Document 2
Asset Category – Wood Poles, Narrow Based Steel Towers and Conductors
EPN

Asset Stewardship Report
2014

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Approved By Richard Wakelen / Barry Hatton

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Document History

Version	Date	Details	Originator	Revision Class	Section Update
1.0	18/02/2014	Original Submission	N/A	N/A	N/A
1.1	18/02/2014	NAMP cost updates to Table 1, 2 and associated paragraphs. HI Profiles and Tables Updated	Robert Lafferty	Minor	Section 1 and 2, Appendix 5
1.2	21/02/2014	Added Appendix 7 - Named Schemes Added Appendix 9 – Benchmarking Added Appendix 10 - Changes	Robert Lafferty	Minor	Appendix 7, 9,10
1.3	24/02/2014	Updated Expenditure and Volume Charts	Robert Lafferty	Minor	Section 7
1.4	24/02/2014	Updated HI profiles and HI/CI Tables	Robert Lafferty	Minor	Section 4.7, Section 8 and Appendix 2
1.5	24/02/2014	Updated Appendix 5, HV Conductor Volumes and Expenditure, LV Pole Expenditure, 33kv Conductor Expenditure	Robert Lafferty	Minor	Appendix 5
1.6	24/02/2014	Updated Appendix 10 to explain CV5 movements	Robert Lafferty	Minor	Appendix 10
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Version	Date	Details	Originator	Revision Class	Section Update
		Gold Standard	Lafferty		against Gold checklist, Appendices re-ordered and updated.
1.8	25/02/2014	Appendix 8 added and aligned to the document.	Robert Lafferty	Minor	Appendix 8.
1.9	25/02/2014	Removed Risk Tables and risk reference Exec Summary	Robert Lafferty	Minor	Section 8 and Exec Summary
1.10	25/02/14	Added RIGS and NAMP References to be in alignment and Year for document Preface added MEAV, populations updated to 240214	Robert Lafferty	Minor	References added to all sections Preface added Exec Summary
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Preface

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

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

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

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

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

1. **Appendix 8 - Output NAMP/ED1 Business Plan Data Table reconciliation:** This section explains the 'line of sight' between the UKPN Network Asset Management Plan (NAMP) and the replacement volumes contained in the Ofgem RIGS tables. The NAMP is the UKPN ten year rolling asset management investment plan. It is used as the overarching plan to drive both direct and indirect Capex and Opex interventions volumes and costs. The volume and cost data used in this ASR to explain our investment plan is taken from the UK Power Networks NAMP. Appendix 8 explains how the NAMP outputs are translated into the Ofgem RIGS tables. The translation of costs from the NAMP to the ED1 RIGS tables is more complex and it is not possible to explain this in a simple table. This is because the costs of a project in the 'NAMP' are allocated to a wide variety of tables and rows in the RIGS. For example the costs of a typical switchgear replacement project will be allocated to a range of different Ofgem ED1 RIGs tables and rows such as CV3 (Replacement), CV5 (Refurbishment) CV6 (Civil works) and CV105 (Operational IT Technology and Telecoms). However guidance notes of the destination RIGs tables for NAMP expenditure are included in the table in the Section 1.1 of the Executive Summary of each ASR.
2. **Appendix 9 – Efficiency benchmarking with other DNO's:** This helps to inform readers how UK Power Networks is positioned from a benchmarking position with

other DNO's. It aims to show why we believe our investment plans in terms of both volume and money is the right answer when compared to the industry, and why we believe our asset inspection and intervention proposals are efficient and effective and in the best interest for our customers.

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

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

Contents

1.0 Executive Summary EPN Wood Poles and Conductors

1.1 Scope

This document details UK Power Networks' non-load related expenditure (NLRE) replacement and refurbishment proposals for wood poles and conductors at all voltages for the ED1 period. Indicative proposals for the ED2 period are also included.

There are 155 poles on the 132kV network, with an estimated Modern Equivalent Asset Value (MEAV) of £0.5m; and 15km of conductor with an estimated MEAV of £0.9m.

There are 35,031 poles on the 33kV network, with an estimated MEAV of £95m; and 2,851km of conductor, with an estimated MEAV of £162.1m. The proposed investment is £18m for the ED1 period, which equates to 7% of the MEAV for this asset category.

There are 214,343 poles on the HV network, with an estimated MEAV of £372.1m; and 19,113km of conductor, with an estimated MEAV of £423.4m. The proposed investment is £48.6m for the ED1 period, which equates to 6.1% of the MEAV for this asset category.

There are 247,363 poles on the LV network, with an estimated MEAV of £367.9m and 9,160km of conductor, with an estimated MEAV of £123.6m. The proposed investment is £37.5m for the ED1 period, which equates to 7.6% of the MEAV for this asset category.

Table 1 shows that there is no investment planned for 132kV wood poles in ED1 due to the age and condition of the circuit.

	INVESTMENT TYPE	ED1 COSTS	NAMP LINE	RIGS REFERENCE (TABLE CV3)
Wood pole replacement	LV wood pole replacement	£21.3m	1.44.01	Additions CV3 Row 8 – LV poles Removals CV3 Row 136 – LV poles
	HV wood pole replacement	£13.9m	1.19.12	Additions CV3 Row 27 – HV (6.6/11kV) poles Removals CV3 Row 155 – HV (6.6/11kV) poles
	33kV wood pole replacement	£4.0m	1.09.04	Additions CV3 Row 53 – 33kV Pole Removals CV3 Row 181– 33kV Pole
Conductor replacement	LV overhead line Renewal	£16.2m	1.41.03	Additions CV3 Row 6 – LV main (OHL) conductor Removals CV3 Row 134 – LV main (OHL) conductor
	HV OHL conductor replacement	£34.7m	1.32.19 1.32.13	Additions CV3 Row 23, 24 – HV OHL conductor Removals CV3 Row 151 - HV OHL conductor
	33kV overhead Renewals	£13.5m	1.09.01	Additions CV3 Row 53 – 33kV pole CV3 Row 52 – 33kV OHL conductor Removals CV3 Row 181 – 33kV pole CV3 Row 180 – 33kV OHL conductor
Refurbishment	33kV Refurbishment	£0.5m	1.09.05	CV 5 Row 28 – Refurbishment 33kv Pole

Table 1 – Investment Summary (Source: 21st February 2014 ED1 RIGs)

1.2 Investment Strategy

The investment strategy for wood poles at all voltages is that they should have the same Health Index references of HI4 or HI5 at the end of ED1 as they do at the start.

Any new pole installed on the network should have a ‘pole saver’ fitted that will extend the life of a wooden pole; this strategy is referred to in section 6.3.

Further intervention, such as boron rods, which can delay or defer a replacement on suitable poles, will be installed throughout ED1; this strategy is referred to in section 6.1.

The investment plan has been developed in accordance with this strategy and by making use of the Asset Risk and Prioritisation (ARP) model to assess all asset data available in order to determine asset health, criticality and consequence of failure. This has enabled the construction of a well-justified plan based on detailed knowledge of individual assets rather than age or statistical modelling approaches.

1.3 ED1 Proposals

The proposed investment level for the replacement of LV, HV and 33kV wood poles and conductors in EPN is £103.1m, and the annual expenditure profile is broken down in Table 2. The trend shows an increase in the replacement volumes between DPCR5 and ED1 period for HV and LV poles and a decrease in volumes for 33kV poles detailed in section 7.4 .This increase is driven from the output of the ARP model and is based on the condition.

		Sub-category	NAMP line(s)	NAMP description	2015 /2016	2016 /2017	2017 /2018	2018 /2019	2019 /2020	2020 /2021	2021 /2022	2022 /2023
EPN	**Wood pole**	*LV wood pole*	*1.44.01*	*Replace LV wood poles ('D' condition)*	*2659*	*2659*	*2659*	*2659*	*2659*	*2659*	*2659*	*2659*
			1.41.03	*LV overhead line Renewal (including ABC)*	*2,024*	*2024*	*2024*	*2024*	*2024*	*2024*	*2024*	*2024*
		HV wood pole	*1.19.12*	*Replace HV wood poles*	*1,736*	*1,736*	*1,736*	*1,736*	*1,736*	*1,736*	*1,736*	*1,736*
			1.32.13	*HV OHL Renewal*	*1420*	*1420*	*1420*	*1420*	*1420*	*1420*	*1420*	*1420*
		HV Conductor	*1.32.19*	*Replace 0.025 11KV conductor*	*2914*	*2914*	*2914*	*2914*	*2914*	*2914*	*2914*	*2914*
		33kV wood pole	*1.09.04*	*Replace 33 KV wood poles*	*389*	*389*	*389*	*389*	*389*	*389*	*389*	*389*
			1.09.01	*33kV wood pole OHL Renewal*	348	1534	3090	3021	2512	907	1148	1984
			1.09.05	*33kV Wood Pole Refurbishment*	*57*	*57*	*57*	*57*	*57*	*57*	*57*	*57*
		Total (£k)			11,547	12,733	14,289	14,220	13,711	12,106	12,347	13,183

Table 2 – ED1 Investment Proposals (Source – 19th February 2014 NAMP Table J Less Indirect)

Appendix 9 benchmarks our ED1 proposals with reference to other DNOs July 2013 submissions. It shows that for Wood Poles and Conductors we are proposing to replace **5%** of our assets while other DNOs were seeking funding to replace **11%** of these assets on average. This demonstrates the effectiveness of our asset risk management systems and the value for money of our proposals.

1.4 Innovation

Innovative ideas identified and planned include:

- Pole saver – A moisture barrier wrap installed at ground level on new poles.
- Micro-bore pressure sensing drill (resistograph) – A technique that can accurately record the internal condition of a wood pole, with the ability to undertake a below-ground condition assessment of the wood without the need to excavate.
- Pole support system – Installed adjacent to a pole where minor rot has been detected on a certain part of the pole at base level.
- Boron rods – Solid rods of high-strength boron 173 that are used to protect wooden poles that are constantly or occasionally damp.

1.5 Risks and Opportunities

	Description of similarly likely opportunities or risks arising in ED1 period	**Uncertainties**
Opportunity	Pole support system for woodpecker attacks on poles not at ground level	May increase or decrease the level of investment required for pole support system in ED1. +/- 5% of ED1 investment plan
Risk	Boron rods do not offer life expectancy as expected	£90 expenditure per installation achieves no benefit for prolonging age of pole
Risk	In trial, micro-bore pressure sensing drill advised that 70% of the poles originally thought to require changing did not. If the system does not show that level of re-categorisation, the cost of refurbishment rises in the ED1 period	The technique has not been validated against existing pole-testing methods. Much more analysis is required before re-categorisation can be realised to the level anticipated

Table 3 – Risk and opportunities arising in ED1

2.0 Description of Wood Poles and Conductors

2.1 132kV Wood Poles and Conductors

There are 155 poles on the 132kV network and approximately 15km of conductor. The OHL conductor on these circuits is 175mm² ACSR.

It can be seen from the age profile in Figure 1 that the majority of poles were installed in 1979. The conductor age is the same as the poles. There are no plans to refurbish or replace this OHL in ED1 because the circuit is in relatively good condition. Any defects found at inspection will be dealt with as part of the defect management project.

Ref RIGs code: Asset additions and disposal volumes are included in CV3 table, rows 88, 89 and 215, 216

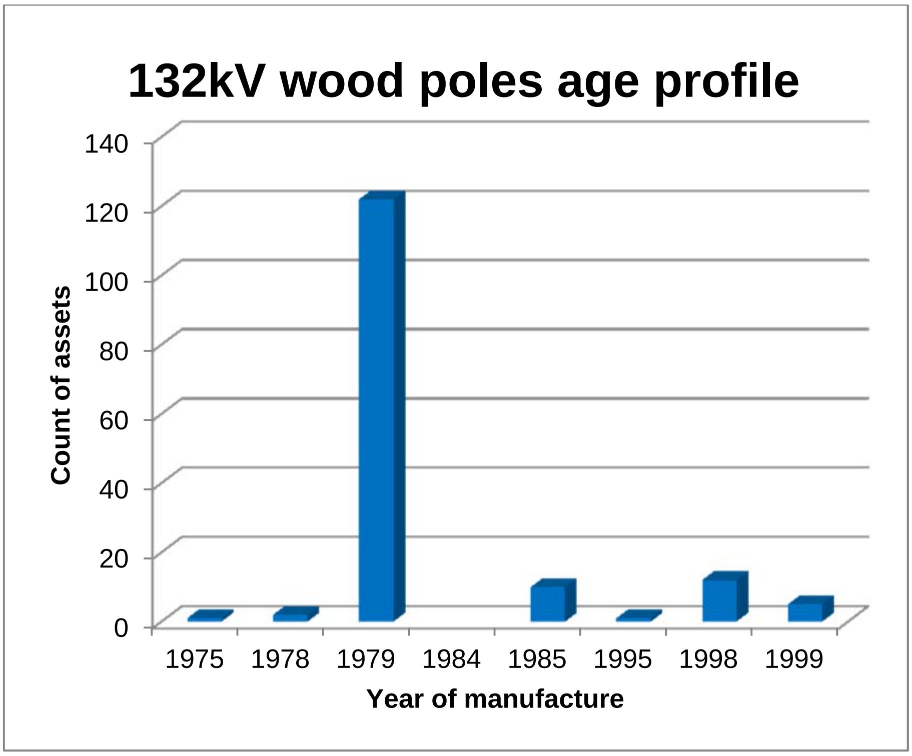

Figure 1 – Age profile for 132kV wood poles

(Source – RIGS 2012 CV3 Table V5)

2.2 33kV Wood Poles and Conductors

There are 35,031 poles on the 33kV network and approximately 2,851km of conductor. The majority of OHL conductors at this voltage are copper.

It can be seen from the age profile in Figure 2 that there was significant investment in 1955 and 1969, resulting in an ageing wood pole asset. The average age is approximately 45 years.

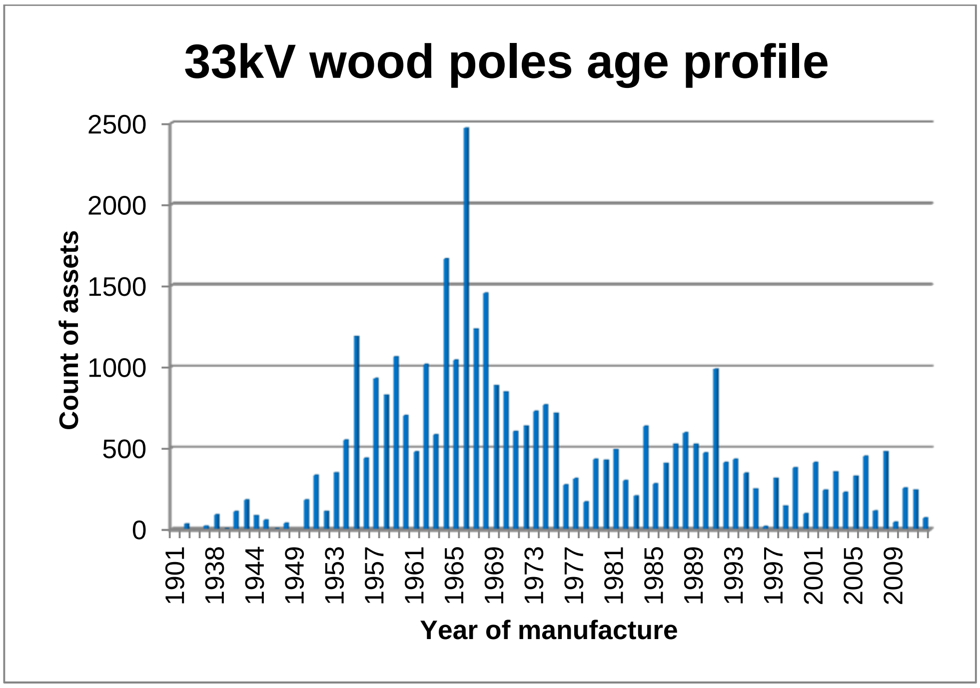

Figure 2 – Age profile for 33kV wood poles

(Source – RIGS 2012 CV3 Table V5)

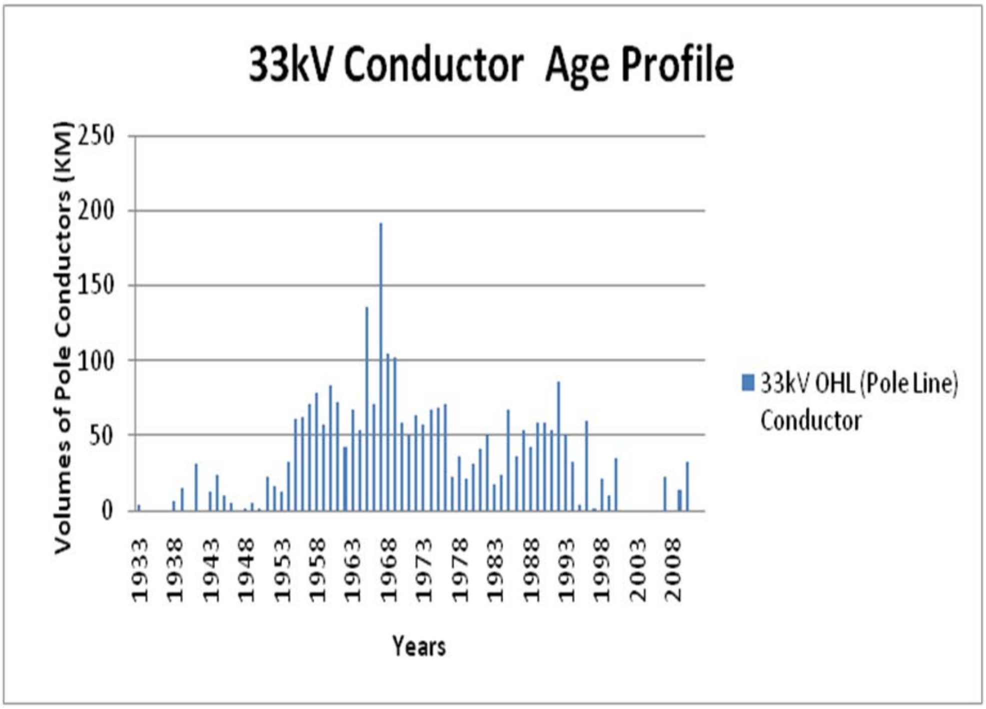

Figure 3 – Age profile for 33kV conductors

(Source – RIGS 2012 CV3 Table V5)

Ref NAMP line: 1.09.01,1.09.04,1.09.05

Ref RIGs code: Asset additions and disposal volumes are included in CV3 table, rows 52, 53, 166,167 and CV5 table, row 28.

2.3 HV Wood Poles and Conductors

There are 214,343 poles on the HV network and approximately 19,113km of conductor. The majority of OHL conductors at this voltage are copper.

It can be seen from the age profile in Figure 4 that there was significant investment between 1954 - 1978, 1989 - 1993, and 1998 - 1999, resulting in an ageing wood pole asset. The average age is approximately 50 years.

