163	163	163	163
EHV Cable Damage Non Pressurised	0	0	0	0	0	0	0	0
33kV Overhead Line Damage	1	1	1	1	1	1	1	1
Services - LV Cable Damage	1160	1160	1160	1160	1160	1160	1160	1160
132kV Cable Damage Non Pressurised	0	0	0	0	0	0	0	0

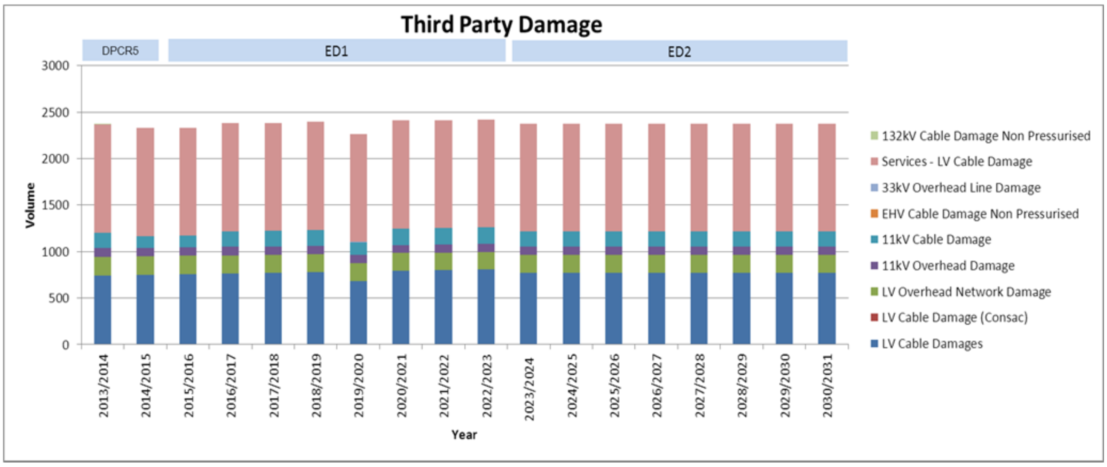

Figure 47 - DPCR5, ED1 & ED2 Historical and Forecast Values

14.0 Trees

Please refer to document 22 for tree related faults data.

15.0 Appendices

Appendix 1 Age Profiles

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Appendix 2 HI Profiles N/A

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Appendix 3: Fault Data

Towers (Broad Based) and Conductors

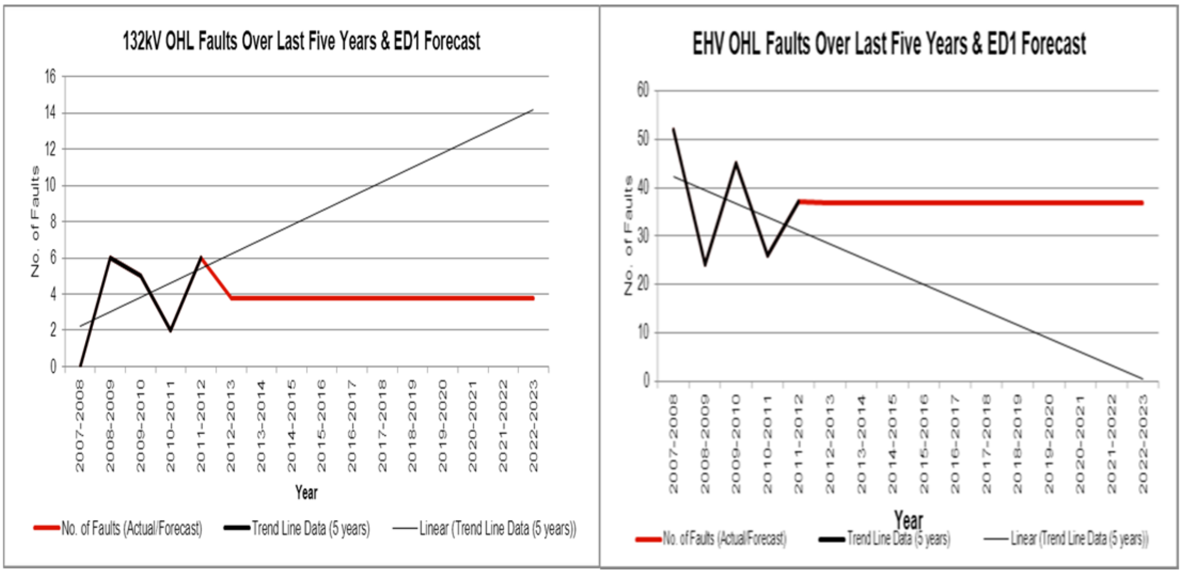

Figure 48 Fault trends for towers

Wood Poles and conductors

Figure 49 Fault trends for wood pole overhead lines

OHL Service

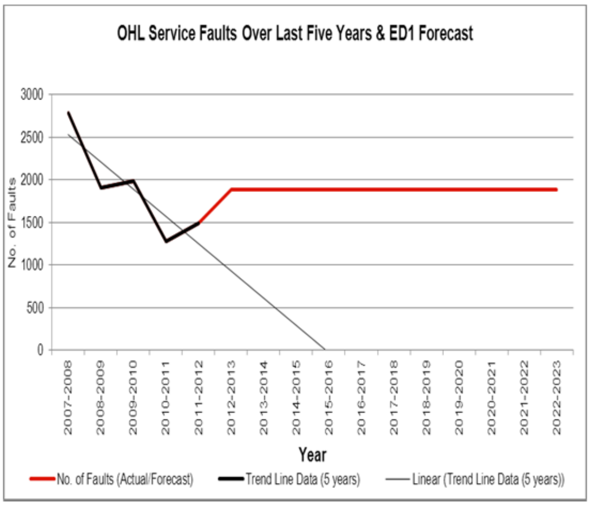

Figure 50 Fault trends for overhead services

Cables

Figure 51 Fault trends for cables

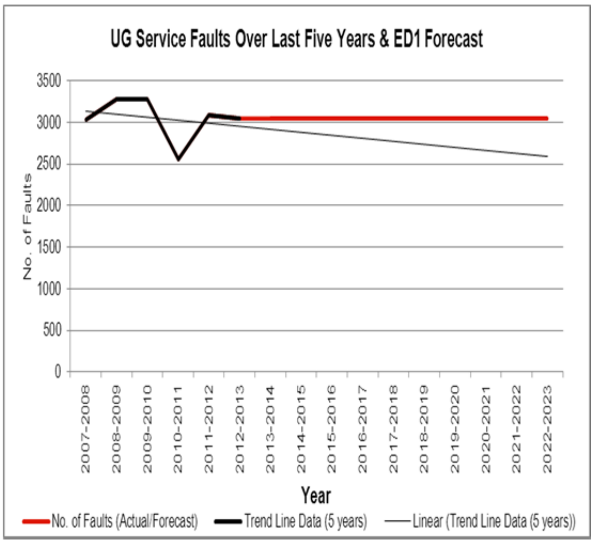

Figure 52 Fault trends for underground services

132kV Switchgear

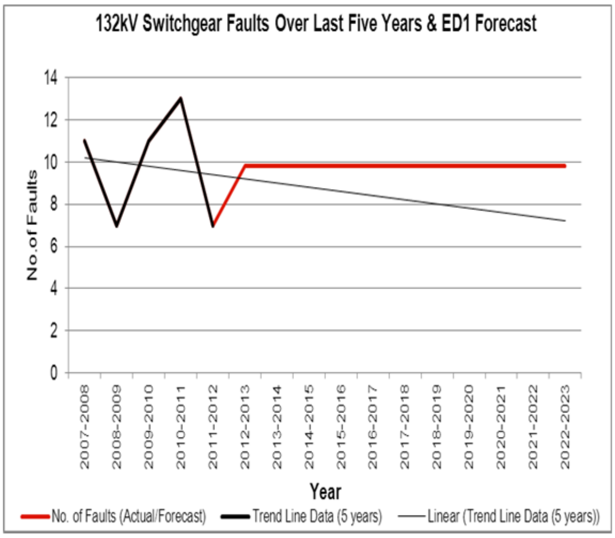

Figure 53 Fault trends for 132kV switchgear

EHV Switchgear

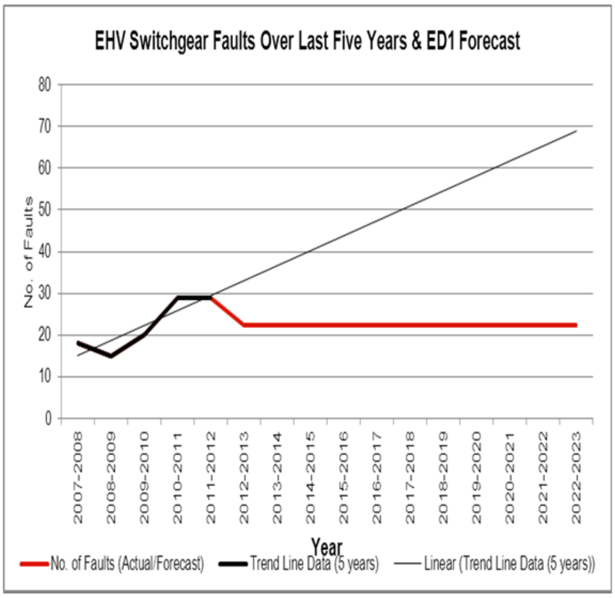

Figure 54 Fault trends for EHV switchgear

HV Switchgear and LV Plant

Figure 55 Fault trends for HV switchgear and LV plant

Grid and Primary Transformers

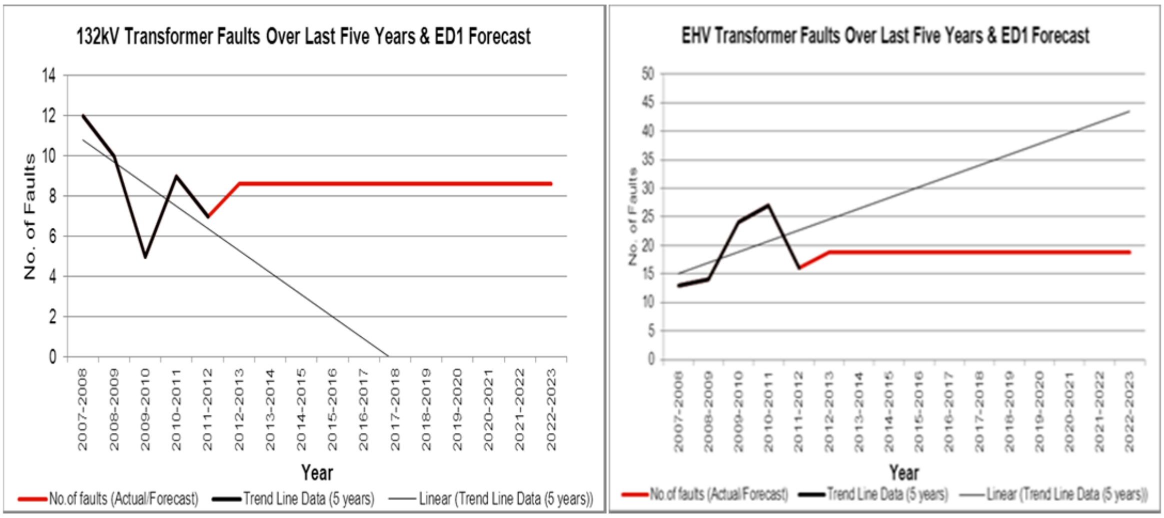

Figure 56 Fault trends for 132kV transformers

Distribution Transformers

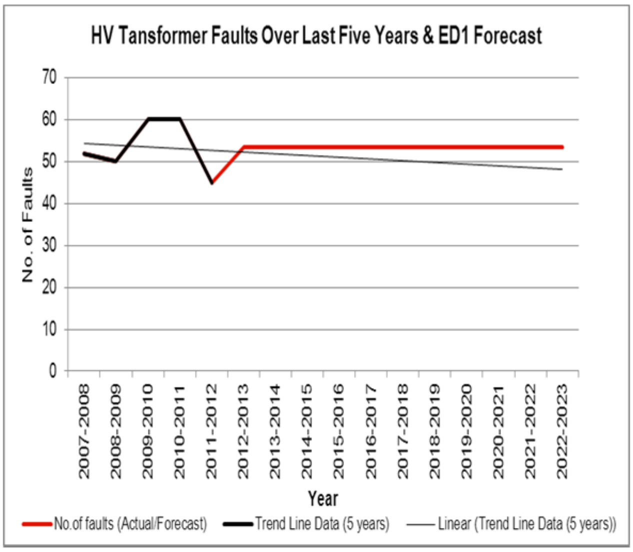

Figure 57 Fault trends for distribution transformers

Appendix 4 WLC Case Studies – risk, cost, performance, condition, profiles for various options

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Appendix 5 NLRE Expenditure Plan

Activity	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	Sum of DPCR5	Sum of RIIO-ED1
Faults	55.2	46.5	50.4	50.7	40.9	37.9	37.6	37.3	37.0	36.2	36.7	37.2	37.6	243.8	297.5
Inspection (I)	5.3	6.5	5.3	8.3	10	6.2	5.8	5.8	5.8	5.8	5.8	5.7	5.8	35.5	46.6
Maintenance (M)	16.3	16.6	12.6	6.9	10.6	9.9	9.7	9.7	9.7	9.6	9.8	9.9	9.8	63	78.1
I&M	21.6	23.1	17.9	15.2	20.7	16	15.4	15.6	15.5	15.4	15.6	15.6	15.6	98.5	124.7
Total	76.8	69.6	68.3	65.9	61.6	53.9	53.0	52.9	52.5	51.6	52.3	52.8	53.2	342.3	422.2

Table 52: I&M and Faults all costs

Activity	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	Sum of DPCR5	Sum of RIIO-ED1
Faults	55.2	46.5	50.4	50.7	40.9	37.9	37.6	37.3	37.0	36.2	36.7	37.2	37.6	243.8	297.5
Inspection (I)	5.3	6.5	5.2	8.3	10	6.2	5.8	5.8	5.8	5.8	5.8	5.7	5.7	35.4	46.6
Maintenance (M)	11.2	11.6	9.3	3.1	4.6	4.8	4.5	4.6	4.5	4.5	4.7	4.8	4.7	39.8	37.1
I&M	16.5	18.1	14.6	11.4	14.7	10.9	10.3	10.4	10.3	10.2	10.5	10.5	10.5	75.2	83.7
Total	71.7	64.6	65.0	62.1	55.6	48.8	47.9	47.7	47.3	46.4	47.2	47.7	48.1	319.0	381.2

Table 33: I&M and Faults excluding civils and Protection

Appendix 6 Sensitivity Analysis

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Appendix 7 Named Schemes

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Appendix 8 Output NAMP/ED1 RIGs reconciliation