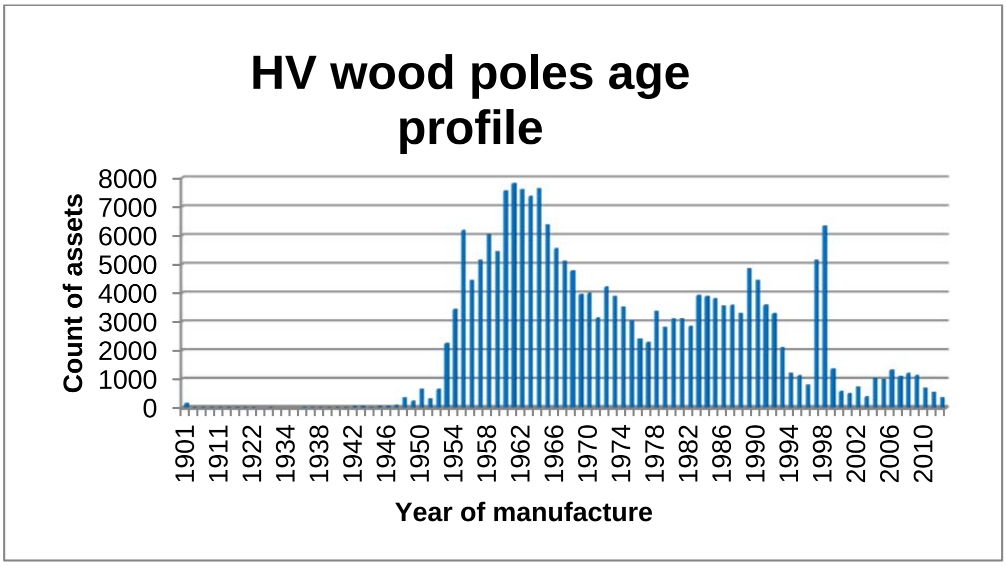

Figure 4 – Age profile for HV wood poles

(Source – RIGS 2012 CV3 Table V5)

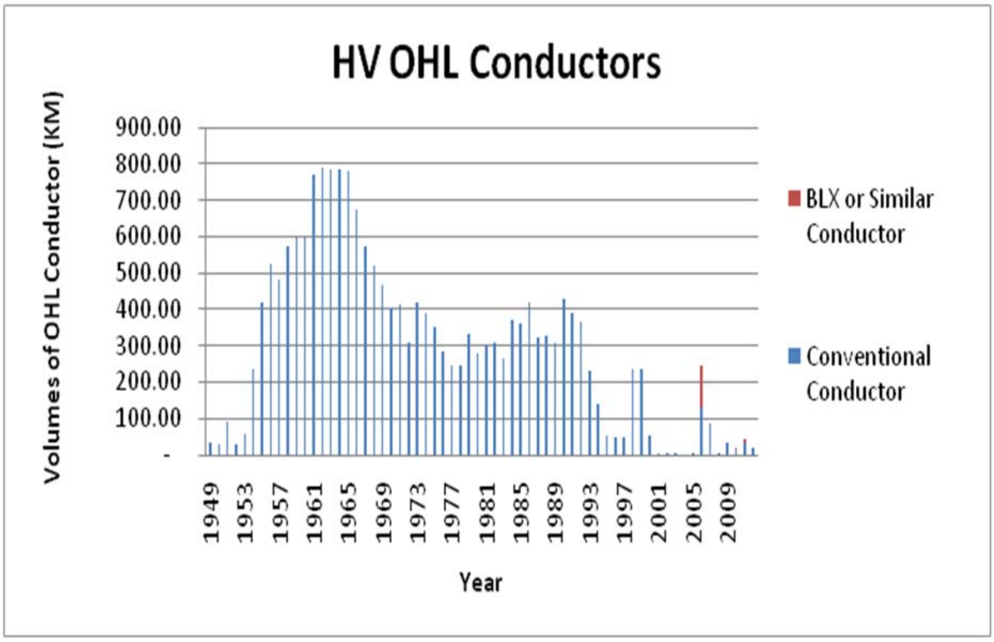

Figure 5 – Age profile for HV conductors

(Source – RIGS 2012 CV3 Table V5)

Ref NAMP lines: 1.19.12, 1.32.13, 1.32.19

Ref RIGs code: Asset additions and disposal volumes are included in CV3 table, rows 23, 24, 27 and 151, 155 LV Wood Poles and Conductors

There are 247,363 poles on the LV network and approximately 9,160km of conductor. The majority of OHL conductors at this voltage are copper.

It can be seen from the age profile in Figure 6 that there was significant investment between 1954 - 1976, 1979 - 1991, and 2006 - 2009, resulting in an ageing wood pole asset. The average age is approximately 40 years.

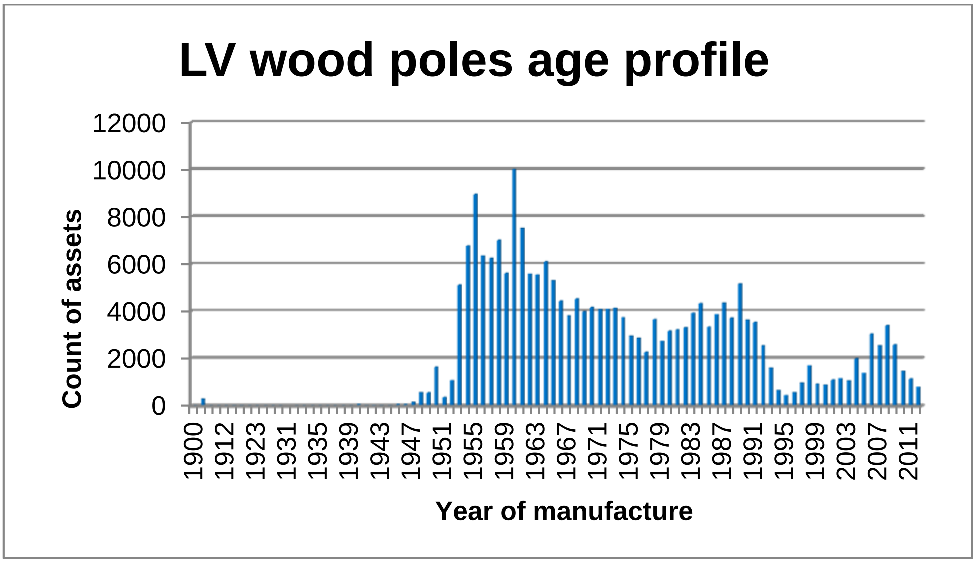

Figure 6 – Age profile for LV wood poles

(Source – RIGS 2012 CV3 Table V5)

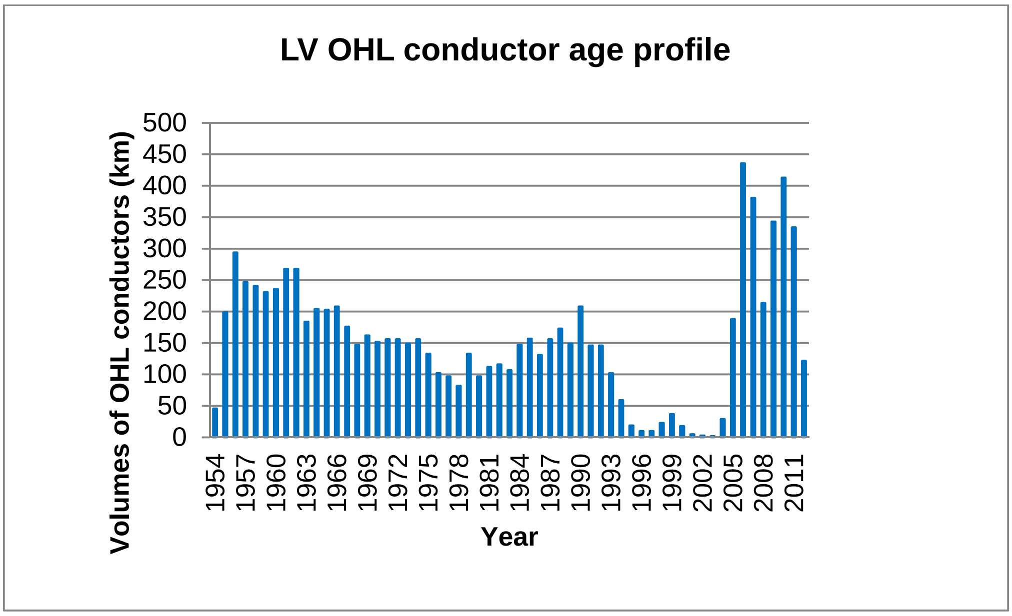

Figure 7 – Age profile for LV conductors on wood poles

(Source – RIGS 2012 CV3 Table V5)

Ref NAMP lines: 1.41.03 and 1.44.01

Ref RIGs code: Asset additions and disposal volumes are included in CV3 table, rows 6, 8 and 134, 136.

3.0 Investment Drivers

3.1 Overview

The main investment drivers that influence the actions and decisions involved in the management of overhead lines on wood poles and narrow-based supports and associated assets are primarily:

- Public and operator safety
- Asset and network performance
- Major defects in some asset types
- Compliance with statutory regulations, including Electricity Safety, Quality and Compliance (ESQC) risks.

These drivers will be supported by:

- Asset condition reports
- Condition-based reliability studies
- Asset and network performance
- Analysis of current and future work costs
- Electricity Safety, Quality and Compliance Regulations (ESQCR) risk assessments
- Historic, current and emerging equipment and diagnostic technologies
- Stakeholder options
- Customer requests
- Faults.

Specific information is also obtained from defect reports by other users of the same type of overhead line assets through the National Equipment Defect Reporting Scheme (NEDeRS).

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3.2 Condition and Defects

3.2.1 Condition and defects used as replacement drivers

The condition of a wood pole overhead line is assessed based on a number of condition assessment measures and defects collected during routine inspections. ESQCR compliance condition/defect, information is also collected during routine inspections. In order to ensure good quality data is captured and recorded in the asset register in a timely manner, handheld devices (HHD) are used on site at the point of inspection and the information uploaded into the Asset Management Data Base (ELLIPSE).

Condition assessment on all wood pole overhead line assets, including the conductor and the structure, are visual, except for hammer tests, pole ultra-sonic rot locator (PURL) tests, auger tests and the resistograph, which determine the residual strength of a pole.

Key condition points collected during inspections or as part of tests are summarised in Table 4.

Grouping	Condition measure/ Defect/ESQC rating
Conductor	Conductor out of regulation
	Damaged insulated conductor
	Conductor damage
	Conductor integrity
	Jumpers
Pole of narrow-based tower	Badly leaning pole
	Pole condition
	Condition of steel structure
Pole top	Insulator/fittings condition
	Condition of cross arm
ESQC location risk	ESQC location risk
Other ESQC drivers	'Danger of death' sign defective; stay defective; inadequate ground clearance; condition of anti-climbing device; climbable trees

Table 4 – Condition measures and defects

Condition points are stored in Ellipse on a scale of 1 to 4 as shown in Table 5, and defects are assessed either as a CR1 or CR4.

Condition value	Description
1	Generally in 'as new' or very good condition
2	Acceptable or satisfactory condition
3	Indication that either minor work is required or the condition indicates that future repair or replacement is required
4	This category indicates that significantly/urgent repair or replacement is required

Table 5 – Condition value descriptions

Condition assessment measures shown in Table 5 are used as inputs to the asset risk and prioritisation models. The Asset Risk and Prioritisation model will be used to prioritise the replacement of these assets.

The risk rating of a wood pole or steel structure and their associated spans are assessed as per UKPN Engineering operating policy (EOP)09-0061, (*Assessing the Risk to the Public from Overhead and Substation Assets*). This applies to:

- Overhead line structures and spans with high-risk and very high risk ESQC ratings
- Overhead line structures and spans with key risks.

Examples of overhead line key risks

Code	Title	Description
K1	NONE	No additional hazards to overhead line
K3	CLIMBING AID	Any device or vegetation that by its position would enable a person to gain accesses to pole or tower e.g hedges ,ivy, walls ,fence, pallet stack,unauthorised private signs.
K4	KITE/AEROPLANE FLYING	Where there is risk of contact with the overhead line by the flying of kites or aeroplanes
K9	VEHICLE / MACHINERY CONTACT	Vehicle or machinery that by its location infringes ,or by its position allows access to infringe within the safety clearance of the line (this key risk shall only be recorded if there is an evidence of electrical infringement or if there is evidence of frequent movement of vehicles or machinery under the line which could infringe safety clearance).

3.2.2 Examples of condition and defects

Figure 8 – Woodpecker damage

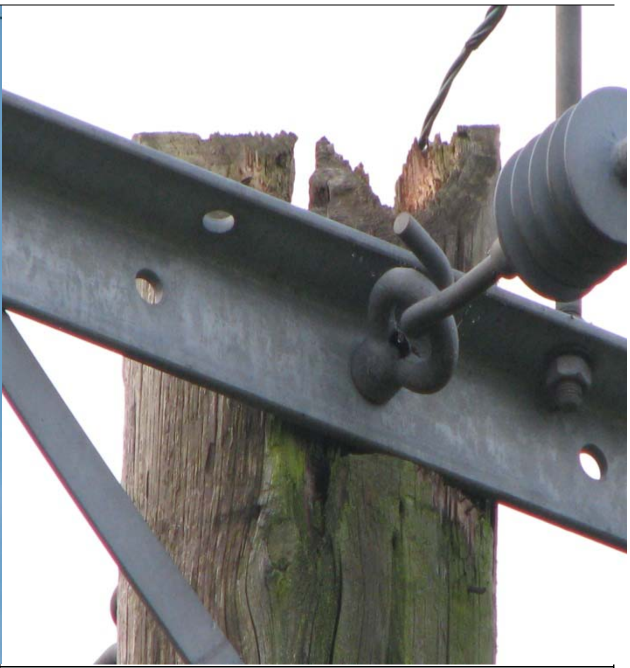


Figure 9 – Pole top rotting

Figure 10 – Pole base rotting

Figure 11 – Conductor damage

Woodpecker damage – The damage caused by woodpeckers on wooden poles affects the maximum loading of the pole at the point of the woodpecker attack. By considering the geometry of the entry hole and nesting hole, it is possible to establish the minimum height from ground level at which the holes will not affect the ultimate strength of the pole.

Each separate hole needs to be assessed and, if possible, filled with Hydrofil (a resin-based material) and finished to the profile of the pole. As an example, a light pole with a nesting cavity diameter greater than 110mm shall be changed. For a medium pole, the diameter criteria is 130mm. For a stout pole, it is 150mm. There could be many holes in a pole that will not affect the overall strength. However, nesting holes have an inner cavity that can go deep into the pole and there is no acceptable method of infill mitigation.

Pole top rotting – Ingress of water into the top of the pole occurs when there is cracking/splitting that results in water getting into untreated wood through the grain. The top of the pole is shaped like a cone to stop water pooling, but the effect of wind, rain and sun will result in the wood splitting over time in some exposed locations.

Pole base rot – Pole base rot can be caused by a number of conditions including:

- Internal rot
- External rot
- Termites
- Cracking and splitting
- Third-party damage.

There are various stages in the process of decay. In the earliest stages, the wood appears to be hard and firm. The only evidence of attack, if any, is a slight or marked colour change from normal. This is known as the ‘incipient’ or ‘initial’ stage. In some cases, there is no indication of incipient decay, hyphae extending for half a metre or more longitudinally in advance of the visible evidence of rot.

After the incipient stage has passed, the wood becomes more and more noticeably affected until it is completely changed in appearance and structure, with the continuity of the wood tissues destroyed. This is known as the ‘advanced’ stage; the strength of the wood has been reduced so much that it can be crumbled between the fingers or easily broken (refer to Figure 10).

Fungi requires oxygen, moisture and a substrate to feed on. It tends to be ‘light-shy’, i.e. developing inside the timber. The internal timber condition is usually far worse than it appears externally.

Conductor damage – Damage to an OHL conductor can occur by:

- Conductors clashing
- Third-party damage
- Lightning
- Degradation of steel wires
- Sulphur corrosion of aluminium strands
- Falling trees
- Fatigue on high tower lines
- Small section conductors.

3.2.3 Correlation between Defects and Age

The majority of defects raised over time associated to wood poles are related directly to the date of installation (i.e the age). Taking this into account, it is recognised that the number of defects associated to wood poles may increase over time however the level of defects will be controlled through effective inspection and maintenance regimes.

Figures 12, 13 and 14 shows the comparison between:

- Current age profile of the population
- Number of defects reported historically (including the age of the transformer when the defect was reported)

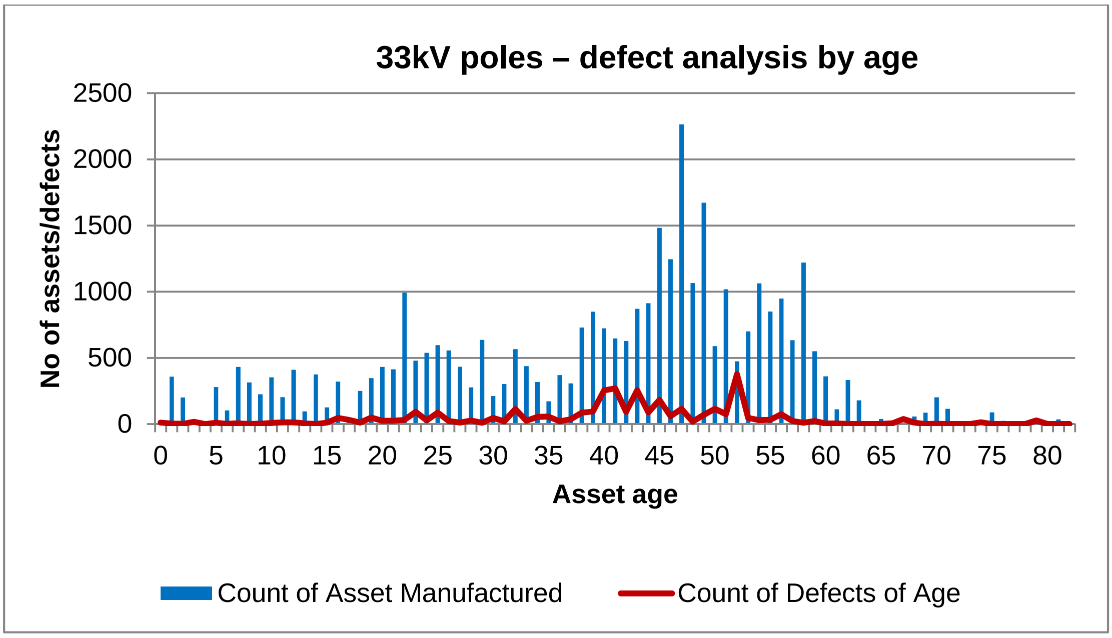


Figure 12 - Correlation between Defects and Asset Age

Two observations can be made from Figure 12;

1. The number of defects is low in the 33kV population due to the high importance of maintaining a safe and effective high voltage network and the nature of planned works carried out.
2. The small spikes in the number of defects are due to recognised routes/circuits in poor condition with most of the assets of the same age. These spikes have been identified and incorporated into our ED1 asset replacement plans.