I&M – CV13

MappedRigs Table Row	Row Number	Current NAMP Reference	ProjectID	ProjectName	2016	2017	2018	2019	2020	2021	2022	2023	Grand Total
CV13	7	4.21.10	7455	Full Patrol Wood Pole/Lattice LV	20,964	20,964	20,964	20,964	20,964	20,964	20,964	20,964	167,712
CV13	7	4.21.13	7459	Safety Patrol Wood Pole/Lattice LV	40,688	40,688	40,688	40,688	40,688	40,688	40,688	41,228	326,044
CV13	7	4.22.04	7476	S poles - LV Structural Test After Hammer Test	680	680	680	680	680	680	680	680	5,440
CV13 7 Total					62,332	62,332	62,332	62,332	62,332	62,332	62,332	62,872	499,196
CV13	8	1.13.20	8974	Boron Rods EPN (LV Poles)	9,903	9,903	9,903	9,903	9,903	9,903	9,903	9,903	79,224
CV13	8	2.14.03	9262	Follow Up - LV	200	203	204	207	209	212	213	216	1,664
CV13 8 Total					10,103	10,106	10,107	10,110	10,112	10,115	10,116	10,119	80,888
CV13	9	2.14.04	9037	Shrouding for LV Mains and Services	953	953	953	953	953	953	953	953	7,624
CV13	10	2.07.09	9820	Network Pillar Inspection	122	122	122	122	122	122	122	122	976
CV13	10	4.07.02	7368	Inspect LV Link Box	4,262	4,262	4,262	4,262	4,262	4,262	4,262	4,262	34,096
CV13	10	4.07.03	7370	Inspect Network LV Pillar	229	229	229	229	229	229	229	229	1,832
CV13	10	4.07.07	7377	Inspect Service Turret	159	161	161	161	161	161	161	161	1,286
CV13 10 Total					4,772	4,774	4,774	4,774	4,774	4,774	4,774	4,774	38,190
CV13	11	1.44.07	9133	Replace Covers & Frames	300	300	300	300	300	300	300	300	2,400
CV13	11	2.23.02	9304	Defect Repair - LV G/M S/S Equipment	65	66	63	53	54	55	56	60	472
CV13	11	4.04.27	7269	Maintain LV AC Board	3	9	14	16	6	1	3	4	56
CV13	11	4.08.18	7406	Maintain LV Dist.Board (Pillar/TOC)	719	1,137	1,005	567	580	1,233	1,645	1,369	8,255
CV13	11	4.08.19	7409	Maintain LV ACB	30	30	30	30	30	30	30	30	240
CV13	11	4.08.24	6268	Trip Test LV ACB	7	4	7	4	7	4	7	2	42

CV13 11 Total					1,124	1,546	1,419	970	977	1,623	2,041	1,765	11,465
CV13	16	2.30.15	7120	Cable Pit Inspection (LV)	392	392	392	392	392	392	149	149	2,650
CV13	16	2.35.01	9342	UMS Services Inspected	10,526	10,526	10,526	10,526	10,526	10,526	10,526	10,526	84,208
CV13	16	2.36.03	8162	Idle Service Inspection	9,066	9,066	9,066	9,066	9,066	9,066	9,066	9,066	72,528
CV13 16 Total					19,984	19,984	19,984	19,984	19,984	19,984	19,741	19,741	159,386
CV13	19	4.21.08	8704	EPN 11KV Full Patrol Wood Pole/Lattice	17,806	17,806	17,806	17,806	17,806	17,806	17,806	17,806	142,448
CV13	19	4.21.12	7457	Safety Patrol Wood Pole/Lattice HV	35,668	35,668	35,668	35,668	35,668	35,668	35,668	35,668	285,344
CV13	19	4.21.25	7463	ESQC Inspection Wood Pole/Lattice HV	9,091	9,091	9,091	9,091	9,091	9,091	9,091	9,091	72,728
CV13	19	4.22.05	7478	S poles - 11kV Structural Test After Hammer Test	150	150	150	150	150	150	150	150	1,200
CV13 19 Total					62,715	62,715	62,715	62,715	62,715	62,715	62,715	62,715	501,720
CV13	20	1.13.20	8975	Boron Rods EPN (HV Poles)	8,575	8,575	8,575	8,575	8,575	8,575	8,575	8,575	68,600
CV13	20	2.14.02	9261	Follow Up - 11kV	88	89	89	90	92	92	94	94	728
CV13 20 Total					8,663	8,664	8,664	8,665	8,667	8,667	8,669	8,669	69,328
CV13	21	2.07.11	7002	Partial Discharge Mapping - HV	8	8	8	8	8	8	8	8	64
CV13	21	2.08.12	7022	Installation & Maintenance of On-Line PD Monitoring	60	60	60	60	60	60	60	60	480
CV13	21	2.30.15	8994	Cable Pit Inspection (HV)	263	263	263	263	263	263	100	100	1,778
CV13 21 Total					331	331	331	331	331	331	168	168	2,322
CV13	23	2.21.09	9766	Reserve Sub Station Inspection	652	652	652	652	652	652	652	652	5,216
CV13	23	2.21.12	6242	VMX Discharge Testing	177	177	177	177	177	177	177	177	1,416
CV13	23	2.34.04	9340	Voltage/Load Investigations	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472	11,776
CV13	23	4.07.01	7365	Inspect Secondary Substation	10,764	11,673	12,986	10,780	11,658	13,001	10,765	11,672	93,299
CV13	23	4.07.06	7375	Inspect ESQC Secondary Substation High Risk	4,300	4,300	4,300	4,300	4,300	4,300	4,300	4,300	34,400
CV13 23 Total					17,365	18,274	19,587	17,381	18,259	19,602	17,366	18,273	146,107
CV13	25	1.47.39	8333	Dist S/S - Replace Trench Covers	1	0	0	0	0	0	0	1	2
CV13	25	2.23.01	9303	Defect Repair - 11kV Distribution substation	175	147	78	150	183	184	187	188	1,292
CV13	25	2.32.05	9330	Maintain Distribution Sites & Building - 11kV	604	620	620	620	620	620	620	620	4,944
CV13	25	2.32.08	9333	Vegetation Clearance - 11kV	36,138	36,138	36,138	36,138	36,138	36,138	36,138	36,137	289,103