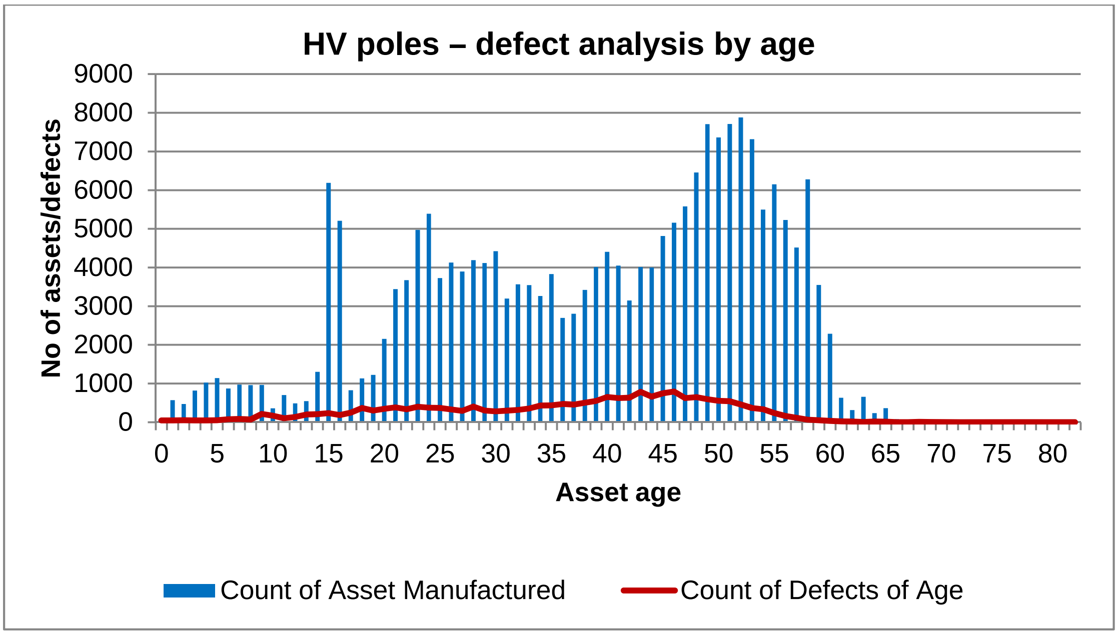


Figure 13 - Correlation between Defects and Asset Age

Three observations can be made from Figure 13;

1. The number of defects increases with age
2. There is a steady and stable increase in the number of defects from 20 years up until 45-50 years which aligns with an increase in population volumes with age.
3. Older assets closer to their expected life have had their defects mitigated/reduced.

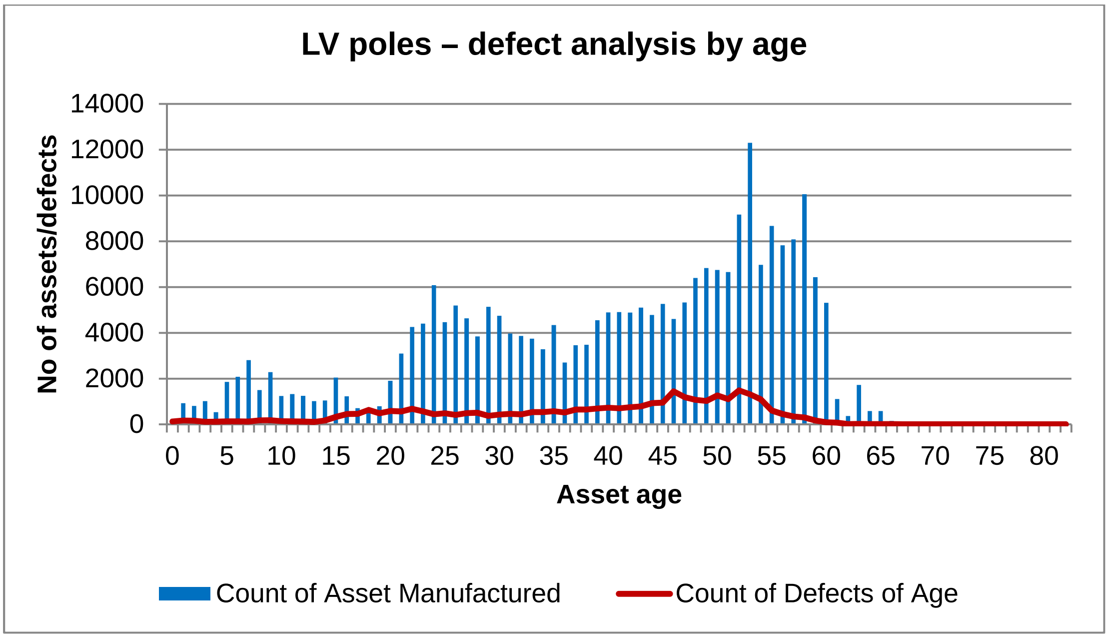


Figure 14 - Correlation between Defects and Asset Age

Three observations can be made from Figure 14;

1. The number of defects increases with age
2. There is a steady and stable increase in the number of defects from 20 years up until 50-55 years which aligns with an increase in population volumes with age.
3. Older assets closer to their expected life have had their defects mitigated.

3.2.4 Analysis of health indices vs. age

An analysis of all LV, HV and 33kV wood pole health indices against the age is shown in Figures 15 16 and 17, which indicates the percentage of assets with HI4 and HI5 indices.

The trend shows a higher number of assets (HI4 and HI5) within the age band for 61–80 for the HV poles. Similarly, for LV poles, the trend appears to be rising , with more HI4 and HI5 assets in the age band 51-60 even more for 61-70 and start decreasing for the age band 71–80 and even less in the age band 81-90,as the LV poles and the associated conductors are replaced by 70 years due to its age . For the 33kV poles, the trend appears to have the same percentage of HI4 and HI5 assets under the age band 61–70. There are no assets within the age band 80–90.

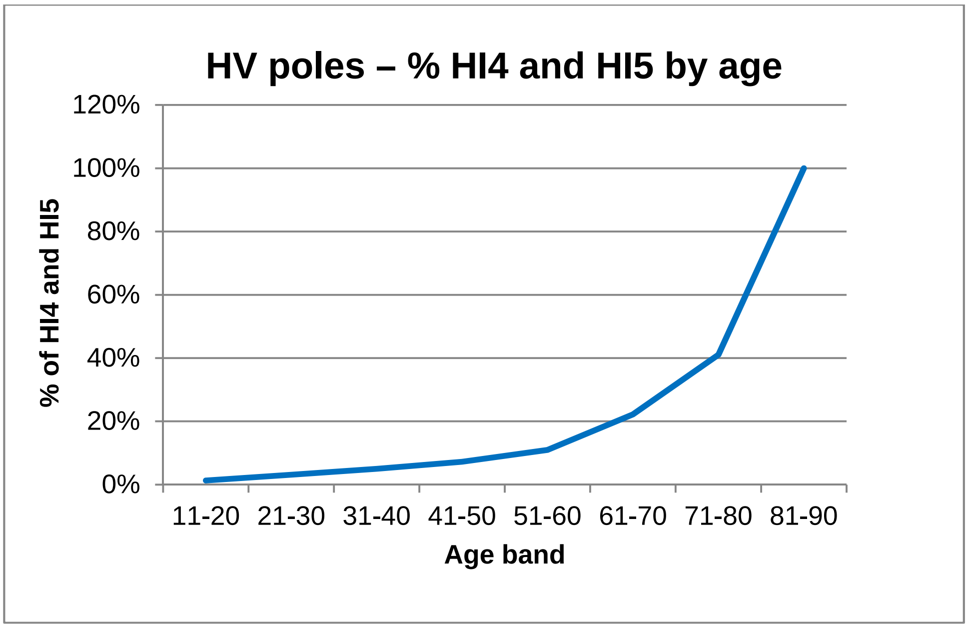


Figure 15 – HV pole: HI profiles by age

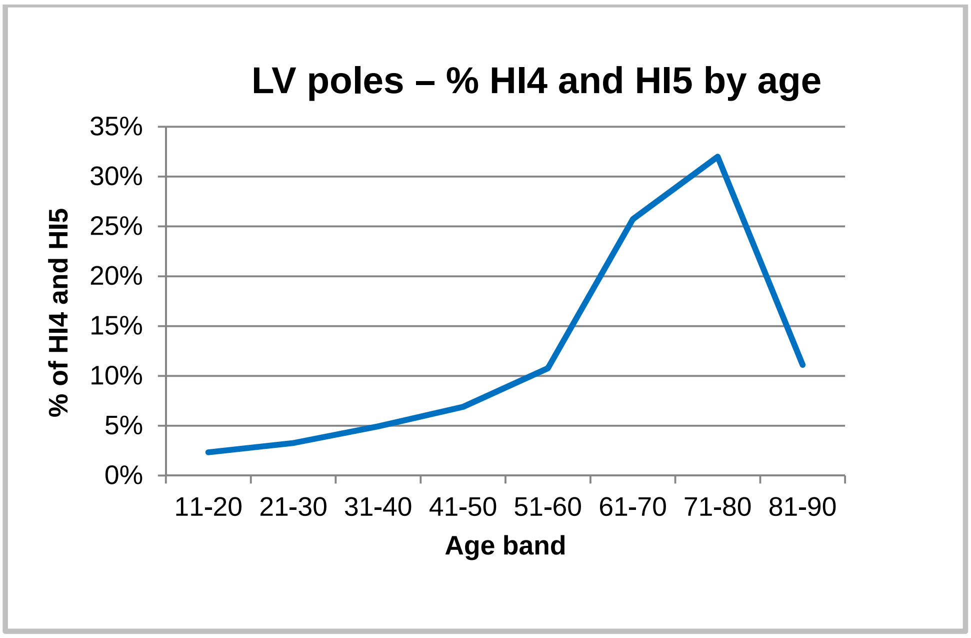


Figure 16 – LV pole: HI profile by age

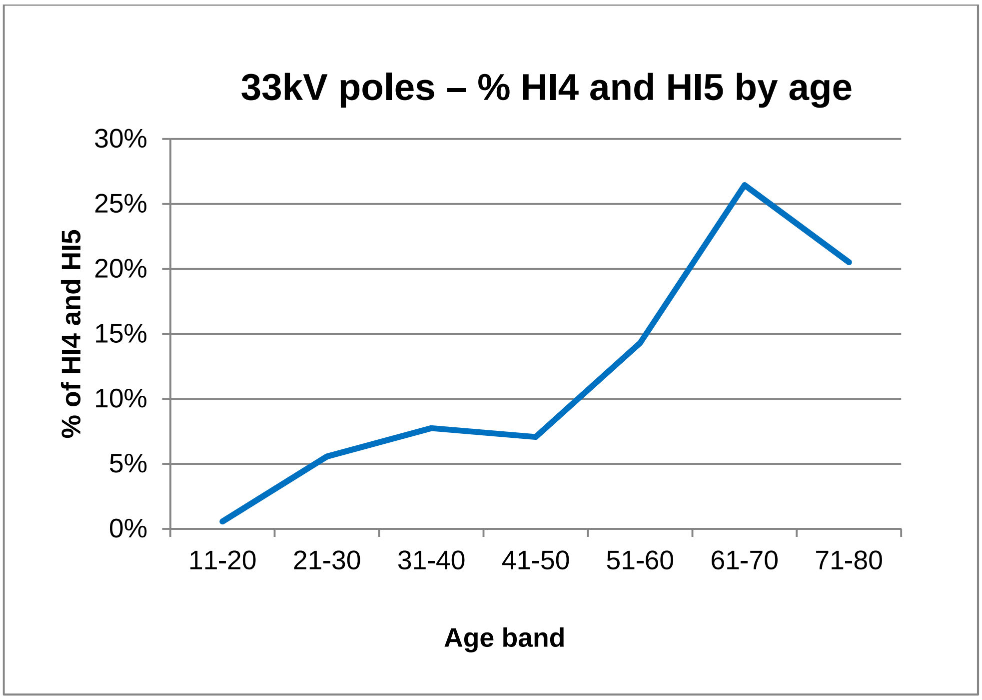


Figure 17 – 33kV pole: HI profile by age

3.2.5 Fault Rate

The fault rate trends for 132kV, 33kV, HV and LV OHL conductors are shown in Figures 18, 19, 20 and 21. The fault data has been split into two categories: condition and non-condition faults. Non-condition faults relate to any fault not caused by the asset itself, such as third-party damage and weather.

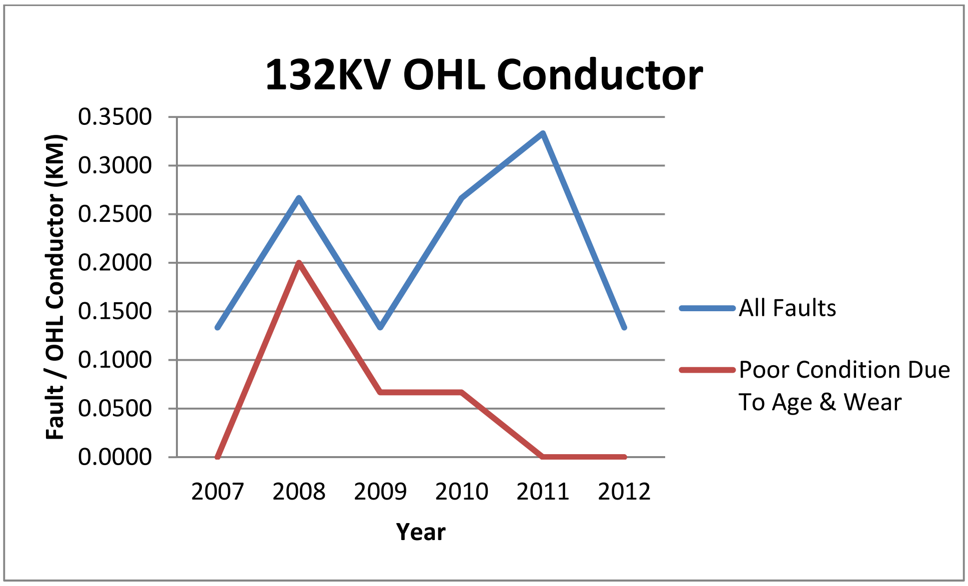


Figure 18 – 132kV OHL conductor fault rate

(Source - UKPN Fault Cube)

The fault trend has been falling for 132kV pole conductors. A further breakdown of fault causes shows that a small proportion of these faults is due to poor condition (age or wear). Furthermore, there is a single fault in 2009 and 2010, which is related specifically to the condition .

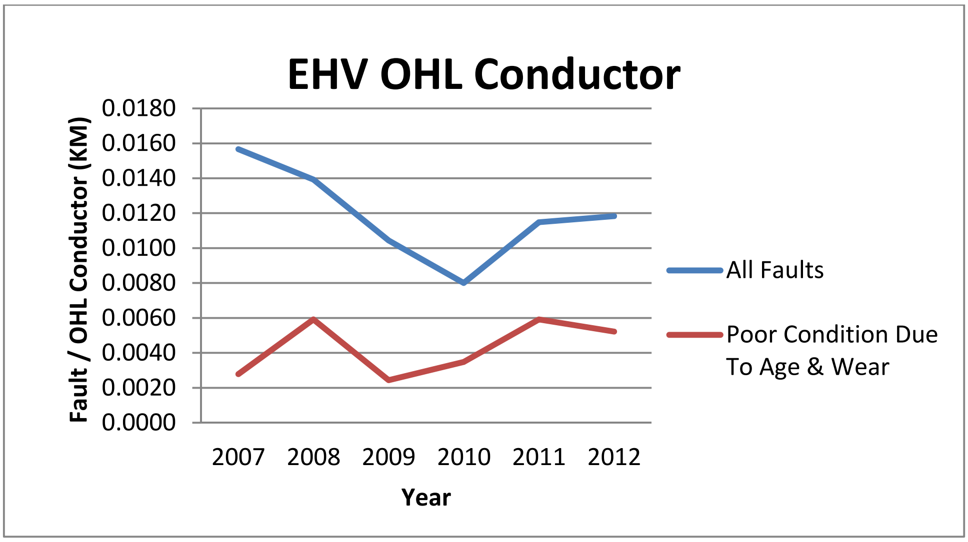


Figure 19 – EHV OHL conductor fault rate

(Source - UKPN Fault Cube)

The fault trend has been falling since 2011 for 33kV pole conductors. A further breakdown shows that significant number of faults are due to poor condition (age or wear). Furthermore, there is a peak increase in faults in 2011, which is related specifically to the condition.

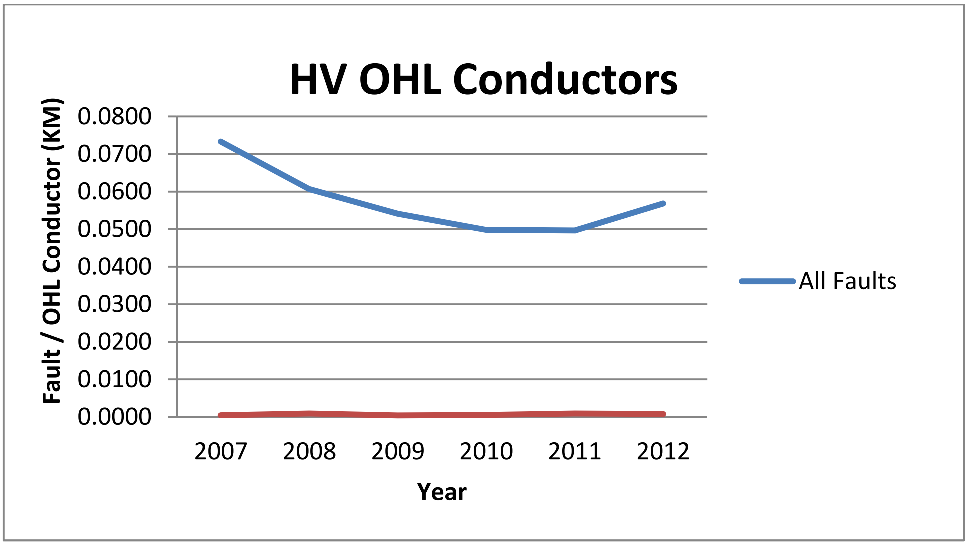


Figure 20 – HV OHL conductor fault rate

(Source - UKPN Fault Cube)

The fault trend has been falling for HV pole conductors. A further breakdown of fault causes shows that only a small proportion of these faults is due to poor condition (age or wear) .Total faults due to condition specific is 97,while total faults on the HV OHL conductor is 6605.

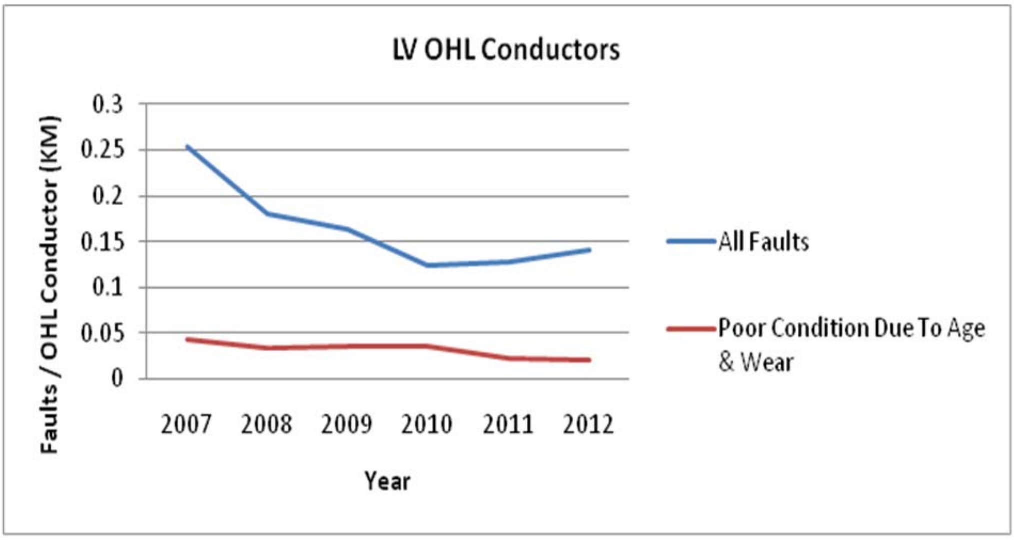


Figure 21 – LV OHL conductor fault rate

(Source - UKPN Fault Cube)

The fault trend has been rising since 2011 for LV OHL conductors. A further breakdown of fault causes shows that a small proportion of these faults is due to poor condition (age or wear).

Trends observed from the graphs:

- Condition-related faults represent a small proportion of total faults.
- There is a relatively flat trend across all voltage levels, given the small numbers.

The system for fault reporting changed in 2007-2008, leading to some inconsistencies in data sets and making it difficult to predict accurate trends going forward. The past five years' data has been reported on a consistent basis and is considered to be more relevant than previous data, although it includes some abnormal volumes caused by flooding and severe weather patterns. It is envisaged that the level of new installations and other improvements will balance this out in a number of asset groups, resulting in a steady state forecast.

Expenditure to clear faults on HV and LV overhead lines is expected to reduce during the ED1 period. This is 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).

3.3 Condition Measurements

3.3.1 OHL inspection

The main source of asset external condition data is from OHL inspectors. As such, during DPCR5 (2010), a review of the *Overhead Line Inspectors' Handbook* was carried out and a new handbook was issued. Each inspector of OHL assets was required to undertake a training course and pass the theory and practical examinations before being re-certified as a competent inspector.

Figure 22 – Example of a handheld device and inspection manual

In order to ensure good quality data is captured and recorded in the asset register in a timely manner, handheld devices (HHD) are used on site at the point of inspection and uploaded into the Asset Management Data Base (ELLIPSE). When an inspection HHD script is run, the user answers set questions, specific to the asset about its condition, allowing defects to be recorded, reviewed and cleared in a consistent manner by all inspectors. Using a pre-determined script allows for a consistent approach to inspections.

3.3.2 Frequency of inspection and maintenance for wood poles

The scheduling of maintenance has a critical impact on the utilisation and effectiveness of an asset. The inspection and maintenance of distribution wood pole assets will be carried out at regular intervals, in accordance with UK Power Networks' inspection and maintenance standards, to ensure that they reliably perform their functions throughout their time in service and to ensure the safety of UK Power Networks staff and the public. In line with *EMS 10-0002*, the frequency of work for the SPN licensed network relating to the inspection and maintenance of HV and LV wood pole assets is shown in Table 6.

Voltage	Safety inspection frequency	Full inspection frequency	Fault inspection frequency
132kV wood pole	Every 2 years	Every 2 years	After fault trip where cause is unknown
33kV wood pole	Every 4 years	Every 12 years	After 3 reclose sequences within 31 days
HV wood pole	Every 4 years	Every 12 years	After 3 reclose sequences within 31 days
LV wood pole	Every 4 years	Every 12 years	None

Table 6 – Wood pole frequency of inspection

3.3.3 Testing of a pole using existing techniques

The values that are used for the basis of Residual Strength Value (RSV) in UK Power Networks is based on values from BS 1990 Part 1: 1984.

The condition of a wood pole is assessed by a trained craftsman at the full inspection with a hammer test**.** The pole should be hit with a hammer weighing about 3lbs, starting near the ground and continuing upwards circumferentially around the pole to a height of approximately six feet. A good pole will produce a clear sound, while a decayed pole will sound dull. It is not possible to ascertain the actual RSV during an inspection using this process. If a pole is suspected of having decay, it is labelled accordingly either with an 'S' (suspected pole rot below 10% rot) or with a 'D' (suspected pole rot of 20%). Further analysis would be arranged using one of the following methods:

> **The PURL ultra-sonic tester** – EA Technology makes pole ultra-sonic rot locators (PURL). It is operated at several points along a circumferential line around the pole. The readings obtained are analysed using a computer program, which produces an estimate of the likely area of internal decay and predicts the residual bending strengths of the pole at the chosen cross-section (expressed as a percentage of the original strength). A decision on whether to replace the pole or allow it to remain in service is made upon this analysis.

Auger – This method of testing uses a screw thread with a hollow inner that goes into a pole. Once the auger is fully inserted in the pole, the internal part of the auger is pulled out – and with it some of the internal parts of the pole for the length of the drill. The internal wood density is assessed to determine the condition of the pole and its serviceability.

3.3.4 Pole condition based on Health Index

In order to get a Health Index (HI) rating for a pole, the residual strength percentage needs to be calculated. This is based on the size of the pole and the condition rating of the overall pole structure (between 1 and 4: UK Power Networks' internal condition scoring).

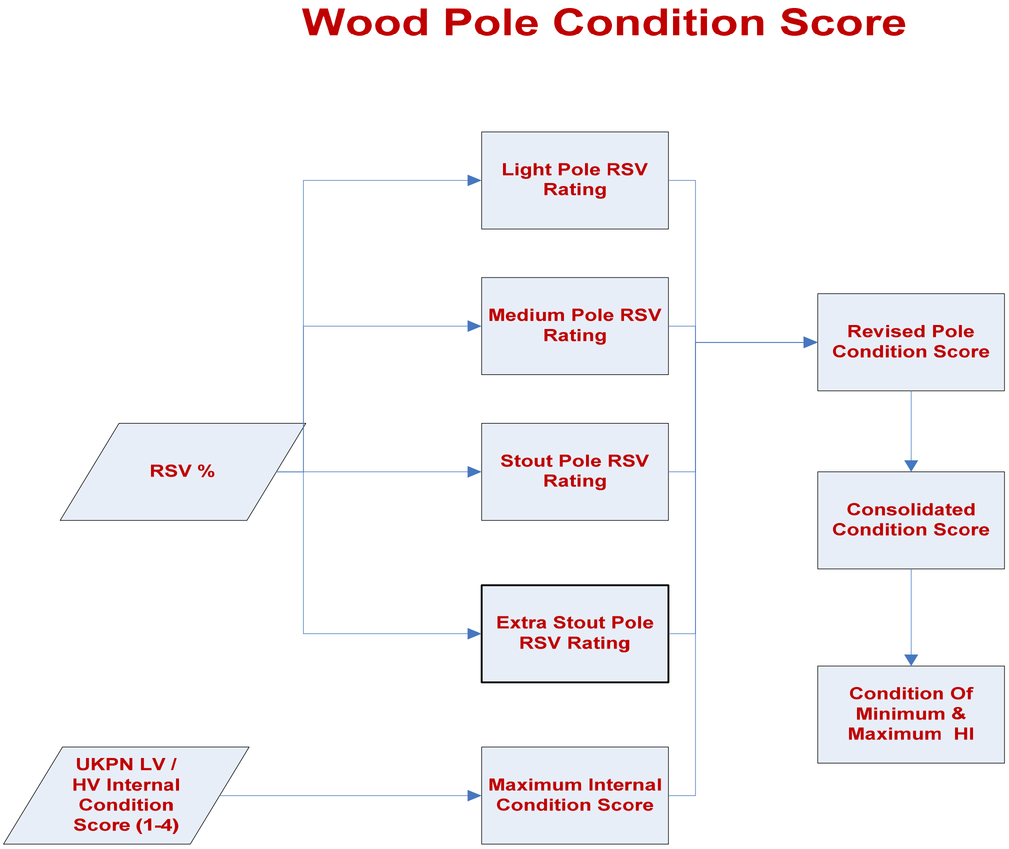


Figure 23 – Pole condition based on HI

4.0 Asset Assessment

4.1 Asset Health

An innovative asset health modelling tool, the Asset Risk and Prioritisation (ARP) model, has been developed for several asset categories, including wood poles. The methodology behind the modelling is the same for all asset categories.

The general methodology for the ARP model can be found in *Commentary 15: Model Overview*. The wood pole ARP model uses both the age and condition data to calculate a Health Index for the asset. An initial HI is based on the year of manufacture and expected average life. The environmental factors considered include the distance from the coast. An average life is assigned to show the expected time from when the asset was manufactured until it shows signs of increased deterioration. It is not the time from when the asset is commissioned until it is decommissioned. This initial HI is capped at HI3.

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

4.2 Asset Criticality & Network Risk

The ARP model can also be used to calculate the criticality of a particular wood pole asset ; this methodology is still under development. This then assigns a Criticality Index 1 to 4, with 1 being the least critical and 4 being the most. A detailed methodology for calculating the Criticality Index can be found in *Commentary 15: Model Overview Description*.

Asset Criticality provides a measure of the consequence of failure and is evaluated in terms of the following four criticality areas are considered

- Network performance
- Safety
- Financial ,OPEX and CAPEX
- Environmental

For network performance, the key factors are the condition performance risk, condition of load at risk during failure, and average value of critical asset. The safety criticality specific to overhead lines is based around the condition safety risk and average value of critical asset. The financial criticality is split into operational and capital expenditure sections, and all faults are associated with an operation cost for the overhead line. Finally, the environmental section considers the proximity of major crossings and environmentally sensitive areas.

4.2.1 Network Risk

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

4.3 Data Validation

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

4.4 Data Verification

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

4.5 Data Completeness

The completeness, accuracy and timeliness of the data used in the ARP model are routinely checked. For the results of data for wood poles, refer to Table 7.

Asset category	Completeness	Timeliness	CAT score
33kV pole	69.69%	92.55%	75.40%
HV pole	69.07%	92.27%	74.87%
LV pole	68.06%	94.18%	74.59%

Table 7 – CAT scoring analysis

Data Source: ARP Wood pole data quality report 08_02_2013

The completeness score is a combination of wood poles nameplate and condition data. The overall completeness of data is 68%. The main drivers for improving CAT scores for this asset group are inspector training courses and cyclic inspection schedules, which will improve this data over the forthcoming years.

The timeliness score shows the percentage of assets that have condition data recorded and aligned to the inspection and maintenance frequency schedule. DPCR5 has seen a rise in comprehensive condition and defect data, and our strategy is to gain even better data so that we can efficiently and effectively manage the growing risks from ageing assets and greater defects. As a consequence, UK Power Networks is prepared to carry the risk associated with missing asset and condition data.

4.6 HI Profiles With and Without Investment

Figures 24–26 show the output from the models with and without the planned ED1 investment. This highlights the start point for the ED1 period. The investment levels during ED1 have been set to manage the risk due to the condition of the asset and to replace HI4 /HI5 in order to maintain an asset profile consistently during ED1.

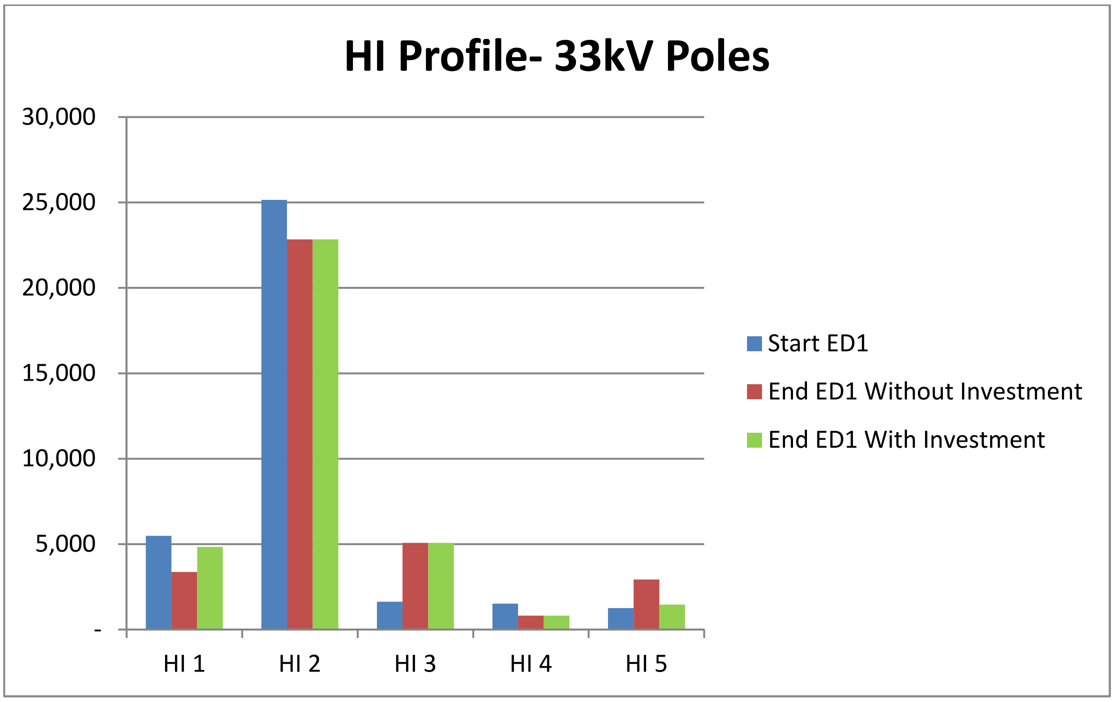


Figure 24 – HI profile 33kV poles

(Source:ARP: 25July 2012)

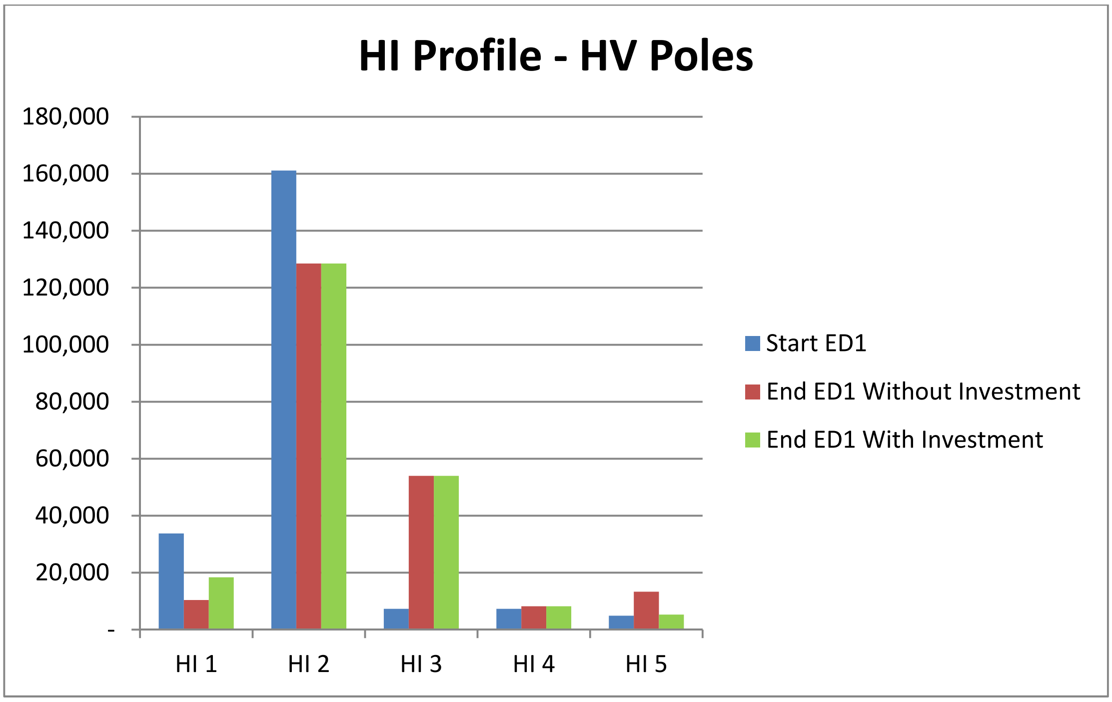


Figure 25 – HI profile HV poles

(Source:ARP: 25July 2012)

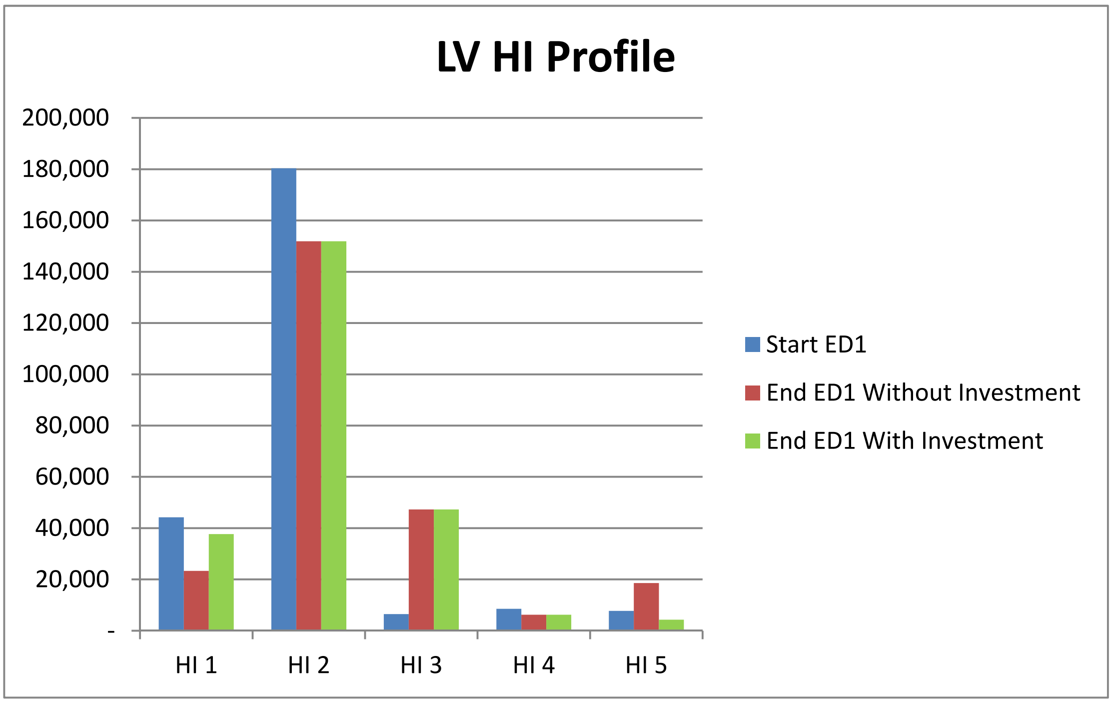


Figure 26 – HI profile LV poles

(Source:ARP: 25July 2012)

5.0 Intervention Policies

5.1 Interventions: Description of Intervention Options

There are four types of intervention that are applicable to overhead lines. These are:

- Overhead line rebuilds
- Overhead line refurbishments
- Component replacements
- ESQCR replacements and refurbishment (see ESQCR justification document).

5.1.1 Overhead line rebuilds and refurbishments

An overhead line shall be considered for rebuilding when 60% of the overhead line supports have a condition rating of 4; or the fault performance of the overhead line is unacceptable and is therefore driving the installation of covered conductors. This will result in either the entire overhead line or manageable sections of the overhead line being rebuilt.

An overhead line shall be considered for refurbishment when more than 20% of the line’s components have a condition rating of 4 or the fault performance of the line is unacceptable. This will result in either the entire line or manageable sections of the line being refurbished.

Overhead line refurbishments and rebuilds form the scope of the following work programmes in the NAMP:

- LV overhead line work programme (1.44.01, 1.41.03)
- HV overhead line work programme (1.19.12, 1.32.13, 1.32.19)
- 33kV overhead line work programme (1.09.01, 1.09.04, 1.09.05)

5.1.2 Component replacements/refurbishment

Replacement – Component replacements shall be carried out if less than 20% of the overhead line components have a condition rating of 4. This intervention forms the basis of the ‘D’ pole replacement work programme .On new poles the pole saver is installed as standard.

Refurbishment (Life Extension) – The categories of interventions have been considered for wood poles activities(Boron rods / pole support).These are summarised in Table 8 and explained in more detail later in this section.