CV13	**25**	2.32.15	**6250**	Tree Trimming (Distribution Sites)	1,346	1,346	1,346	1,346	1,346	1,346	1,346	1,346	10,768
CV13	**25**	2.33.02	**8046**	Defect Repair - Secondary Substation Civils	1,000	1,008	1,020	1,028	1,040	1,048	1,060	1,072	8,276
CV13	**25**	2.33.24	**7076**	Electrical Wiring - Defect Repair at Secondary Substations	133	134	136	137	138	132	119	142	1,071
CV13	**25**	2.34.16	**8159**	Demolish Abandoned/Unsafe Buildings	1	1	1	0	0	0	0	1	4
CV13 25 Total					39,398	39,394	39,339	39,419	39,465	39,468	39,470	39,507	315,460
CV13	**27**	2.20.01	**9295**	Defect Repair - 11kV Circuit Breakers at grid/primary substation	197	200	201	204	205	206	208	212	1,633
CV13	**27**	4.06.01	**7341**	Maint FULL 11/6.6kV SF6/Vac CB W/B Feed	106	156	134	139	237	167	80	179	1,198
CV13	**27**	4.06.02	**7344**	Maint FULL 11/6.6kV SF6/Vac CB F/B Feed	58	88	116	98	128	119	126	108	841
CV13	**27**	4.06.06	**7350**	Maint MECH 11/6.6kV OCB Feeder	84	95	83	32	38	75	100	92	599
CV13	**27**	4.06.07	**7353**	Maint MECH 11/6.6kV SF6/Vac CB W/B Feed	65	65	65	65	65	65	65	65	520
CV13	**27**	4.06.08	**7356**	Maint MECH 11/6.6kV SF6/Vac CB F/B Feed	5	5	5	5	5	5	5	5	40
CV13	**27**	4.06.10	**7362**	Maint FULL 11/6.6kV OCB Feeder	97	97	79	57	75	75	83	120	683
CV13	**27**	4.08.25	**7421**	Maint FULL 11/6.6kV SF6/Vac CB F/P S/SUB	26	40	51	36	29	40	46	56	324
CV13	**27**	4.08.26	**7424**	Maint FULL 11/6.6kV SF6/Vac CB W/D S/SUB	6	5	6	1	7	10	4	13	52
CV13	**27**	4.08.29	**7433**	Maint MECH 11/6.6kV SF6/Vac CB F/P S/SUB	5	12	12	5	4	2			40
CV13	**27**	4.08.30	**7436**	Maint MECH 11/6.6kV SF6/Vac CB W/D S/SUB	10	6	4	1	5	1	3		30
CV13	**27**	4.24.01	**7484**	Maint FULL 11/6.6kV OCB TSC	81	66	52	60	67	63	77	91	557
CV13	**27**	4.24.02	**7487**	Maint FULL 11/6.6kV SF6/Vac CB W/B TSC	24	24	28	16	19	18	12	23	164
CV13	**27**	4.24.03	**7490**	Maint FULL 11/6.6kV SF6/Vac CB F/B TSC	36	41	48	37	43	33	29	37	304
CV13	**27**	4.24.05	**7496**	Maint MECH 11/6.6kV OCB TSC	70	89	76	35	39	49	78	69	505
CV13	**27**	4.24.06	**7499**	Maint MECH 11/6.6kV SF6/Vac CB W/B TSC	3	3	3	3	3	3	3	3	24
CV13	**27**	4.24.07	**7502**	Maint MECH 11/6.6kV SF6/Vac CB F/B TSC	3	3	3	3	3	3	3	3	24
CV13	**27**	4.24.08	**6203**	Trip Test 11/6.6KV CB TSC	242	242	242	242	242	242	242	242	1,936
CV13 27 Total					1,118	1,237	1,208	1,039	1,214	1,176	1,164	1,318	9,474
CV13	**28**	4.08.21	**7412**	Maint FULL 11/6.6kV OCB at S/SUB	17	39	88	73	51	89	84	104	545
CV13	**28**	4.08.28	**7430**	Maint MECH 11/6.6kV OCB at S/SUB	87	31	26	12	24	64	37	31	312
CV13 28 Total					104	70	114	85	75	153	121	135	857

CV13	**30**	1.19.04	**9058**	Replace EFPI	290	290	290	290	290	290	290	290	2,320
CV13	**30**	2.22.05	**6428**	Plant Paint 11kV & Below	694	857	1,029	1,179	1,179	1,179	1,179	1,179	8,475
CV13	**30**	4.02.16	**6262**	Oil Sample Regulator/Balancer			0	1	2				3
CV13	**30**	4.08.03	**7380**	Maintain Non-Isolatable Oil Switch	5	4	13	18	10	13	26	17	106
CV13	**30**	4.08.04	**7381**	Maintain Non-Isolatable Gas/Vac.Switch	7	6	7	3	4	4	4	4	39
CV13	**30**	4.08.06	**6267**	Maintain Non-Isolatable RMU (Oil) - Contractor	44	26	31	27	35	63	60	26	312
CV13	**30**	4.08.06	**6790**	Maintain Non-Isolatable RMU (Oil)	366	11	25	31	46	42	108	158	787
CV13	**30**	4.08.07	**7386**	Maintain Non-Isolatable RMU (Gas/Vacuum)	13	17	25	14	18	10	10	16	123
CV13	**30**	4.08.08	**7388**	Maintain Isolatable Oil Switch	5	9	14	19	2	10	11	16	86
CV13	**30**	4.08.10	**6804**	Maintain Switch Fuse - Contractors	0								0
CV13	**30**	4.08.10	**7391**	Maintain Switch Fuse	0	3	16	44	13	37	66	106	285
CV13	**30**	4.08.13	**7395**	Maintain HV Metering Unit	0	0	0	0	1	1	0	3	5
CV13	**30**	4.08.16	**7400**	Maintain Fused End Box	176	265	245	136	143	227	189	155	1,536
CV13 30 Total					616	341	376	292	272	407	474	501	3,279
CV13	**31**	2.25.06	**9837**	11kV Feeder Protection	351	351	351	351	351	351	351	351	2,808
CV13	**31**	2.25.13	**9844**	Trip Testing 11kV Sequence Closing	739	739	739	739	739	739	739	739	5,912
CV13	**31**	2.26.03	**9319**	Defect Repair - 11kV Protection	13	13	13	13	13	13	13	13	104
CV13	**31**	2.28.05	**9479**	3rd Party Circuit Faults	0	0	0	1	1	1	1	1	5
CV13	**31**	2.28.07	**6243**	UKPN Circuit Faults	18	18	19	20	20	21	21	21	158
CV13	**31**	2.28.16	**9732**	SCS Comms/Plant Faults	800	849	900	950	985	970	940	910	7,304
CV13	**31**	2.28.30	**9485**	RTU Battery Faults	38	40	40	40	40	40	40	40	318
CV13 31 Total	**31**				1,959	2,010	2,062	2,114	2,149	2,135	2,105	2,075	16,609
CV13	**32**	4.08.17	**7403**	Maintain Distribution Tx	813	1,280	1,137	697	687	1,283	1,414	1,543	8,854
CV13	**32**	4.08.22	**7415**	Oil Sample Dist Tx	412	412	412	412	412	412	412	412	3,296
CV13 32 Total					1,225	1,692	1,549	1,109	1,099	1,695	1,826	1,955	12,150
CV13	**35**	1.19.09	**9060**	Replace 11kV Surge Divertors	150	150	150	150	150	150	150	150	1,200
CV13	**35**	4.22.02	**7472**	Maintain ABSD 11kV	181	181	181	181	181	181	181	181	1,448