Validates pole condition				
Diagnostic	**Application**	**Comment**	**Cost**	**Net benefit/ HI benefit**
Micro-bore pressure sensing drill (resistograph)	A battery-operated machine that bores a drill into the wood. The resistance is analysed to assess the internal strength of the pole. It measures the section depth of the pole at several locations, giving an internal view of the pole's overall strength	UK Power Networks is pioneering the use of the micro-bore pressure sensing drill – a technique that can accurately record the internal condition of a wood pole, with the ability to undertake below-ground condition assessment of the wood without the need to excavate .	£21/pole	If the results following testing show that the decay within a pole is not as first thought using existing simplified methods, the HI of a pole can reduce from HI5 to HI4 and even HI4 to HI3. This is due to below-ground testing being possible rot in poles is known to be most prevalent.
Intervention on Existing Poles	**Application**	**Comment**	**Cost**	**Net benefit/ HI benefit**
Boron rods	Pole is drilled at base and boron rod inserted	Where pole is in a wet environment, the rods will delay the rotting process.	£30/pole (NAMP line 1.13.20)	Life of the pole will be extended by up to 10 years
Pole support system	Installed adjacent to a pole where minor rot has been detected on a certain part of the pole at base level. This metal plate would be better installed on wood poles that are in good condition but have been damaged at ground level	Where base rot has been detected, the support can be installed and fixed to the pole. This will provide physical strength to a pole that may be slightly weakened by rot. Although being promoted to support rotten poles, the application on a D rotted pole would not be	£250/pole	If used in conjunction with boron rods, this will delay the need to change a pole. It will delay the asset going from HI 2/3 to HI4. The HI4 damaged wood poles would be reclassified as an HI2. This is a repair-only option.

		supported by operational staff, also working practice issues. Restriction to clean poles only as the plate raises the datum line up at least 1 metre.		
Intervention on New Poles	**Application**	**Comment**	**Cost**	**Net benefit/ HI benefit**
Pole saver	Installed on a new AC500 preservative-treated pole by the supplier prior to delivery, to cover the area above and below ground level where pole rot is most common	A retrofit sleeve that fits around a pole and protects dampness to the pole at ground level. This is only fitted on a new green pole that has been treated with the AC500 preservative.	£12/pole	Will significantly delay the process of rot, as it does not allow moisture to enter at the base where pole strength is necessary. The AC500-treated poles have been given a 25-year lifespan. The pole saver will help increase this lifespan to up to 40 years

Table 8 – Summary of interventions

Pole saver – A wood pole rot mitigation application is shown in Figure 27. This comes in the form of a moisture barrier wrap installed at ground level on new poles. One long-term benefit is that it improves the life of AC500 preservative (for green poles) to beyond that of the traditional creosoted option.

Boron rods – In order to minimise on-going decay in a wood pole, UK Power Networks will install boron rods in all poles between 25 and 58 years of age. Boron rods are only effective when the moisture content is above a certain level in the pole, which typically takes 20-25 years from new. By installing the boron rods, the life of the pole is extended by 8–10 years. The upper age limit is simply for efficiency, so that boron rods are not installed in poles that are due for replacement in ED1 and ED2. By ramping up pole replacement over ED1 and ED2 and installing boron rods to extend the life of the remaining poles, the age profile peak from the 1950s and 1960s can be smoothed out. This makes the replacement programme feasible, cost efficient and low risk.

The benefits of boron rod installation, based on the condition data taken from ARP, is summarised in Table 9.

	Number of poles	
Condition	**Non Boron Rod**	**Boron rod**
1	287,330	175,751
3	11,795	7,568
4	11,894	5,860
	Mean life of poles	
Condition	**Non Boron Rod**	**Boron rod**
1	31	39
3	43	44
4	44	44

Table 9 – Summary of benefits of boron rods

Pole support system – Installed adjacent to a pole where minor rot has been detected to a certain part of the pole at base level, this is an innovative pole-support system, designed to provide structural stability to a wood pole that has been physically damaged or subject to rot, ultimately extending its life.

5.2 Proposed expenditure by interventions

The proposed volumes 'with intervention' and 'without interventions' for ED1 and ED2 period is shown below for comparison. The potential saving with various intervention options per year during the ED1 period is detailed in the section 6, £1.8m for LV poles and £2.5m for the HV.

The current modelled average end-of-life for a wooden pole is 60 years without intervention. With intervention, a wooden pole can have an average end-of-life extended to 70 years.

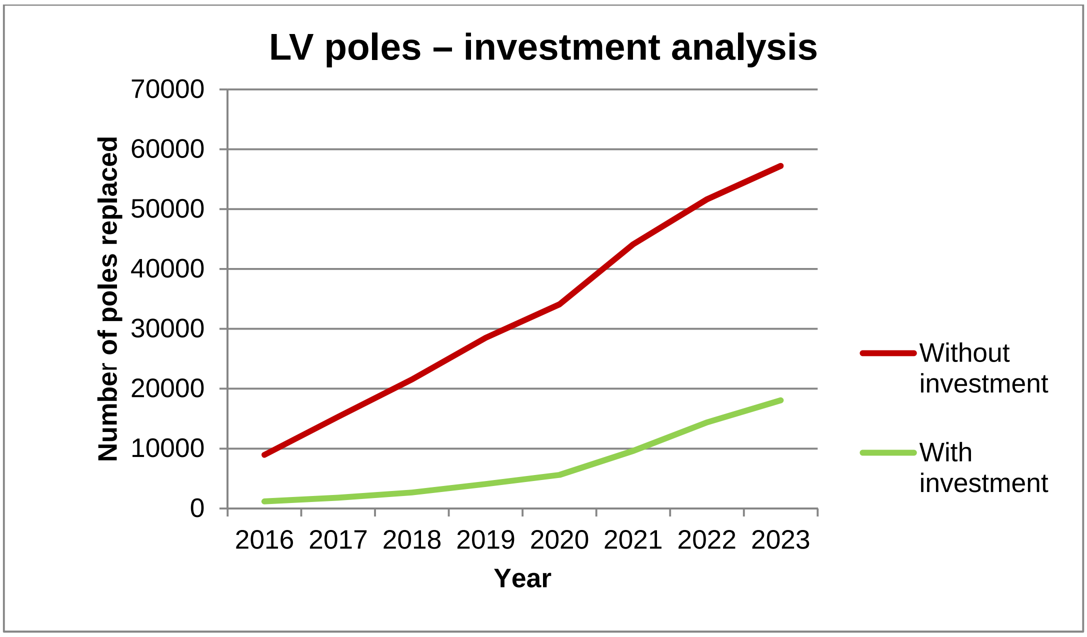


Figure 27 – Investment analysis for LV poles

(source; 19th February 2014 NAMP Table O)

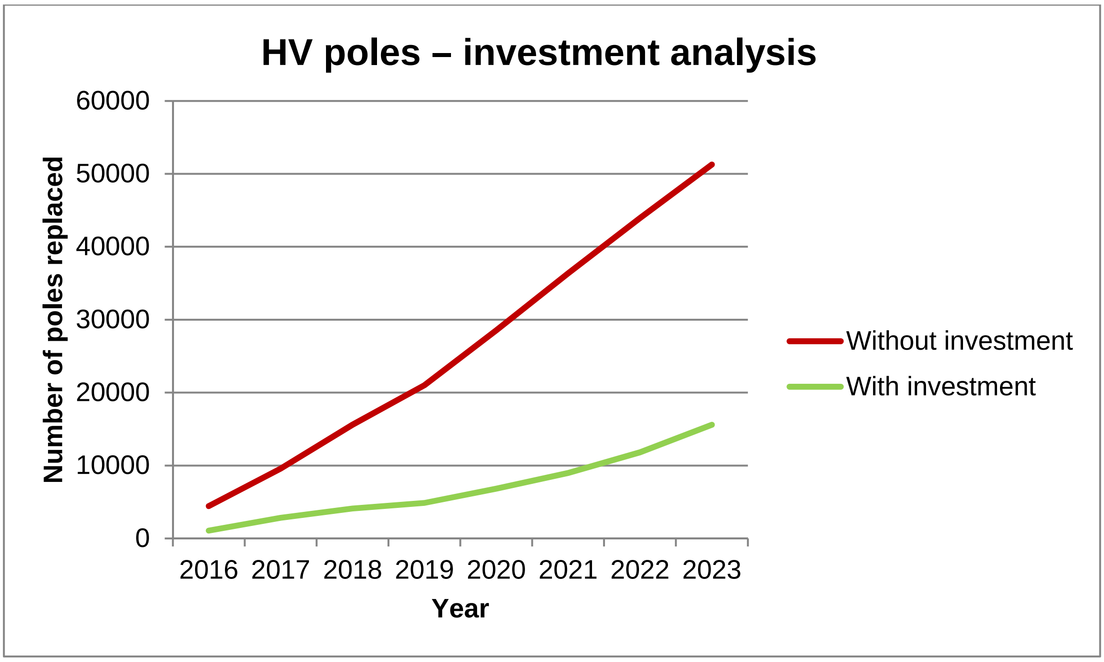


Figure 28 – Investment analysis for HV poles

(source; 19th February 2014 NAMP Table O)

5.3 Policies: Selecting Preferred Interventions

Preferred interventions for each asset and justification for selection

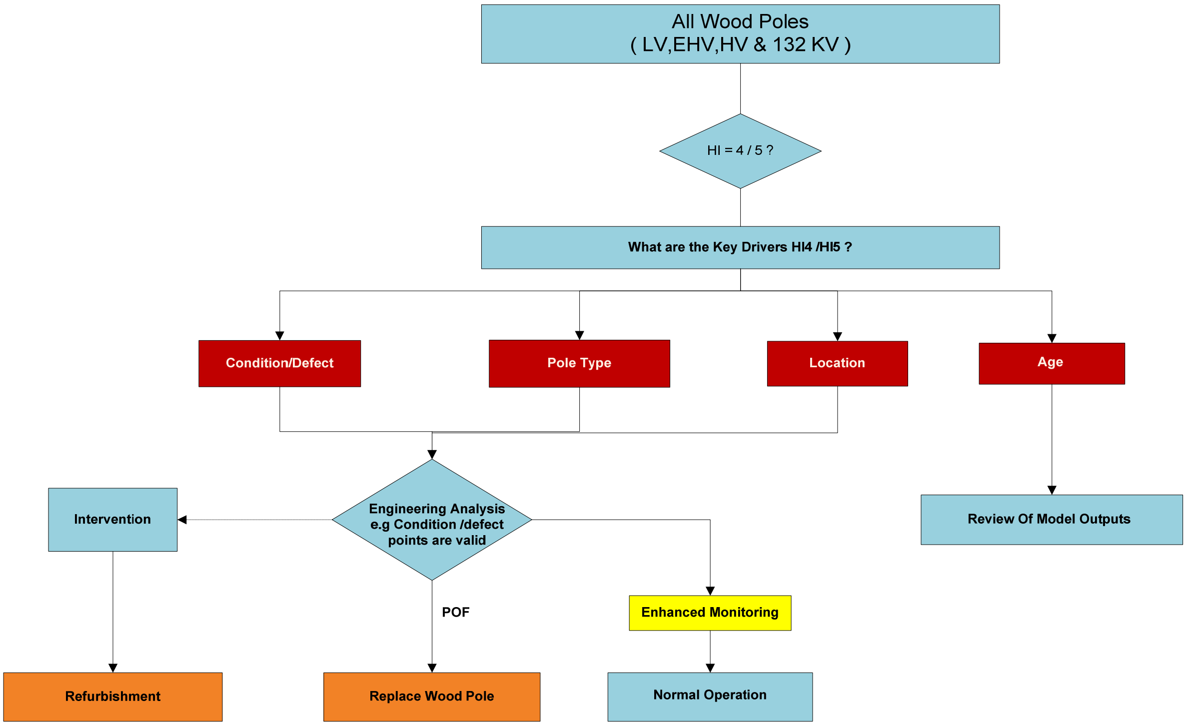


Figure 29 – Intervention decision flow chart

6.0 Innovation

6.1 Boron rods

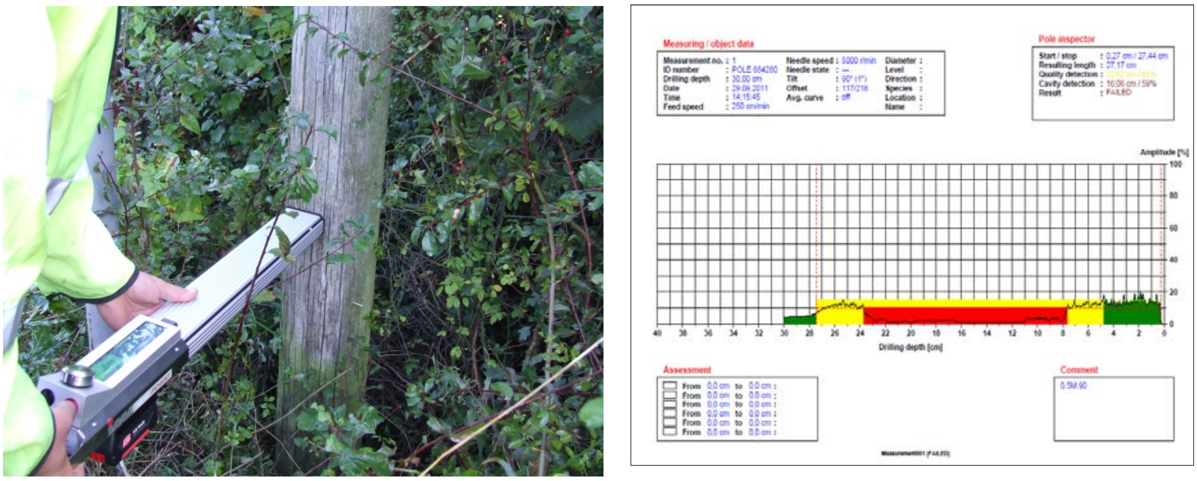
Figure 30 – Boron rod installation

These solid rods of high-strength boron 173 are used to protect wooden poles that are constantly or occasionally damp. The standard size is 8mm x 24mm, which fit into 10mm-diameter holes. Plastic bang-in caps are used to cover the holes.

Wooden poles themselves are susceptible to wet rot and rapid insect attack after the pressure creosote treatment has diminished, especially in the ground zone, where splits and shakes allow moisture and air into the core. Boron rods are used to prevent further decay and extend the working life of the poles.

6.2 Micro-Bore Pressure Sensing Drill (Resistograph)

UK Power Networks is pioneering the use of the micro-bore pressure sensing drill (Figure 31), a technique that can accurately record the internal condition of a wood pole, with the ability to undertake a below-ground condition assessment of the wood without the need to excavate.



Measuring / object data

Measurement no. : 1
ID number : POLE 684260
Drilling depth : 30.00 cm
Date : 29.09.2011
Time : 14:15:45
Feed speed : 250 cm/min
Needle speed : 5000 r/min
Needle state : —
Tilt : 90° (1°)
Offset : 117/218
Avg. curve : off
Diameter :
Level :
Direction :
Species :
Location :
Name :

Pole inspector

Start / stop : 0.27 cm / 27.44 cm
Resulting length : 27.17 cm
Quality detection : [illegible]
Cavity detection : 16.06 cm / 59%
Result : FAILED

Assessment

☐ From 0.0 cm to 0.0 cm :
☐ From 0.0 cm to 0.0 cm :
☐ From 0.0 cm to 0.0 cm :
☐ From 0.0 cm to 0.0 cm :
☐ From 0.0 cm to 0.0 cm :
☐ From 0.0 cm to 0.0 cm :

Comment

0.5M 90

Figure 31 – Micro-bore pressure sensing drill in use and output information

6.3 Pole Saver

This is a wood pole rot mitigation application, as shown in Figure 32. This takes the form of a moisture barrier wrap installed at ground level on new poles. One long-term benefit is that it improves the life of AC500 preservative (for green poles) beyond that of the traditional creosoted option.

Figure 32 – Pole saver installed on a wood pole

6.4 Pole Brace

On a pole that still has good residual strength across the majority of the pole, but requires additional mechanical support at the base, a single galvanised metal pole brace is installed and fixed to the butt with coach screws. The brace extends below ground level by three feet and above ground by a similar height. The brace provides sufficient support to the pole so that it does not need to be changed. The amount of pole rot would be isolated to a part of the pole; this type of mitigation is intended to provide additional support, not residual strength.

Figure 33 – Pole brace installed

6.5 Composite Poles

Innovation in materials has allowed the use of composite type poles to be installed where wooden types are normally used. The majority of installed poles are in Scandinavia, where the technique was developed. The composite poles can be used on all voltages where a wooden pole is currently used.

As with all innovations, the cost is higher per single composite pole compared to a wooden equivalent. So, widespread use may not be undertaken, but targeted use, where there are known local problems, such as woodpeckers, is possible.

Figure 34 – Composite poles

6.6 Woodpecker Mitigation

Damage to wooden poles by woodpeckers generally occurs six feet above ground level and all the way to the top of the pole. It is generally accepted that while 25% of the pole above six feet can be lost to woodpecker damage, there needs to be some intervention to avert any associated rot that may be caused due to untreated wood being exposed to the elements.

Materials are continually being developed that fill the hole and provide sufficient mechanical strength to a pole damaged by woodpeckers. The most common type of infill material is resin-based. It is also thought that woodpeckers are attracted to poles that vibrate at a frequency similar to mites' nests. Where this occurs, the previously mentioned composite pole may prove to be the mitigation.

Figure 35 – Woodpecker damage on an HV wood pole

The potential saving with various intervention options per year during the ED1 period is shown below, £1.8m for LV poles and £2.5m for the HV poles.

With the assumptions:

1. For every 100 poles, 70 extend their useful life from 60 to 70 years, with the use of Boron rods, at a cost of £30 per pole.

2. For every 100 poles, 27 are tested with a micro- bore pressure sensing drill and are then replaced, at cost of £2000 per pole.

3. For every 100 poles, 3 are supplied with a pole support system, at a cost of £250 per pole.

Asset Category	Activity (intervention options)	Unit Cost (£)	Volume of poles	Total Cost (£m)
LV Poles	Micro- bore pressure sensing drill	2000	825	1.65
	Boron Rods	30	5040	0.1512
	Pole support systems	250	67	0.01675
Total Expenditure				**1.82**
HV Poles	Micro- bore pressure sensing drill	2000	1162	2.324
	Boron Rods	30	4308	0.12924
	Pole support systems	250	57	0.01425
Total Expenditure				**2.47**

Table 10 – Innovation Costs

7.0 ED1 Expenditure Requirements for Wood Poles and Conductors

7.1 Method

Figure 36 shows an overview of the method used to construct the ED1 NLRE investment plans.

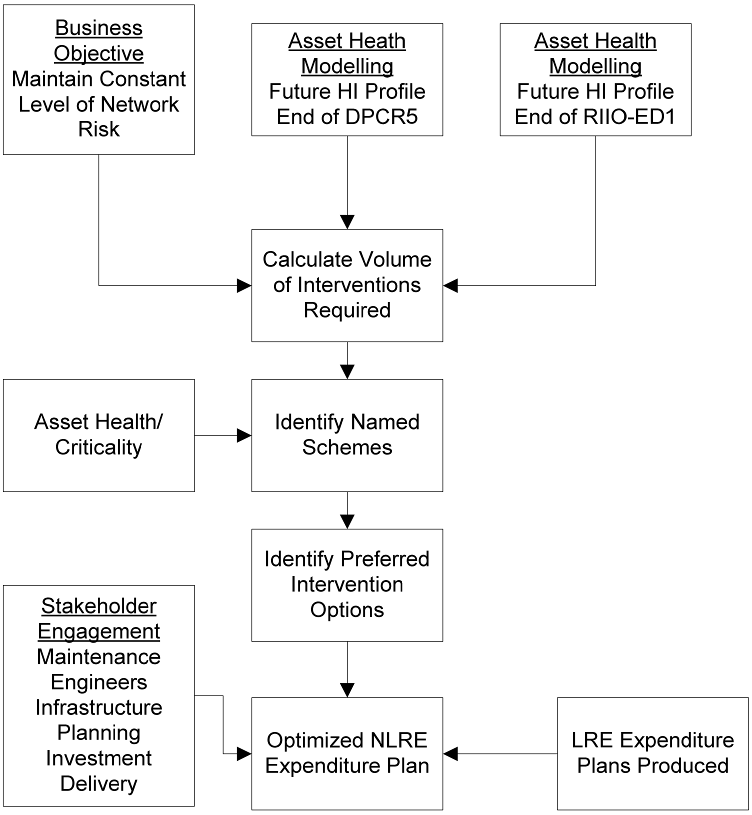


Figure 36 – Constructing the NLRE plan

7.2 Constructing the Plan

7.2.1 Approach to network risk – keeping HI4/5 constant

The business objective throughout the planning process for ED1 NLRE was to maintain an approximately constant level of risk within each asset category. To achieve this, the ARP model was used to determine the HI profiles at the end of DPCR5 and the end of ED1 to project how the number of HI4s and HI5s would increase without investment. This provided the basis for the volume of interventions required during ED1.

7.2.2 Optimising the plan

Internal stakeholder engagement was an important part of the process to finalise the ED1 plan. This provided another way of ensuring that the data being used in the ARP model reflected stakeholders' own assessments of the assets' conditions. There was also detailed consultation with those involved in constructing the ED1 LRE expenditure plans to ensure the optimal investment for maximum achievement.

7.3 Additional Considerations

If during scheduled work, engineers identify a need for further maintenance work on a pole, they will consider carrying out this additional unplanned work there and then, so that there is no need for a revisit. Other considerations may follow the defect identification and inspector interventions.

7.4 Asset Volumes and Expenditure [RIGs references]

The proposed asset replacement and retrofit volumes for ED1 are shown in Figures 37–40, along with volumes for DPCR4, DPCR5 and ED2 for comparison. The ED2 figures shown in the charts have been derived from age-based modelling. Further work will be done in ED1 to explore additional intervention options that can be used to extend asset life. Intervention volumes can be found in more detail in Appendix 5.

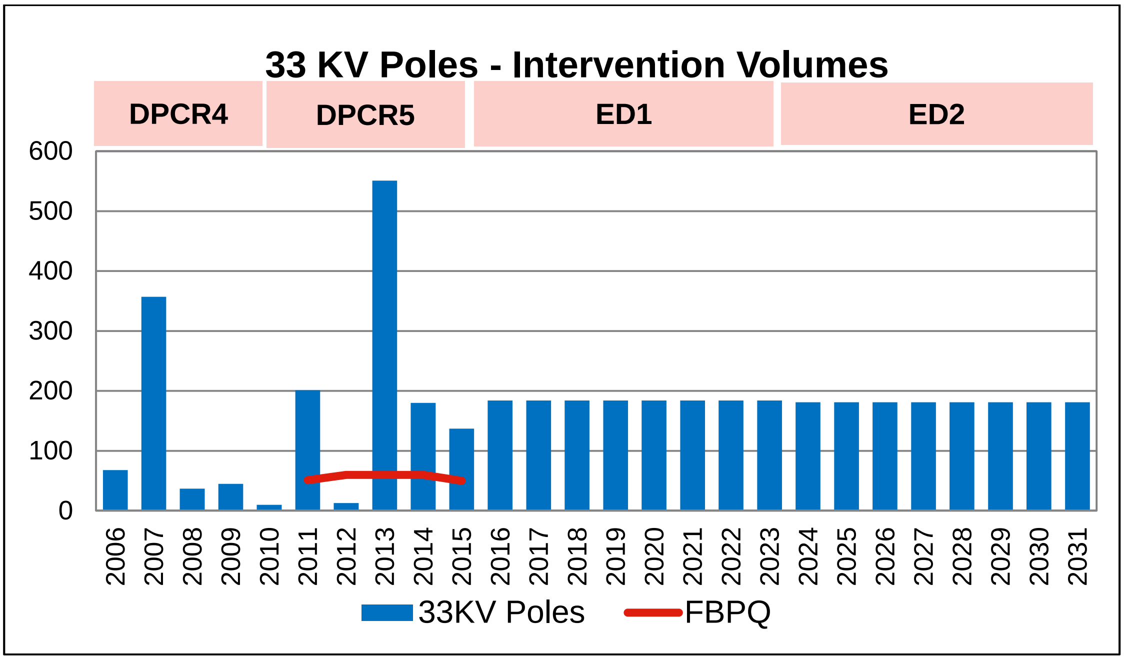


Figure 37 – 33kV wood poles intervention volumes

Sources :

DPCR4 & DPCR5 FBPQ - Table NL3 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) - 2013/2014 RIGS CV3 table
ED1 - 2013/2014 RIGS CV3 table
ED2 - From Age-Based Analysis

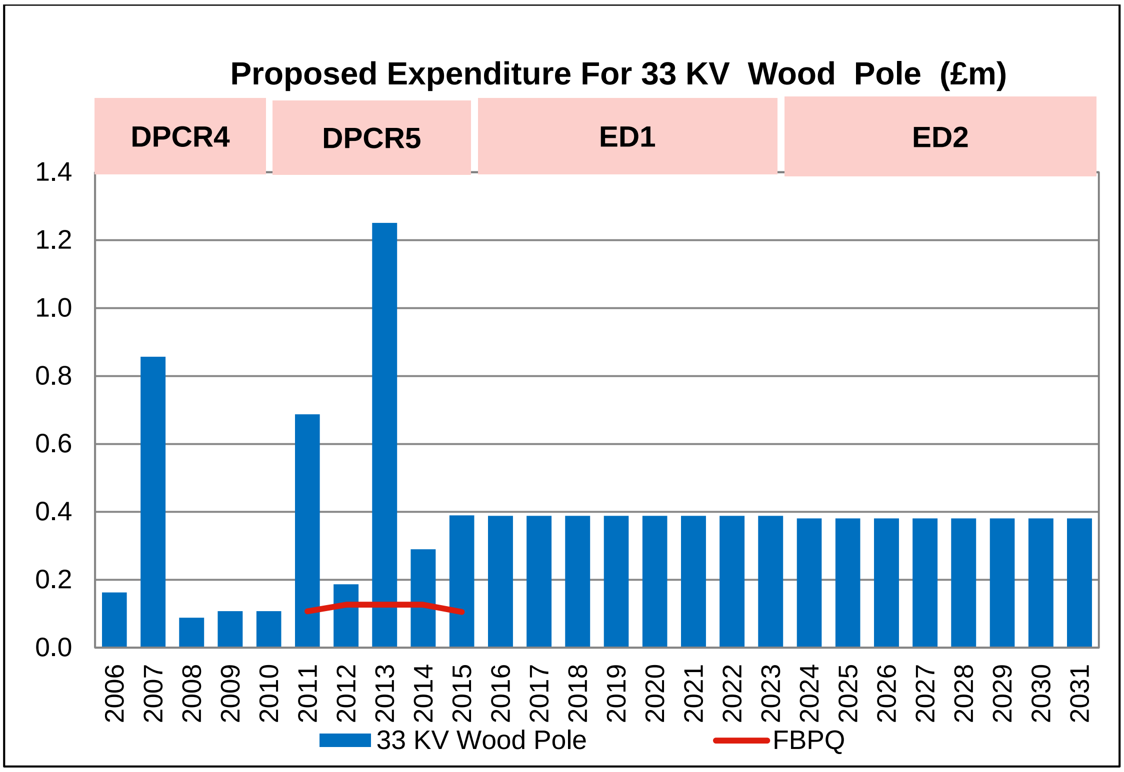


Figure 38 – Proposed expenditure for 33kV poles (£m)

Sources:
DPCR4 & DPCR5 FBPQ - Table NL1 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) – 14thJune NAMP (Table JLI)
ED1 – 19th February NAMP (Table J Less Indirect)
ED2 - From Age-Based Analysis * UCI

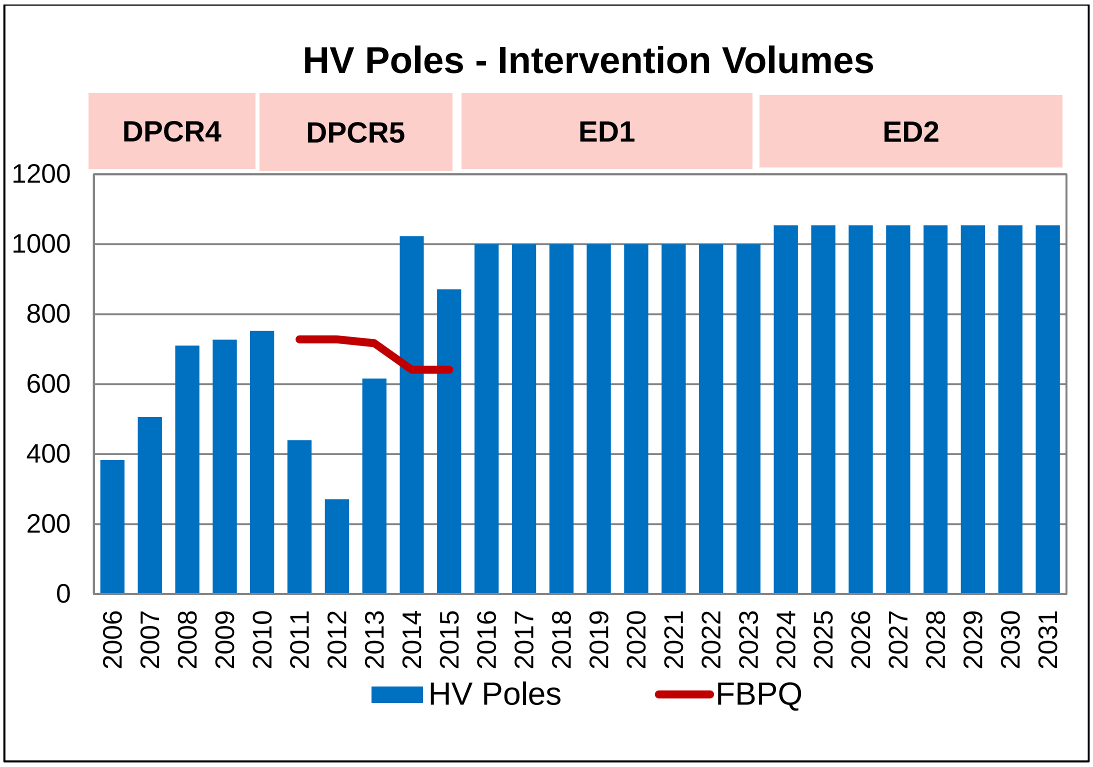


Figure 39 – HV wood poles intervention volumes

Sources :

DPCR4 & DPCR5 FBPQ - Table NL3 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) - 2013/2014 RIGS CV3 table
ED1 - 2013/2014 RIGS CV3 table
ED2 - From Age-Based Analysis

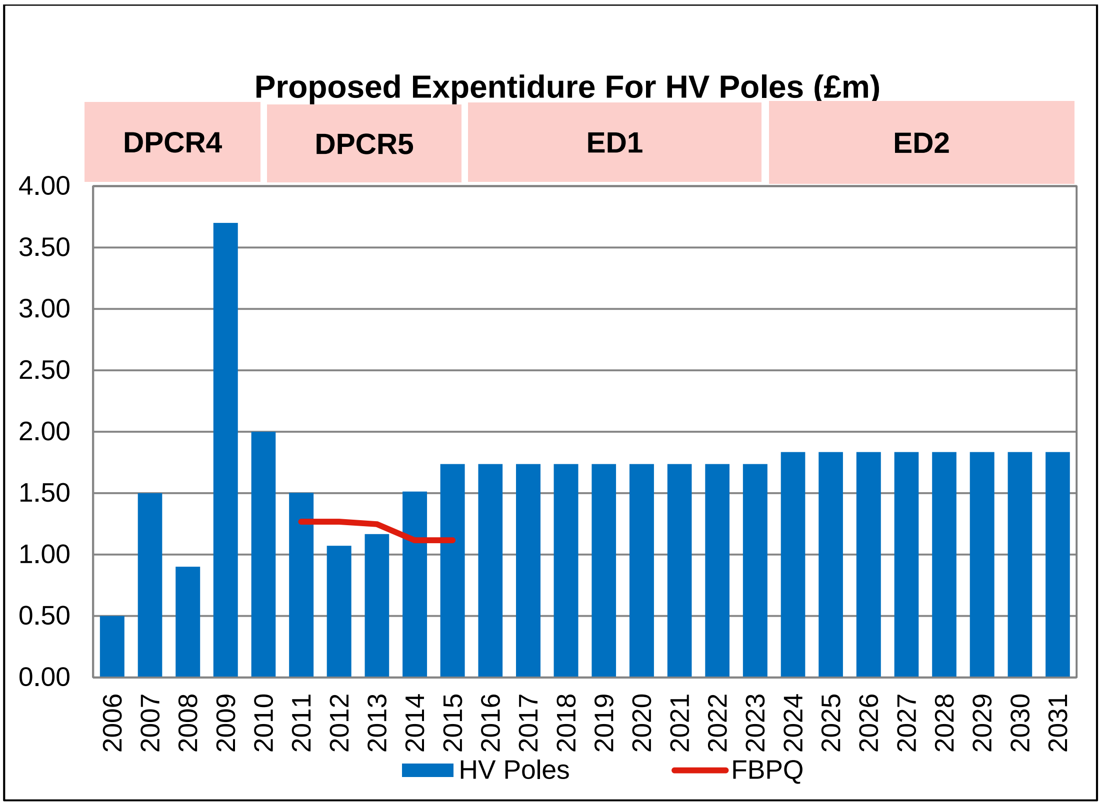


Figure 40 – Proposed expenditure for HV poles (£m)

Sources:
DPCR4 & DPCR5 FBPQ - Table NL1 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) – 14thJune NAMP (Table JLI)
ED1 – 19th February NAMP (Table J Less Indirect)
ED2 - From Age-Based Analysis * UCI

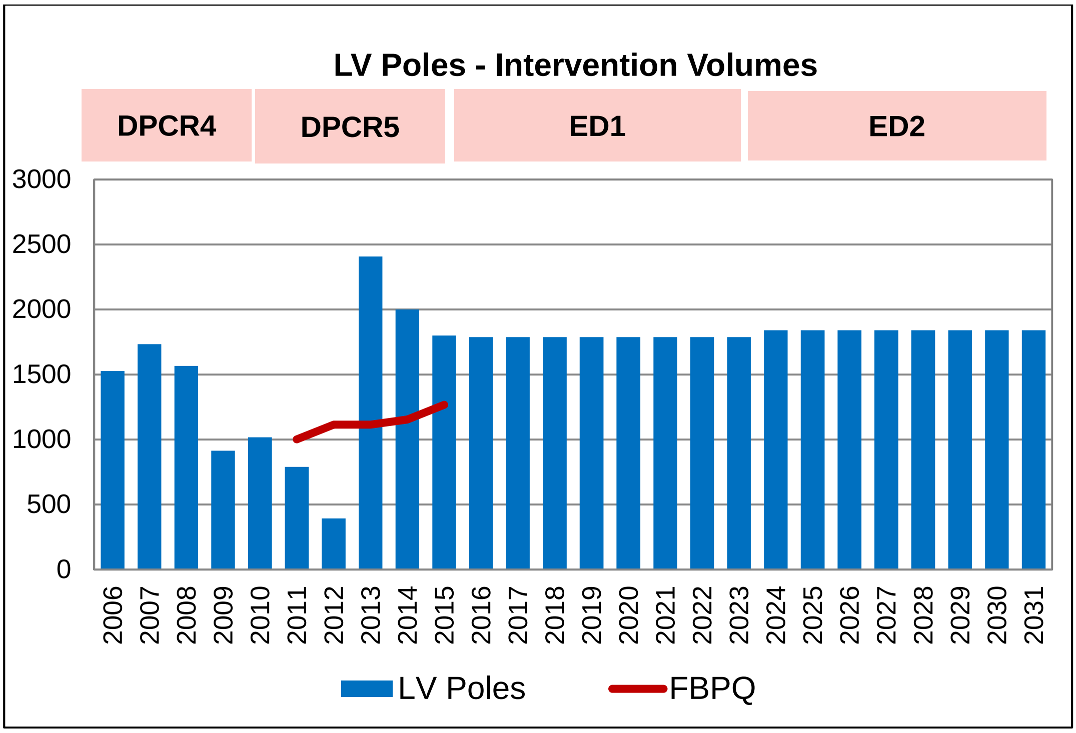


Figure 41 – LV wood poles intervention volumes

Sources :

DPCR4 & DPCR5 FBPQ - Table NL3 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) - 2013/2014 RIGS CV3 table
ED1 - 2013/2014 RIGS CV3 table
ED2 - From Age-Based Analysis

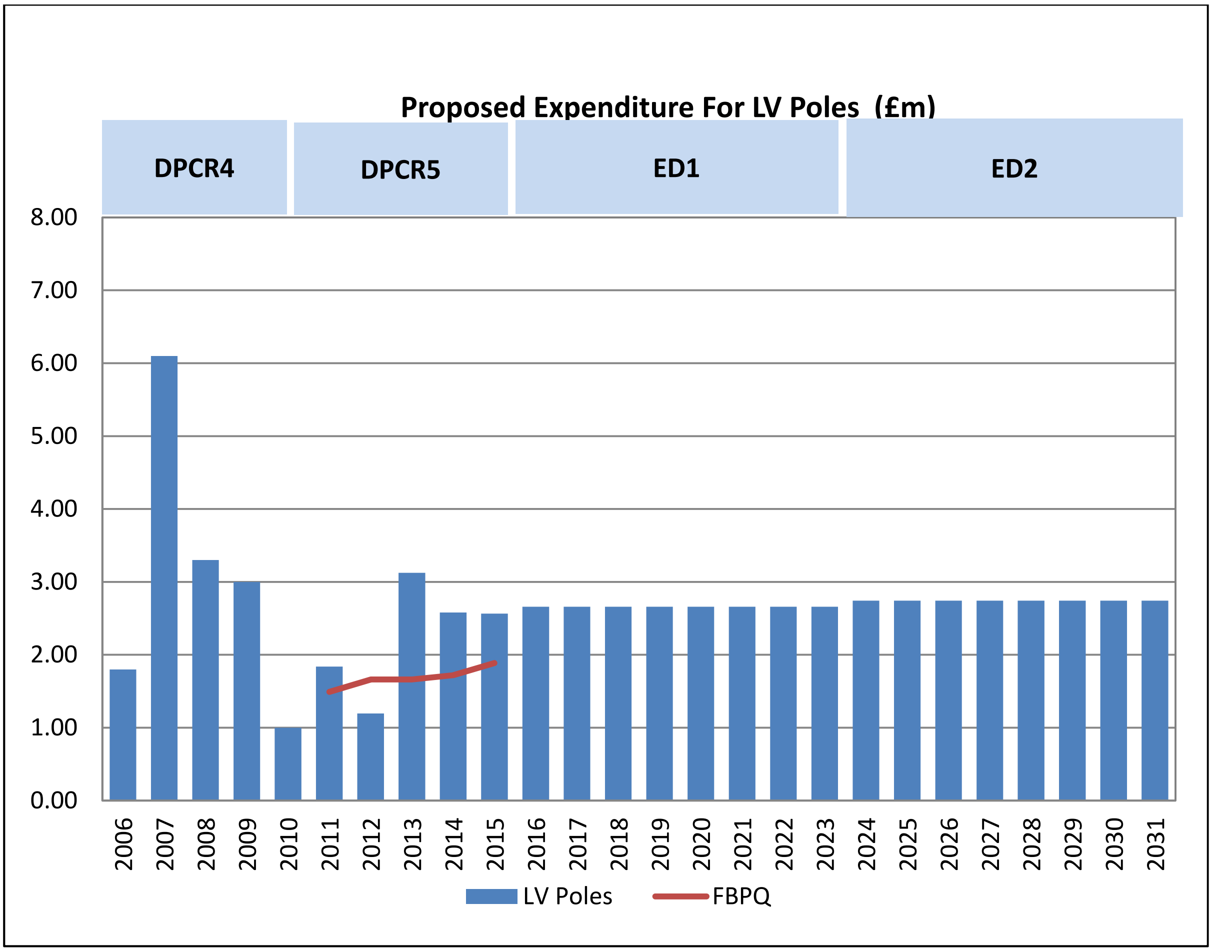


Figure 42 – Proposed expenditure for LV poles (£m)

Sources:
DPCR4 & DPCR5 FBPQ - Table NL1 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) – 14thJune NAMP (Table JLI)
ED1 – 19th February NAMP (Table J Less Indirect)
ED2 - From Age-Based Analysis * UCI

The trend shows HV and LV pole volumes are high compared with historic achievement, resulting in a large step change into ED1. This is due to the high number of ‘D’ poles in EPN – shown in Table 11, as extracted from Ellipse on March 2013.