CV13 35 Total					331	331	331	331	331	331	331	331	2,648
CV13	37	4.21.08	8702	EPN 33KV Full Patrol Wood Pole/Lattice	4,969	4,969	4,969	4,969	4,969	4,969	4,969	4,969	39,752
CV13	37	4.21.12	8689	Safety Patrol Wood Pole/Lattice EHV	5,868	5,868	5,868	5,868	5,868	5,868	5,868	5,868	46,944
CV13	37	4.22.03	7474	S poles - 33kV Structural Test After Hammer Test	308	308	308	308	308	308	308	308	2,464
CV13 37 Total					11,145	11,145	11,145	11,145	11,145	11,145	11,145	11,145	89,160
CV13	38	1.13.20	6211	Boron Rods EPN (EHV)	1,401	1,401	1,401	1,401	1,401	1,401	1,401	1,401	11,208
CV13	38	2.14.01	9260	Follow Up - 33kV	45	46	46	48	48	49	48	49	379
CV13 38 Total					1,446	1,447	1,447	1,449	1,449	1,450	1,449	1,450	11,587
CV13	39	4.21.21	8681	EPN 33KV Infra Red Tower Route	121	121	121	121	121	121	121	121	968
CV13	40	4.21.02	8699	EPN 33KV Full Patrol Broad Based Tower	577	577	577	577	577	577	577	577	4,616
CV13	40	4.21.04	8693	EPN 33KV Safety Patrols Broad Based Towers	577	577	577	577	577	577	577	577	4,616
CV13	40	4.21.29	8675	EPN 33KV CORMON Testing	10	10	10	10	10	9	10	10	79
CV13 40 Total					1,285	1,285	1,285	1,285	1,285	1,284	1,285	1,285	10,279
CV13	44	2.30.23	8984	Water Quality Testing (Primary Sites)	1,025	1,025	1,025	1,025	1,025	1,025	1,025	1,025	8,200
CV13	44	2.33.25	8456	Drainage Inspection & Maintenance	4	4	4	4	4	4	4	4	32
CV13	44	4.05.57	8996	Inspect ESQC Primary Site High Risk	4,469	3,440	3,440	3,440	3,440	3,440	3,440	3,440	28,549
CV13	44	4.05.60	6815	Record EPR & Identification of Hot Sites	57	57	57	57	57	57	57	57	456
CV13 44 Total					5,555	4,526	4,526	4,526	4,526	4,526	4,526	4,526	37,237
CV13	45	2.28.19	9482	Substation Security System Maintenance	206	206	206	203	183	154	154	154	1,466
CV13	45	2.28.20	9481	Substation Security System Repairs/Fault Rectification	99	99	99	99	93	74	74	74	711
CV13	45	2.32.04	9329	Maintain Primary Sites & Building - 33kV	221	221	221	220	220	220	220	205	1,748
CV13	45	2.32.07	9332	Vegetation Clearance - 33kV	450	450	450	450	450	450	450	450	3,600
CV13	45	2.32.12	6926	Maintain Fixed Fire Protection Equipment	5	5	5	5	5	5	5	5	40
CV13	45	2.32.15	8683	Tree Trimming (Primary Sites)	489	489	489	489	489	489	489	489	3,912
CV13	45	2.32.16	6924	Maintain Portable Fire Protection Equipment	68	68	68	68	68	68	68	68	544
CV13	45	2.33.03	8978	Defect Repair - Primary Substation Civils	92	94	95	96	96	98	98	98	767
CV13	45	2.33.16	8697	Primary Substation Earthing - Hot site correction	1	1	1	1	1	1	1	1	8

CV13	**45**	2.33.17	**8048**	Pumping Out Flooded Substations	13	13	13	13	13	13	13	13	104
CV13	**45**	2.33.22	**8981**	Electrical Wiring - Defect Repair at Primarys	184	184	187	188	190	192	194	196	1,515
CV13 45 Total					1,828	1,830	1,834	1,832	1,808	1,764	1,766	1,753	14,415
CV13	**46**	2.16.19	**6367**	33kV OCB Painting	13	12	13	12	13	12	12	12	99
CV13	**46**	2.17.01	**9288**	Defect Repair - 33/22 kV Switchgear	108	110	112	112	113	114	117	117	903
CV13	**46**	2.23.03	**9299**	Plant Forensic Testing and Failure Investigation	17	17	17	17	17	17	17	17	136
CV13	**46**	2.45.01	**6376**	Strategic Spares Provision	75	75	75	75	75	75	75	75	600
CV13	**46**	4.02.08	**7165**	Maintain Fault Throwing Switches	65	66	51	56	48	39	45	42	412
CV13	**46**	4.04.03	**7216**	Maintain 33/22kV Oil CB	24	32	29	24	28	28	29	52	246
CV13	**46**	4.04.04	**7219**	Maint FULL 33/22kV Vac/SF6 O/D CB	14	6	11	18	20	31	20	20	140
CV13	**46**	4.04.05	**7222**	Maint FULL 33/22kV Vac/SF6 F/P & GIS CB	25	28	36	44	58	47	45	77	360
CV13	**46**	4.04.09	**7228**	Maintain MECH 33/22kV Oil CB	34	52	51	54	73	66	40	52	422
CV13	**46**	4.04.10	**7230**	Maint MECH 33/22kV Vac/SF6 O/D CB	4	5	5	4	4	4	4	4	34
CV13	**46**	4.04.11	**7233**	Maint MECH 33/22kV Vac/SF6 F/P & GIS CB	12	12	12	12	12	12	13	12	97
CV13	**46**	4.04.12	**7236**	Trip Test 33/22kV CB Inc Op of Isolators	949	970	949	970	949	970	891	747	7,395
CV13	**46**	4.04.35	**7293**	Maint FULL 33/22kV Vac/SF6 W/D CB	0	0	3	1	2	8	7	3	24
CV13	**46**	4.04.36	**7296**	Maint MECH 33/22kV Vac/SF6 W/D CB	1	1	1	1	1	1	1	1	8
CV13	**46**	4.22.01	**7470**	Maintain ABSD 33kV	31	31	31	31	31	31	31	31	248
CV13 46 Total					1,372	1,417	1,396	1,431	1,444	1,455	1,347	1,262	11,124
CV13	**47**	2.25.04	**9835**	33kV Feeder Protection	93	93	93	93	93	93	93	93	744
CV13	**47**	2.25.05	**9836**	System Transformer Protection	75	75	75	75	75	75	75	75	600
CV13	**47**	2.25.12	**9843**	Trip Testing 33kV AR	195	195	195	195	195	195	195	195	1,560
CV13	**47**	2.26.01	**9317**	Defect Repair - EHV Protection	11	11	11	11	11	11	11	11	88
CV13 47 Total					374	374	374	374	374	374	374	374	2,992
CV13	**47**	2.28.28	**9478**	Satellite Comms Faults	35	35	35	35	35	35	35	35	280
CV13	**48**	2.03.23	**9887**	EHV Transformer / Cooler Painting	28	33	33	33	33	33	33	33	259
CV13	**48**	2.04.02	**9216**	Defect Repair - Primary Transformers/Tapchangers	120	122	123	124	125	127	128	129	997

CV13	48	2.25.01	9316	ASC Retune	72	72	72	72	72	72	72	72	576
CV13	48	4.02.07	7163	Maintain Arc Suppression Coil	11	14	18	14	8	9	9	8	91
CV13	48	4.02.15	7184	Oil Sample ASC	7	5	6	7	10	12	13	14	74
CV13 48 Total					273	281	287	285	283	288	290	291	2,277
CV13	65	4.21.08	7453	EPN 132KV Full Patrol Wood Pole/Lattice	2,775	2,774	2,774	2,774	2,774	2,774	2,774	2,773	22,192
CV13	65	4.21.12	8690	Safety Patrol Wood Pole/Lattice 132kV	31	39	39	39	39	39	39	39	304
CV13 65 Total					2,806	2,813	2,813	2,813	2,813	2,813	2,813	2,812	22,496
CV13	67	4.21.21	7461	EPN 132KV Infra Red Patrol Route	137	137	137	137	137	137	137	137	1096
CV13	68	4.21.02	7445	EPN 132KV Full Patrol Broad Based Tower	2,378	2,378	2,378	2,378	2,378	2,378	2,378	2,378	19,024
CV13	68	4.21.04	7448	EPN 132KV Safety Broad Based Towers Patrol	2,378	2,378	2,378	2,378	2,378	2,378	2,378	2,378	19,024
CV13	68	4.21.05	7451	Climbing Inspection Broad Based Tower	39	39	39	39	39	39	39	39	312
CV13	68	4.21.28	7465	Spacer Checks Twin Bundles	20	20	20	20	20	20	20	20	160
CV13	68	4.21.29	7468	EPN 132KV CORMON Testing	40	40	40	40	40	40	40	40	320
CV13	68	4.22.07	7481	GS6 Enquiries	4,917	4,917	4,917	4,917	4,917	4,917	4,917	4,917	39,336
CV13 68 Total					9,772	9,772	9,772	9,772	9,772	9,772	9,772	9,772	78,176
CV13	69	1.20.03	6215	Install Tower Signs, Colour Plates Etc.	360								360
CV13	70	2.05.09	6559	Gauges-132/33kV Inspect and Alarm Test	270	270	270	270	270	270	270	270	2,160
CV13	70	2.05.11	9818	Sub Standard Gauge Checks (Tank Inspection Above Ground)	61	61	61	61	61	61	61	61	488
CV13	70	2.05.12	9819	Tank Inspection (Above Ground)	130	130	130	130	130	130	130	97	1,007
CV13	70	2.05.14	6770	Gauge Mal Function Investigation	9	9	9	9	9	9	9	9	72
CV13	70	2.07.01	9225	Discharge Mapping - 132-33kV	2	2	2	2	2	2	2	2	16
CV13	70	2.34.07	9341	Abandoned/Unidentified Cable Location	18	18	18	18	18	18	18	18	144
CV13	70	4.25.01	7511	Calibrate Pressure Gauge	6	6	6	6	6	6	6	6	48
CV13	70	4.25.02	7514	Inspect and Test Pressure Gauge	69	69	69	69	69	69	69	69	552
CV13	70	4.25.04	7517	Check Pressure (Oil/Gas)	24	24	24	24	24	24	24	24	192
CV13	70	4.25.05	7520	Test Cable Serving / Oversheath	2	2	2	2	2	2	2	2	16
CV13	70	4.25.06	7523	Test Sheath Voltage Limiters (SVLs)	10	10	10	10	10	10	10	10	80