Asset Category	Number Of S Poles	Number Of D Poles	% Population	
			S poles	**D Poles**
33 KV Pole	1831	1399	5%	4%
HV Pole	9272	6824	4%	3%
LV Pole	13370	11125	5%	4%

Table 11 – Number of ‘D’ and ‘S’ poles in EPN

The increased investment in LV and HV pole replacement in ED1 is due to the ageing population and the large number of decayed poles identified. There are around 11,125 ‘D’ poles and 13,370 ‘S’ poles. We have estimated 1,788 LV poles for replacement per year during the ED1 period. For HV poles, there are 6,824 ‘D’ poles and 9,272 ‘S’ poles in Ellipse, and 1,000 HV poles are planned for replacement per year during the ED1 period. The ED1 volumes have been set to manage the number of outstanding ‘D’ poles, as well as new emerging ‘D’ poles in Ellipse.The increase in volumes is due to the fact that we will be removing a high number of poles that were commissioned between 1955–1970 (as shown in Figure 2,4 and 5) of section 2 that will reach their end of life by the end of ED1. It is expected that ED1 numbers will reduce by using proposed interventions as shown in table 8.

7.4.1 Proposed intervention volumes and expenditure for conductors

Proposed asset replacement volumes for conductors for ED1 are shown in Figures 43, 45 and 47, along with volumes for DPCR4, DPCR5 and ED2 for comparison. It is estimated that 50% of the LV ABC schemes will have an impact on reducing ESQCR issues.

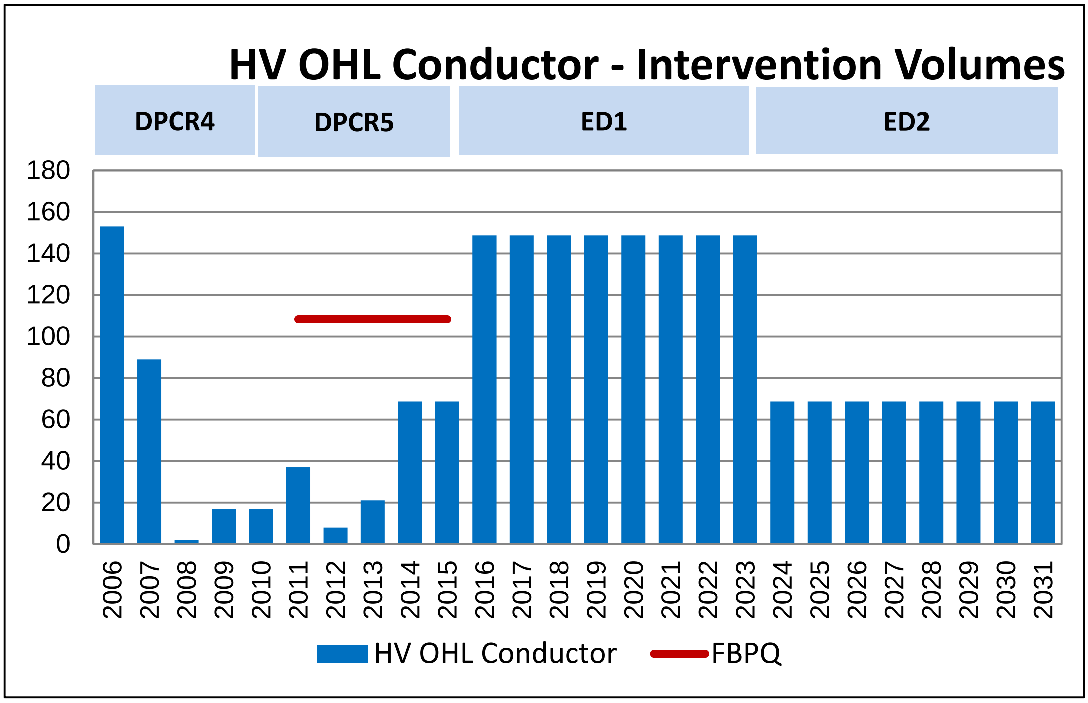


Figure 43 – Intervention volumes for HV OHL conductors

Sources :

DPCR4 & DPCR5 FBPQ - Table NL3 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) - 2013/2014 RIGS CV3 table
ED1 - 2013/2014 RIGS CV3 table
ED2 - From Age-Based Analysis

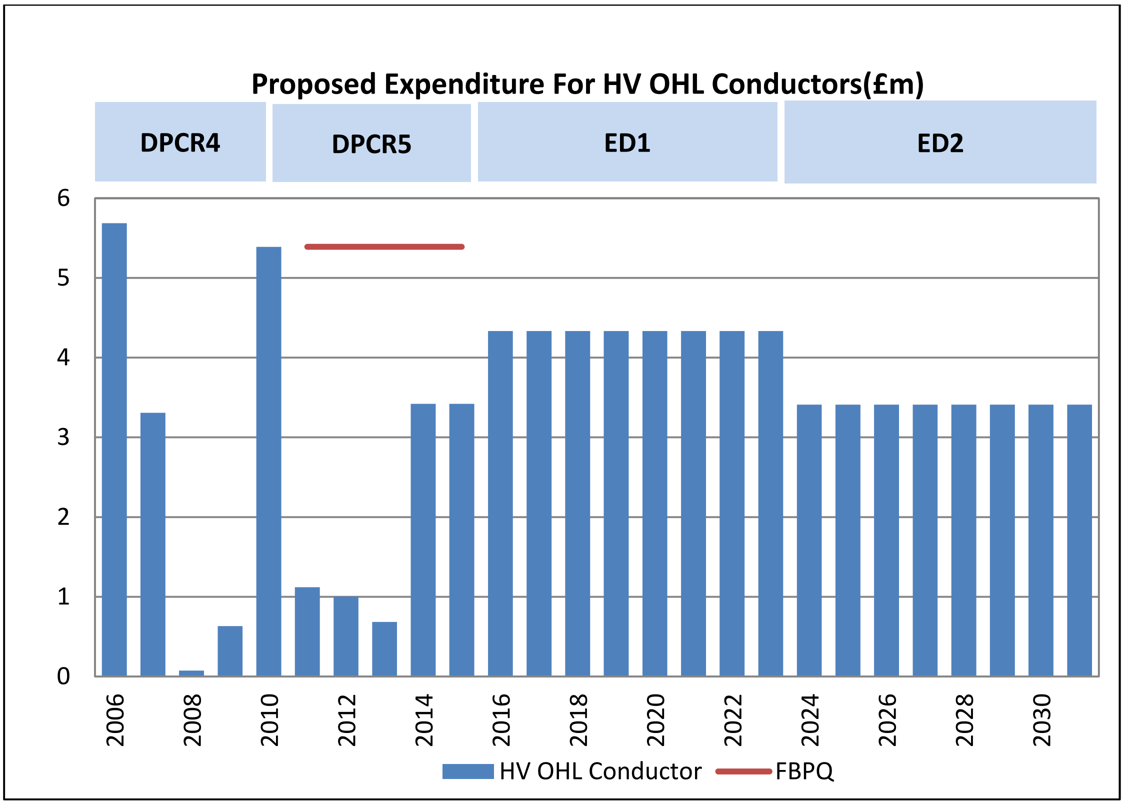


Figure 44 – Proposed expenditure for HV OHL conductors

Sources:
DPCR4 & DPCR5 FBPQ - Table NL1 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) – 14thJune NAMP (Table JLI)
ED1 – 19th February NAMP (Table J Less Indirect)
ED2 - From Age-Based Analysis * UCI

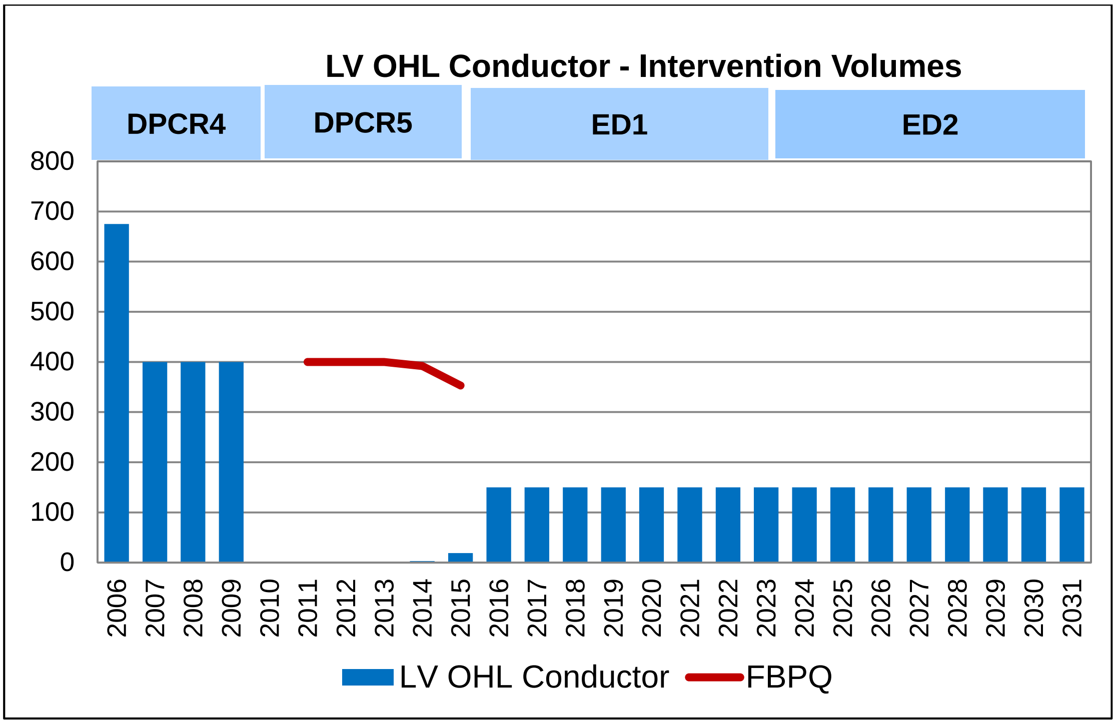


Figure 45 – Intervention volumes for LV OHL conductor

Sources :

DPCR4 & DPCR5 FBPQ - Table NL3 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) - 2013/2014 RIGS CV3 table
ED1 - 2013/2014 RIGS CV3 table
ED2 - From Age-Based Analysis

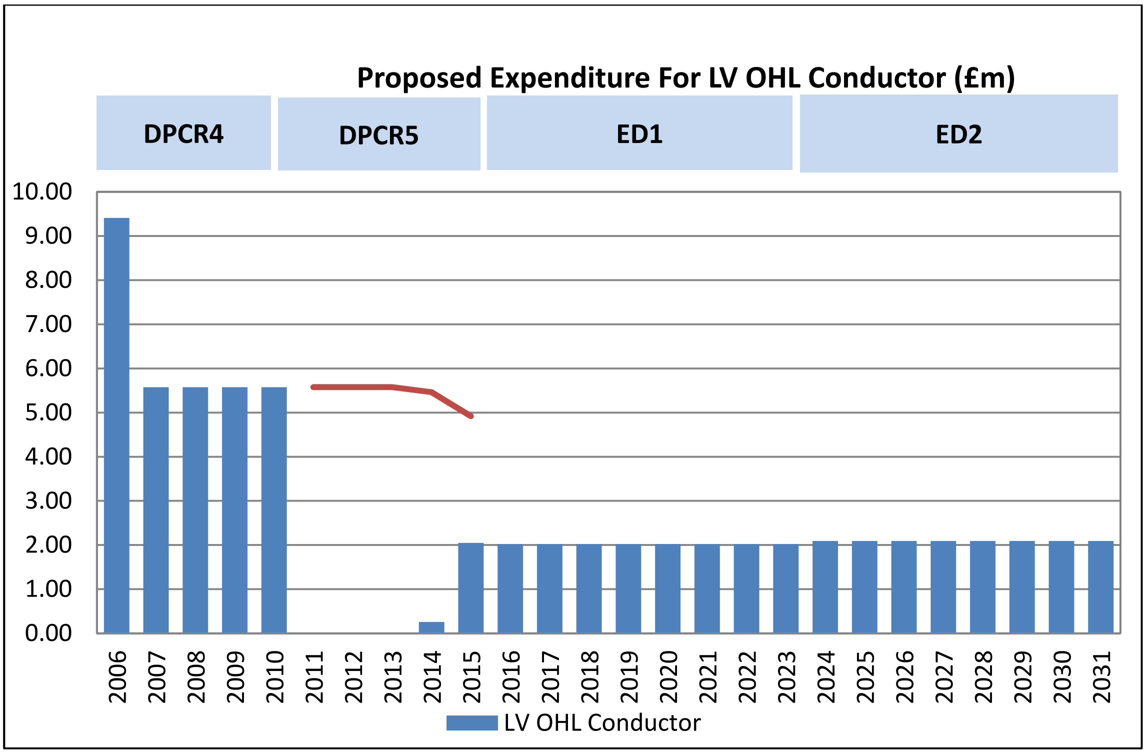


Figure 46 – Proposed expenditure for LV OHL conductors

Sources:
DPCR4 & DPCR5 FBPQ - Table NL1 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) – 14thJune NAMP (Table JLI)
ED1 – 19th February NAMP (Table J Less Indirect)
ED2 - From Age-Based Analysis * UCI

The increase in output during DPCR5 allows us to secure resources to achieve the steady state forecasts in ED1 and ED2. During the period 2011/2012, spend has been reallocated to resolve high risk ESQCR issues as shown in Figure 45 due to targeted replacements /adding of spans with ESQCR non-compliance considerations.

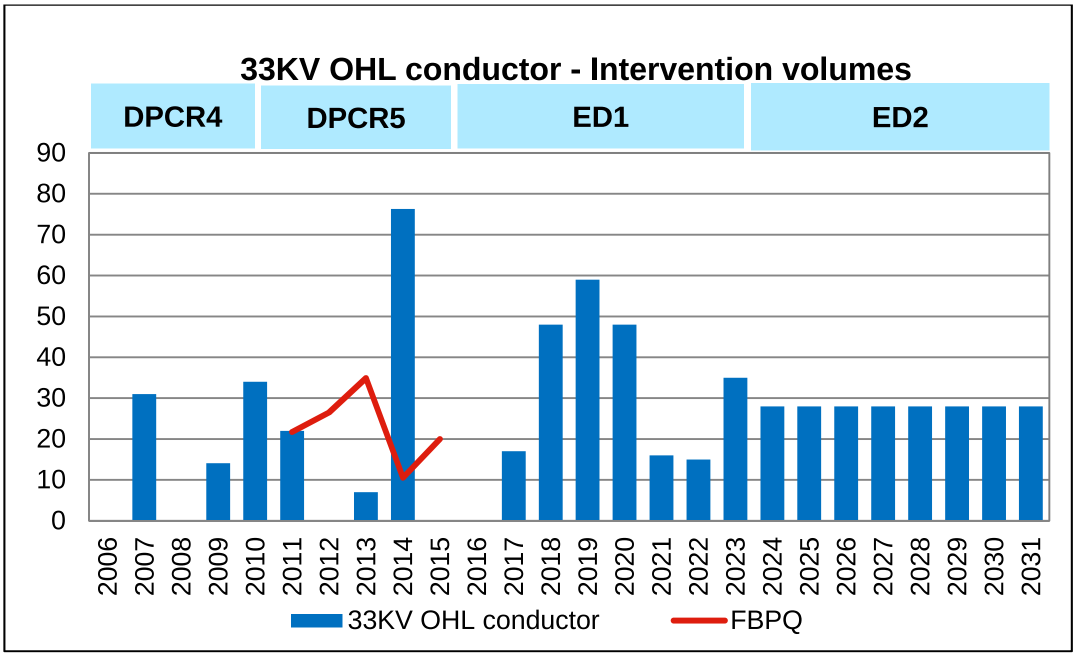


Figure 47 – Intervention volumes for 33KV OHL conductor

Sources :

DPCR4 & DPCR5 FBPQ - Table NL3 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) - 2013/2014 RIGS CV3 table
ED1 - 2013/2014 RIGS CV3 table
ED2 - From Age-Based Analysis

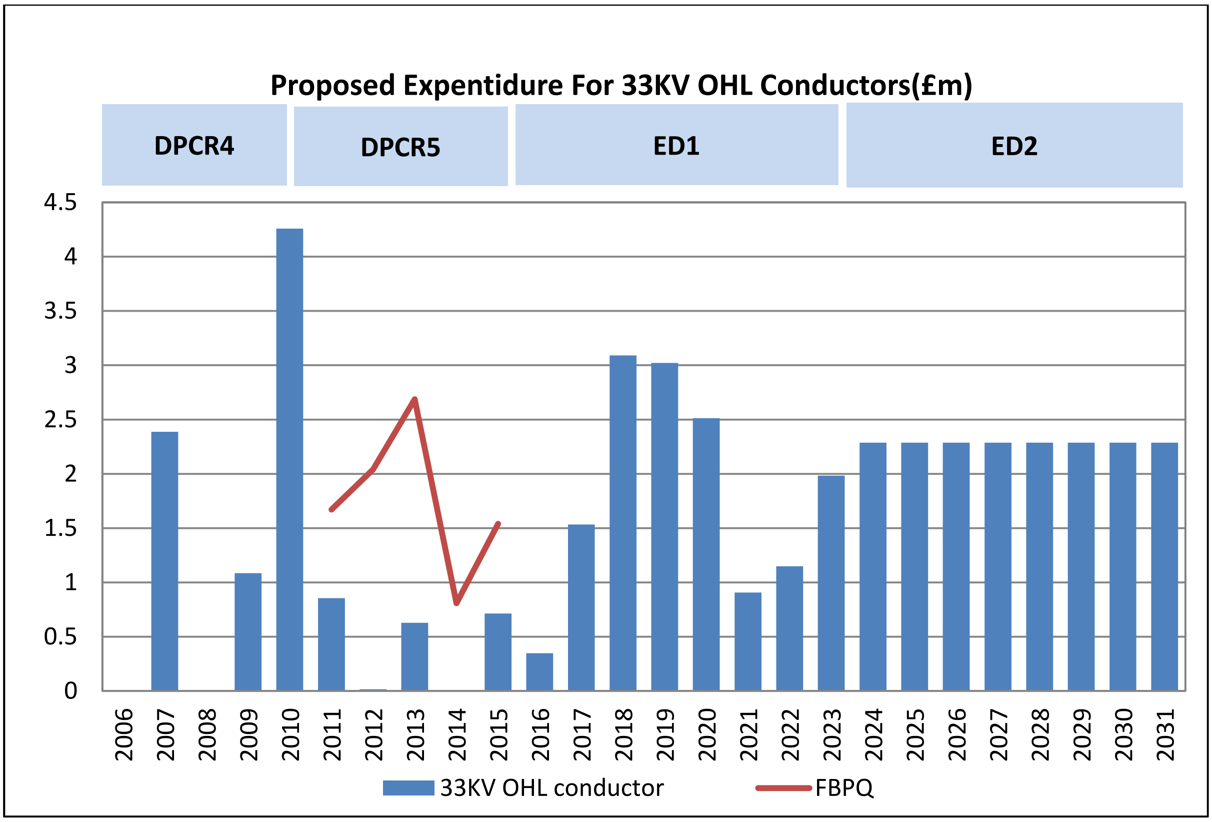


Figure 48 – Proposed expenditure for 33KV OHL conductors

Sources:
DPCR4 & DPCR5 FBPQ - Table NL1 (DPCR5 FBPQ)
DPCR5 (First three years) - 2013/2014 RIGS CV3 table
DPCR5 (Last Two years) – 14thJune NAMP (Table JLI)
ED1 – 19th February NAMP (Table J Less Indirect)
ED2 - From Age-Based Analysis * UCI

7.5 Commentary

The proposed investment level in ED1 for the replacement of LV, HV and 33kV wood poles in EPN is £103.1m.