CV13 70 Total					601	601	601	601	601	601	601	568	4,775
CV13	71	2.05.08	9817	Cable Pit Maintain	78	78	78	78	78	78	12	12	492
CV13	71	2.06.01	6791	Oil Top Up; Pumping & Testing - 132-33kV	55	55	55	55	55	55	55	55	440
CV13	71	2.06.02	6406	Repair Oil Leak	38	42	42	42	42	42	42	42	332
CV13	71	2.06.09	7003	Replace Minor Oil Plant + Sheath Testing	5	5	5	5	5	5	5	5	40
CV13 71 Total					176	180	180	180	180	180	114	114	1,304
CV13	72	2.17.04	6564	Inspection and Testing of Lifting Equipment	4	4	4	3	4	3	4	3	29
CV13	72	2.25.07	9838	AVC checks at Grids & Primaries	96	96	96	96	96	96	96	96	768
CV13	72	2.30.11	9912	Grid and Primary Earthing Inspection	676	676	676	676	676	676	676	676	5,408
CV13	72	2.30.22	6827	PAT Testing at Grid & Primary Substations	7	4	4	4	4	4	7	4	38
CV13	72	2.30.23	8042	Water Quality Testing at Grid & Primary Substations	565	565	565	565	565	565	565	565	4,520
CV13	72	2.33.19	6843	Water Testing - Remedial Works	98	84	84	84	84	84	84	84	686
CV13	72	2.34.03	9339	EMF Enquiries	109	109	109	109	109	109	109	109	872
CV13	72	2.34.08	9699	Noise Complaint Investigations by Operations	2	2	2	2	2	2	2	2	16
CV13	72	4.05.01	7305	Inspect Grid/Primary Site (Minor)	749	749	749	749	749	749	749	749	5,992
CV13	72	4.05.03	7308	Inspect Grid/Primary Site (Major)	705	705	705	705	705	705	705	705	5,640
CV13	72	4.05.37	7311	Inspect Air Compressor	231	232	232	232	232	232	232	232	1,855
CV13	72	4.05.38	7314	Inspect Main Air Receiver	63	63	63	63	63	63	63	63	504
CV13	72	4.05.48	7317	Insurance Insp. Air/Gas Receiver	15	15	15	15	15	15	15	15	120
CV13	72	4.05.49	7320	Insurance Insp. ABCB Complete Unit	29	29	29	29	29	29	29	29	232
CV13	72	4.05.52	7323	Insurance Insp. Air Panel	1	0	2	7	1	0	2	7	20
CV13	72	4.05.53	7326	Inspect Flexible Earths & Rods	220	220	220	220	220	220	220	220	1,760
CV13	72	4.05.56	7329	Infra-Red Inspection Aerial Sets/Busbars	535	535	535	535	535	535	535	535	4,280
CV13	72	4.05.57	7332	Inspect ESQC Grid Site High Risk	1,490	1,148	1,148	1,148	1,148	1,148	1,148	1,148	9,526
CV13	72	4.05.58	7335	Insurance Insp Switchgear Accumulator	4	4	4	4	4	4	4	4	32
CV13 72 Total					5,599	5,240	5,242	5,246	5,241	5,239	5,245	5,246	42,298
CV13	73	2.32.02	8043	Graffitti Removal (was Veg Clearance)	86	86	86	86	86	86	86	86	688

CV13	**73**	2.32.03	**9328**	Maintain Grid Sites & Building - 132kV	304	304	304	304	304	304	304	304	2,432
CV13	**73**	2.32.06	**9331**	Vegetation Clearance - 132kV	107	107	107	107	106	106	106	114	860
CV13	**73**	2.32.15	**8684**	Tree trimming (Grid Sites)	165	165	165	165	165	165	165	165	1,320
CV13	**73**	2.33.03	**6251**	Defect Repair - Grid Substation Civils	92	94	95	96	96	97	98	99	767
CV13	**73**	2.33.06	**8047**	132&33kV Fly Tipping Site Clearance	13	13	13	13	13	13	13	13	104
CV13	**73**	2.33.16	**6560**	Grid Substation Earthing - Hot Site Correction	1	1	1	1	1	1	1	1	8
CV13	**73**	2.33.20	**6878**	Fire Risk Assessment - Remedial Work	404	420	420	420	420	420	420	420	3,344
CV13	**73**	2.33.22	**8049**	Electrical Wiring - Defect Repair at Grids	184	187	187	185	191	192	195	196	1,517
CV13 73 Total					1,356	1,377	1,378	1,377	1,382	1,384	1,388	1,398	11,040
CV13	**74**	2.16.20	**6971**	132/66kV Plant Painting	10	10	10	10	10	10	10	10	80
CV13	**74**	2.17.02	**9289**	Defect Repair - 132/66 kV Switchgear	92	93	94	96	96	97	98	100	766
CV13	**74**	2.25.02	**9833**	132kV CB Feeder Inc BS	19	19	19	19	19	19	19	19	152
CV13	**74**	4.02.09	**7168**	Maintain VT Isolatable	27	27	27	27	27	27	25	15	202
CV13	**74**	4.02.10	**7171**	Maintain VT Non-Isolatable	43	53	58	84	87	98	106	75	604
CV13	**74**	4.02.12	**7177**	Maintain CVT	22	23	16	7	12	2	6	3	91
CV13	**74**	4.02.21	**7199**	Oil Sample VT	5								5
CV13	**74**	4.02.23	**7202**	Oil Sample CT	15								15
CV13	**74**	4.04.13	**7239**	Maint FULL 132/66kV Air Blast CB	4	8	15	9	6	7	12	12	73
CV13	**74**	4.04.14	**7242**	Maint Full 132/66kV Oil CB	0	1	0	1	0	0	0	1	3
CV13	**74**	4.04.16	**7245**	Maint FULL 132/66kV SF6 O/D CB	3	3	5	16	18	18	24	14	101
CV13	**74**	4.04.20	**7251**	Maintain MECH 132/66kV Oil CB	0	2	3	2	1	1	0	1	10
CV13	**74**	4.04.22	**7254**	Maint MECH 132/66kV SF6 O/D CB	4	4	4	4	4	4	4	4	32
CV13	**74**	4.04.23	**7257**	Trip Test 132/66kV CB & Op of Ext Isolators	6	6	6	6	6	5	6	4	45
CV13	**74**	4.04.24	**7260**	Maintain Isolator (Manual)	39	39	39	39	39	39	39	39	312
CV13	**74**	4.04.25	**7263**	Maintain Isolator (Motorised)	11	11	11	11	11	11	11	11	88
CV13	**74**	4.04.26	**7266**	Maintain Earth Switch	39	39	39	39	39	39	39	39	312
CV13	**74**	4.04.28	**7272**	Maintain Air Compressor	29	29	29	29	29	29	29	29	232

CV13	**74**	4.04.33	**7287**	Maintain Mech 132/66kV Air Blast CB	9	10	10	9	9	9	9	9	74
CV13	**74**	4.04.37	**7299**	Maint FULL 132/66kV SF6 GIS CB	12	16	0	0	1	10	21	3	63
CV13	**74**	4.04.38	**7302**	Maint MECH 132/66kV SF6 GIS CB	1	1	1	1	1	1	1	1	8
CV13	**74**	4.05.59	**7338**	Partial Discharge Test of Switchboard	441	441	441	441	441	441	441	441	3,528
CV13 74 Total					831	835	827	850	856	867	900	830	6,796
CV13	**75**	2.25.03	**9834**	Grid Transformer Protection	21	21	21	21	21	21	21	21	168
CV13	**75**	2.25.09	**9840**	Low Frequency - 132kV Injection Test	8	8	8	8	8	8	8	8	64
CV13	**75**	2.25.10	**9841**	132kV Buz Zone	6	6	6	6	6	6	6	6	48
CV13	**75**	2.25.11	**9842**	Trip Testing 132kV DAR	47	47	47	47	47	47	47	47	376
CV13	**75**	2.25.14	**9845**	Single Transformer Auto Changer Scheme Proving	1	1	1	1	1	1	1	1	8
CV13	**75**	2.25.15	**9791**	Pilots and Multicores Test Insulation and Continuity	102	102	102	102	102	102	102	102	816
CV13	**75**	2.25.16	**6435**	NVD Function Test	75	75	75	75	75	75	75	75	600
CV13	**75**	2.28.18	**9734**	Intertripping Faults	100	100	100	97	88	72	45	30	632
CV13	**75**	2.28.29	**9486**	EPN SCADA System Management DR5/ED1	240	240	240	240	240	240	240	240	1,920
CV13 75 Total					600	600	600	597	588	572	545	530	4,632
CV13	**76**	1.51.05	**6563**	Replace Silica Gel Breathers on Grid and System Transformers	41	41	41	41	36	26			226
CV13	**76**	2.04.01	**9215**	Defect Repair - Grid Transformers/Tapchangers	62	63	64	64	65	65	66	67	516
CV13	**76**	4.02.01	**7149**	Maintain Power TX	151	154	134	156	128	116	149	155	1,143
CV13	**76**	4.02.02	**7152**	Oil Sample Power TX	495	484	533	502	495	484	533	502	4,028
CV13	**76**	4.02.03	**7155**	Maintain Auxiliary/Earthing Tx	49	36	33	33	29	37	38	43	298
CV13	**76**	4.02.06	**7161**	Maintain Neutral Earthing Resistor	25	28	24	32	24	15	17	23	188
CV13	**76**	4.02.13	**7180**	Oil Sample Selector	230	235	234	238	229	235	234	240	1,875
CV13	**76**	4.02.14	**7183**	Oil Sample NEX	148	176	165	161	148	177	165	166	1,306
CV13	**76**	4.02.17	**6967**	Maintain Tapchanger Single Tank (Incl Tx)	94	106	87	83	60	73	85	87	675
CV13	**76**	4.02.18	**7190**	Maintain Tapchanger Diverter	64	74	82	96	68	76	86	100	646
CV13	**76**	4.02.19	**7193**	Maintain Tapchanger Selector	18	10	12	21	22	26	43	45	197
CV13	**76**	4.02.20	**6264**	Oil Sample Vacutap	3	5	5	6	3	5	5	7	39

CV13	76	4.02.20	7196	Maintain Tapchanger Vacutap	3	5	4	6	0	0	1	0	19
CV13	76	4.02.24	7205	Oil Sample F/Breathing Barrier Bushings	6	26	26	26	26	26	26	26	188
CV13	76	4.02.26	7210	Maintain Series / Shunt Reactor	3								3
CV13 76 Total					1,392	1,443	1,444	1,465	1,333	1,361	1,448	1,461	11,347
CV13	77	4.04.02	7213	Maintain Batteries and Charger	472	472	472	472	472	472	472	472	3,776
CV13	78	2.30.14	6444	Cable Tunnel Inspections	8	5	5	5	5	5	5	5	43
CV13	78	2.30.21	8040	Building, Tunnel and Bridge Survey	12	12	12	11	11	11	11	13	93
CV13 78 Total					20	17	17	16	16	16	16	18	136
CV13	79	2.32.17	8044	Cable Tunnel Maintenance	3	3	3	3	3	3	3	3	24
CV13	80	2.30.13	6441	Cable Bridge Inspections	62	62	62	62	62	62	62	62	496
CV13	81	2.32.18	8045	Cable Bridge Maintenance - EPN	34	34	34	34	34	34	34	34	272

Table 54 NAMP to RIGS mapping I&M (CV13)

MappedRIGSCostTable	MappedRIGS CostRow	CurrentNamp Reference	ProjectID	ProjectName	2016	2017	2018	2019	2020	2021	2022	2023	Grand Total
CV5	50	2.10.01	9237	132kV / 66kV Tower Painting	402,728	483,981	561,700	801,924	801,924	801,924	801,924	801,924	5,995,090

Table 55 NAMP to RIGS mapping – tower painting (CV5)

MappedRigsVolumeTable	MappedRigsVolumeRow	CurrentNampReference	ProjectID	ProjectName	2016	2017	2018	2019	2020	2021	2022	2023	Grand Total
CV5	50	**2.10.01**	9237	132kV / 66kV Tower Painting	114	137	159	227	227	227	227	227	1,545

Table 55 NAMP to RIGS mapping - Tower painting (CV5)

Faults – CV15a

MappedRigs Table Row	Row Number	Current NAMP Reference	ProjectID	ProjectName	2016	2017	2018	2019	2020	2021	2022	2023	Grand Total
CV15a	**6**	2.01.28	**6748**	Blown LV Fuses at Substations	4,486	4,486	4,486	4,486	4,486	4,486	4,486	4,486	35,888
CV15a	**7**	2.01.44	**8707**	HV Fault Restoration by Switching Only	1,193	1,193	1,193	1,193	1,193	1,193	1,193	1,193	9,544
CV15a	**8**	2.01.50	**8708**	EHV Fault Restoration by Switching Only	56	56	56	56	56	56	56	56	448
CV15a	**9**	2.01.51	**8709**	132kV Fault Restoration by Switching Only	6	6	6	6	6	6	6	6	48
CV15a	**14**	2.01.10	**6741**	LV Service Fault Repairs Overhead	1,889	1,889	1,889	1,889	1,889	1,889	1,889	1,889	15,112
CV15a	**15**	2.01.07	**6740**	LV Service Fault Repairs Underground	3,045	3,045	3,045	3,045	3,045	3,045	3,045	3,045	24,360
CV15a	**15**	3.01.15	**8578**	Services - LV Cable Damage	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160	9,280
CV15a 15 Total					4,205	4,205	4,205	4,205	4,205	4,205	4,205	4,205	33,640
CV15a	**17**	2.01.27	**6747**	LV U/G Cable Fault Repairs	2,819	2,847	2,904	2,933	2,962	2,992	3,022	3,022	23,501

CV15a	**17**	3.01.01	**9360**	LV Cable Damages	754	761	769	777	685	792	800	808	6,146
CV15a 17 Total					3,573	3,608	3,673	3,710	3,647	3,784	3,822	3,830	29,647
CV15a	**18**	2.01.26	**8581**	LV Underground Cable Fault (Consac)	23	23	23	23	23	23	23	23	184
CV15a	**18**	3.01.03	**8589**	LV Cable Damage (Consac)	1	1	1	1	1	1	1	1	8
CV15a 18 Total					24	24	24	24	24	24	24	24	192
CV15a	**19**	2.01.04	**6739**	LV Overhead Network Fault Repairs	1,187	1,175	1,164	1,152	1,140	1,129	1,117	1,106	9,170
CV15a	**19**	3.01.04	**8604**	LV Overhead Network Damage	200	198	196	194	193	191	189	187	1,548
CV15a 19 Total					1,387	1,373	1,360	1,346	1,333	1,320	1,306	1,293	10,718
CV15a	**20**	2.01.19	**6744**	Other Plant (LV Etc)	600	600	600	600	600	600	600	600	4,800
CV15a	**22**	2.01.24	**6746**	HV Cable Fault Repairs	782	790	798	806	814	822	830	839	6,481
CV15a	**22**	3.01.11	**8608**	HV Cable Damage	128	169	169	173	134	176	178	180	1,307
CV15a	**22**				910	959	967	979	948	998	1,008	1,019	7,788
CV15a	**23**	2.01.03	**6738**	HV OHL Fault Repairs	917	907	898	889	881	872	864	855	7,083
CV15a	**23**	3.01.10	**8605**	HV Overhead Damage	89	90	89	88	88	87	86	85	702
CV15a 23 Total					1,006	997	987	977	969	959	950	940	7,785
CV15a	**24**	2.01.17	**8575**	HV Pole Mounted Switchgear (Circuit Breaker) Fault	3	3	3	3	3	3	3	3	24
CV15a	**25**	2.01.18	**8670**	HV Pole Mounted Switchgear (Not CB) Fault	40	40	40	40	40	40	40	40	320
CV15a	**26**	2.50.02	**9682**	Capital Replacement of Damaged PMT	250	250	250	250	250	250	250	250	2,000
CV15a	**27**	2.01.15	**6743**	HV Other Plant Faults	170	170	170	170	170	170	170	170	1,360
CV15a	**29**	2.01.20	**8572**	EHV U/G Fault Pressurised	6	6	6	6	6	6	6	6	51
CV15a	**30**	2.01.21	**6745**	EHV U/G Fault Non Pressurised	82	82	82	82	82	82	82	82	656
CV15a	**31**	2.01.02	**6737**	EHV Overhead Fault Repairs	37	37	37	37	37	37	37	37	296

CV15a	**31**	3.01.14	**8617**	EHV Overhead Line Damage	1	1	1	1	1	1	1	1	8
CV15a 31 Total					38	38	38	38	38	38	38	38	304
CV15a	**32**	2.01.12	**6742**	EHV Plant Faults	42	42	42	42	42	42	42	42	336
CV15a	**34**	2.01.23	**8566**	132kV Cable Fault Pressurised	1	1	1	1	1	1	1	1	8
CV15a	**35**	2.01.22	**8569**	132kV Cable Fault Non Pressurised	6	6	6	6	6	6	6	6	46
CV15a	**36**	2.01.01	**9165**	132kV OHL Fault Repairs	4	4	4	4	4	4	4	4	32
CV15a	**37**	2.01.13	**8623**	132kV Plant Fault	17	17	17	17	17	17	17	17	136

Table 56 NAMP to RIGS mapping – Faults (including Troublecall) (CV15a)

Faults – CV15b

MappedRigs Table Row	Row Number	Current NAMP Reference	ProjectID	ProjectName	2016	2017	2018	2019	2020	2021	2022	2023	Grand Total
CV15b	**6**	2.01.52	**8716**	Emergency Disconnections	1,075	1,075	1,075	1,075	1,075	1,075	1,075	1,075	8,600
CV15b	**7**	2.01.38	**6752**	Street Lighting Fault Replacement - Overhead	148	148	148	148	148	148	148	148	1,184
CV15b	**7**	2.01.39	**6753**	Street Lighting Fault Replacement - Underground	4,182	4,182	4,182	4,182	4,182	4,182	4,182	4,182	33,456
CV15b	**7**	3.02.01	**9362**	Street Ltg. Discons / Recons /Knockdowns /Transfers	1,298	1,298	1,298	1,298	1,298	1,298	1,298	1,298	10,384
CV15b 7 Total					5,628	5,628	5,628	5,628	5,628	5,628	5,628	5,628	45,024
CV15b	**8**	2.50.15	**9047**	Faulted Cut-Out Replacement (Customer-driven)	4,019	2,680	2,680	2,680	2,680	2,680	4,161	4,161	25,741
CV15b	**9**	2.01.96	**8712**	Cut Out Fuses Only	2,593	2,593	2,593	2,593	2,593	2,593	2,593	2,593	20,744
CV15b	**10**	2.01.29	**6749**	Flickering Supplies	6,654	6,654	6,654	6,654	6,654	6,654	6,654	6,654	53,232
CV15b	**14**	3.05.01	**6755**	Abortive Calls (Formerly DST Costs)	9,326	6,995	4,663	2,332	583	583	583	583	25,648
CV15b 15 Total		3.05.02	**8715**	Metering Fault	401	321	257	206	206	206	206	206	2,009
CV15b	**16**	2.01.42	**6754**	Responding to Critical Safety Calls	10,292	10,292	10,292	10,292	10,292	10,292	10,292	10,292	82,336
CV15b	**16**	2.01.49	**8584**	Flooding Burst Water Main	816	816	816	816	816	816	816	816	6,528
CV15b 16 Total					11,108	11,108	11,108	11,108	11,108	11,108	11,108	11,108	88,864
CV15b	**17**	2.01.14	**8960**	Pilot Cable Repairs	20	20	20	20	20	20	20	20	160

Table 57 NAMP to RIGS mapping – Faults (ONIs) (CV15b)

Appendix 9: Material changes since the June 2013 ED1 Submission

Changes between the July 2013 submission and the March 2014 re-submission are summarised in Table 58.

Asset type	Change type	2013	2014	Difference (Reduction)
I&M (CV13)	Volume	2,140,372	2,254,663	114,290
	Investment (£m)	138.2	124.7	(13.5)
	UCI (£k)	0.065	0.055	(0.009)
Faults (CV15a)	Volume	159,874	160,882	1008
	Investment (£m)	195.03	227.17	32.14
	UCI (£k)	1.2	1.4	0.2
Faults (CV15b)	Volume	280,659	270,022	(10,637)
	Investment (£m)	79.8	70.3	(9.5)
	UCI (£k)	0.28	0.26	(0.02)

Table 58 - Source: October 2013 ED1 RIGs and 21st February 2014 ED1 RIGs.FigureFigureFigureFigureFigure

Table 4 provides the differences between the 2013 and 2014 business plan submission for CV13, CV15a and CV15b. The changes were mostly due to mapping and volume corrections.

Some of the key changes made in the revised plans are:

- Corrections to units for overhead line patrols via helicopter
- Remapping of boron rods from asset refurbishment (CV5) to inspection of maintenance
- Correction of units of measure for cable tunnel inspections (from tunnel lengths to number of tunnels)
- Remapping of some substation inspection activities across different voltages
- Vegetation clearance at HV locations - Volumes and UCI's were reduced to reflect actual costs
- Oil top up, pumping & testing - This line used for pressurised oil cable pumping. UCI increased to reflect actual costs