We are currently on target for achieving of DPCR5 wood replacements by the end of March 2015. Resource issues in year 2 contributed to work being behind schedule. However, a rise in contractors is set to increase the number of resources for the remainder of DPCR5.

HV & LV Poles :

As detailed in the section 7.4 (Figure 37 - 42) ,the trend shows HV and LV pole volumes are high compared with historic achievement. The increased investment in LV and HV pole replacement in ED1 is due to the ageing population and the large number of decayed poles identified.

There are currently 11,125 ‘D’ poles and 13,370 ‘S’ poles. We have estimated 1,788 LV poles for replacement per year during the ED1 period. For HV poles, there are 6,824 ‘D’ poles and 9,272 ‘S’ poles in Ellipse, and 1,000 HV poles are planned for replacement per year during the ED1 period.

The ED1 volumes have been set to manage the number of outstanding ‘D’ poles, as well as new emerging ‘D’ poles in Ellipse. The increase in volumes is also due to the fact that we will be removing a high number of poles that were commissioned between 1955–1970 (as shown in Figure 2,4 and 5) of section 2 that will reach their end of life by the end of ED1.

33KV Poles :

As shown in the Figure 37 and Figure 38 the increased investment in 33KV pole replacement in ED1 is due to the ageing population and the large number of decayed poles identified. ED1 volumes have been set to manage the outstanding D poles and we will be removing a high number of poles that were commissioned between 1955–1970 as shown in Figure 2,4 and 5 of section 2 that will reach their end of life by the end of ED1.

This is the worst case scenario considered, it is expected that ED1 and ED2 numbers will reduce by using proposed intervention options. As demonstrated in the section 6 ,with the proposed interventions the modelled average end of asset life of 70 years is achievable of all wood poles. LV poles, while of a small size, are no more likely to decay than a much larger pole.

LV Conductors :

The increase in output during DPCR5 allows us to secure resources to achieve the steady state forecasts in ED1 and ED2. During DPCR5, spend has been reallocated to resolve high risk ESQCR issues as shown in Figure 45 and 46 due to targeted replacements /adding of spans with ESQCR non-compliance considerations. The ED1 volumes have been set to manage /achieve steady state forecast during the ED1 period .

HV Conductors:

ED1 forecasts have been set to remove small section of the conductor and replace spans of conductors with multiple fault history .

33KV Conductors :

The proposed investment level for the 33KV conductor is high ,as it is extracted from ARP as based on condition and age of the conductors. This will lead to consequential benefits by resolving some ESQCR non-compliance including d-poles and associated conductors ,tree clearance issues etc.

7.6 Sensitivity Analysis and Plan Validation

An independent report has been carried out by Decision Lab to understand how the Health Index profile of assets may change if the average life of assets does not turn out as predicted. Table 12 shows all results as the percentages of the population.

7.6.1 33kV wood poles

Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	15.7	69.6	7.7	4.1	2.8
-2	15.7	71.6	5.8	4.1	2.8
-1	16.8	70.9	5.4	4.1	2.8
0	16.8	71.7	4.6	4.3	2.6
1	19.0	71.0	3.1	4.3	2.6
2	19.0	71.5	2.6	4.4	2.5
4	20.2	70.9	2.0	4.4	2.5

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	14.7	57.7	20.7	4.1	2.8
-2	15.1	61.3	17.8	3.0	2.8
-1	15.1	63.0	16.3	2.8	2.8
0	15.1	65.4	14.4	2.3	2.7
1	16.0	66.3	13.1	1.8	2.7
2	16.1	68.3	11.1	1.8	2.7
4	16.1	73.6	6.6	0.9	2.7

Table 12 – Results of sensitivity analysis for EHV poles

In Table 12, each average life change of years +/- 1, 2 and 4 is represented as a percentage of the current population. With each change in average life, there is a subsequent movement in the percentage of population in each Health Index. An average life at 0 represents the current population split within each Health Index with intervention strategies applied. The two tables range from the start of ED1 (2015) and the end of ED1 (2023).

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

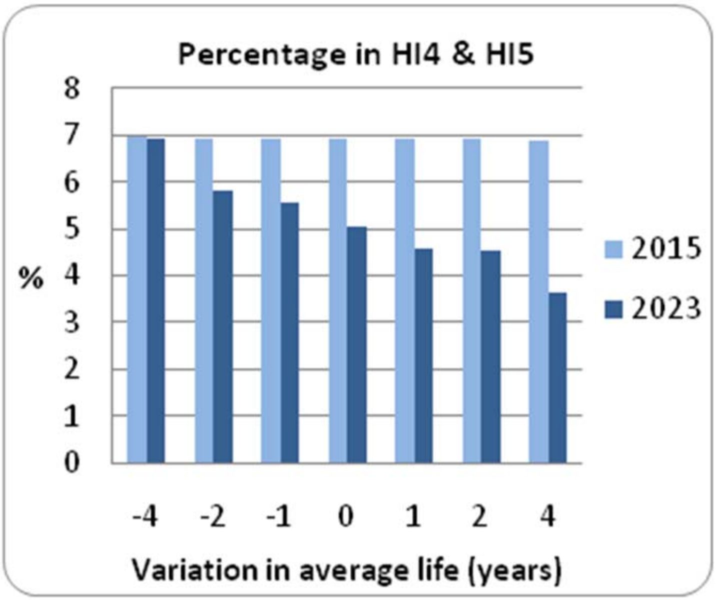


Figure 49 – Effect of average life variation on volumes of HI4 and HI5

Figure 46 represents summed HI4s and HI5s as a percentage of the population, showing the change at each average life iteration, comparing 2015 with 2023.

7.6.2 HV wood poles

Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	14.2	73.9	6.1	3.4	2.3
-2	14.2	75.4	4.6	3.4	2.3
-1	15.7	74.5	4.1	3.4	2.3
0	15.7	75.2	3.4	3.4	2.3
1	17.4	74.0	2.9	3.4	2.2
2	17.4	74.3	2.6	3.4	2.2
4	19.2	72.8	2.3	3.4	2.2

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	11.4	60.8	22.5	3.3	2.0
-2	13.6	64.8	17.0	2.6	2.0
-1	13.6	67.1	14.9	2.4	1.9
0	13.6	69.5	12.7	2.2	1.9
1	14.1	71.5	10.5	2.0	1.9
2	14.1	73.5	8.8	1.7	1.9
4	14.7	77.5	4.8	1.2	1.9

Table 13 – Results of sensitivity analysis for HV poles

In Table 13, each average life change of years +/- 1, 2 and 4 is represented as a percentage of the current population. With each change in average life, there is a subsequent movement in the percentage of population in each Health Index. An average life at 0 represents the current population split within each Health Index with intervention strategies applied. The two tables range from the start of ED1 (2015) and the end of ED1 (2023).

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

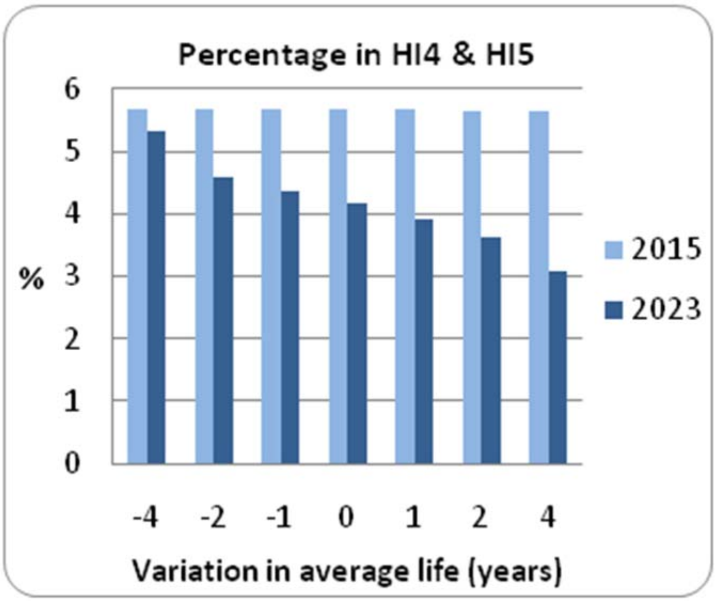


Figure 50 – Effect of average life variation on volumes of HI4 and HI5

7.6.3 LV wood poles

Average life change	2015 percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	14.8	74.3	4.3	3.4	3.1
-2	16.5	73.7	3.2	3.4	3.1
-1	17.8	72.8	2.9	3.4	3.1
0	17.8	73.1	2.6	3.4	3.1
1	19.3	71.8	2.3	3.4	3.1
2	19.3	72.0	2.2	3.5	3.1
4	20.6	71.1	1.8	3.5	3.0

Average life change	2023 percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	16.0	63.6	17.3	2.3	0.8
-2	16.4	67.7	13.1	2.0	0.8
-1	17.0	69.4	10.9	1.8	0.8
0	17.0	74.6	5.8	1.7	0.8
1	18.0	75.5	4.2	1.5	0.8
2	18.0	76.2	3.8	1.2	0.8
4	19.2	75.9	3.3	0.8	0.8

Table 14 – Results of sensitivity analysis for LV poles

In Table 14, each average life change of years +/- 1, 2 and 4 are represented as a percentage of the current population. With each change in average life, there is a subsequent movement in the percentage of population in each Health Index. An average life at 0 represents the current population split within each Health Index with intervention strategies applied. The two tables range from the start of ED1 (2015) and the end of ED1 (2023).

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

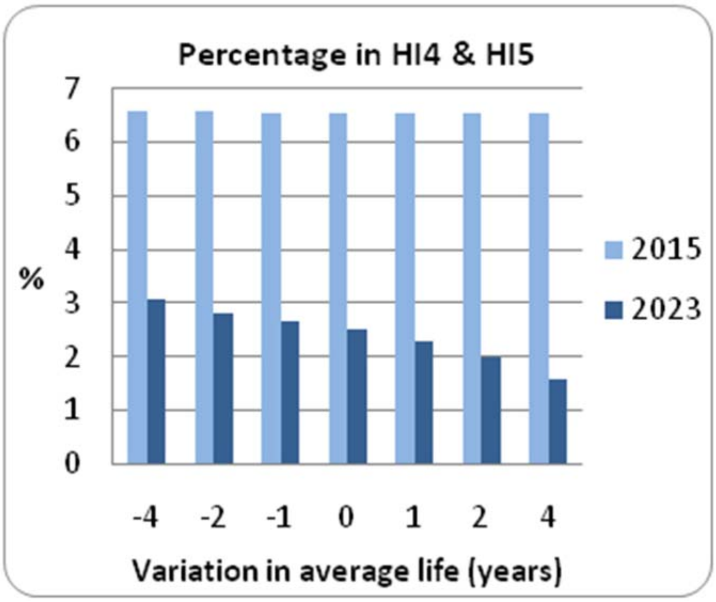


Figure 51 – Effect of average life variation on volumes of HI4 and HI5

7.7 Model Testing

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

7.7.1 Algorithm testing

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

7.7.2 Software testing

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

7.7.3 Data flow testing

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

7.7.4 User and methodology testing

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

7.8 Network Risk

As described in section 4 of this document, the ARP model (and in-house criticality modelling techniques for non-ARP assets) has the capability of producing a criticality index (C1-4) for each individual asset, although this is a new concept that is still being developed. The criticality index can be used with the health index to give an indication of the level of risk that can be seen on the network.

[Source: Strategy Decision for the RIIO-ED1 Electricity Distribution Price Control – Reliability and Safety 04/03/2012. Criticality & Health Index Working Group – Recommendations for Common Principles for Criticality Index Measures 13/12/2012].

33KV Poles :

Asset categories		Units	Estimated Asset Health and Criticality Profile 2015with Investment					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2015
33 KV Poles	Low	No. Assets	1181	5421	350	326	270	7548
	Average	No. Assets	4303	19734	1275	1189	982	27483
	High	No. Assets	0	0	0	0	0	0
	Very High	No. Assets	0	0	0	0	0	0

Table 15: Asset Health and Criticality 2015 *Source ARP Model (HI :25th July 2012 ,Criticality : 27th November 2012)*

Asset categories		Units	Estimated Asset Health and Criticality Profile 2023 with Investment					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2023
33 KV Poles	Low	No. Assets	1043	4922	1093	176	314	7548
	Average	No. Assets	3795	17922	3979	640	1147	27483
	High	No. Assets	0	0	0	0	0	0
	Very High	No. Assets	0	0	0	0	0	0

Table 16: Asset Health and Criticality 2023 *Source ARP Model (HI :25th July 2012 ,Criticality : 27th November 2012)*

HV Poles :

Asset categories		**Units**	**Estimated Asset Health and Criticality Profile 2015 with Investment**					**Asset Register**
			Asset health index					
			HI1	**HI2**	**HI3**	**HI4**	**HI5**	**2015**
HV Poles	Low	No. Assets	12	103	14	2	4	135
	Average	No. Assets	30344	147825	6695	6814	4848	196,526
	High	No. Assets	3370	13180	604	469	0	17,623
	Very High	No. Assets	14	38	1	6	0	59

Table 17: Asset Health and Criticality 2015 *Source ARP Model (HI :25th July 2012 ,Criticality : 27th November 2012)*

Asset categories		**Units**	**Estimated Asset Health and Criticality Profile 2023 with Investment**					**Asset Register**
			Asset health index					
			HI1	**HI2**	**HI3**	**HI4**	**HI5**	**2023**
HV Poles	Low	No. Assets	7	81	34	5	8	135
	Average	No. Assets	16643	117840	49495	7489	5059	196,526
	High	No. Assets	1712	10577	4441	664	229	17,623
	Very High	No. Assets	10	29	11	9	0	59

Table 18: Asset Health and Criticality 2023 *Source ARP Model (HI :25th July 2012 ,Criticality : 27th November 2012)*

LV Poles :

Asset categories		Units	Estimated Asset Health and Criticality Profile 2015 with Intervention					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2015
LV Poles	Low	No. Assets	0	0	0	0	0	0
	Average	No. Assets	44138	179341	6435	8501	7691	246,106
	High	No. Assets	115	1016	14	62	48	1,255
	Very High	No. Assets	1	0	0	0	1	2

Table 19: Asset Health and Criticality 2015 Source ARP Model (HI :25th July 2012 ,Criticality : 27th November 2012

Asset categories		Units	Estimated Asset Health and Criticality Profile 2023 with Investment					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2023
LV Poles	Low	No. Assets	0	0	0	0	0	0
	Average	No. Assets	37480	151153	47037	6192	4244	246,106
	High	No. Assets	183	771	240	32	29	1,255
	Very High	No. Assets	1	1	0	0	0	2

Table 20: Asset Health and Criticality 2015 Source ARP Model (HI :25th July 2012 ,Criticality : 27th November 2012

8.0 Deliverability

The volumes of work proposed in ED1 are comparable to that achieved in DPCR4 and are spread fairly evenly across the network, so network access and outage availability issues are not anticipated.

Hired contractors and current framework contracts are in place, with a view to delivering the targets through ED1.

The various innovations for extending pole serviceability will be incorporated within existing resources (inspectors); the contractors will undertake specialised activities.

All ED1 projects have been created in the Network Asset Management Plan (NAMP). This application costs the project based on compatible units and automatically creates an entry in the NAMP. The majority of projects are for specifically named schemes. Where this is not possible, a financial provision has been created.

Appendix 1 – Age Profiles

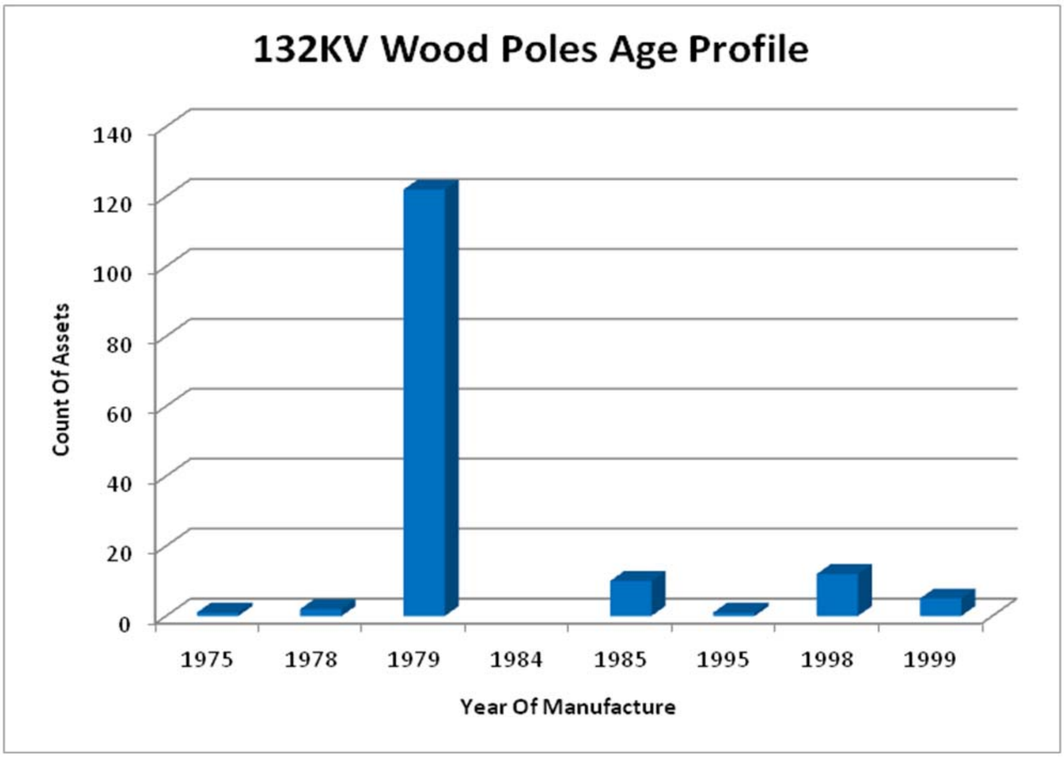


Figure 52 – 132kV Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

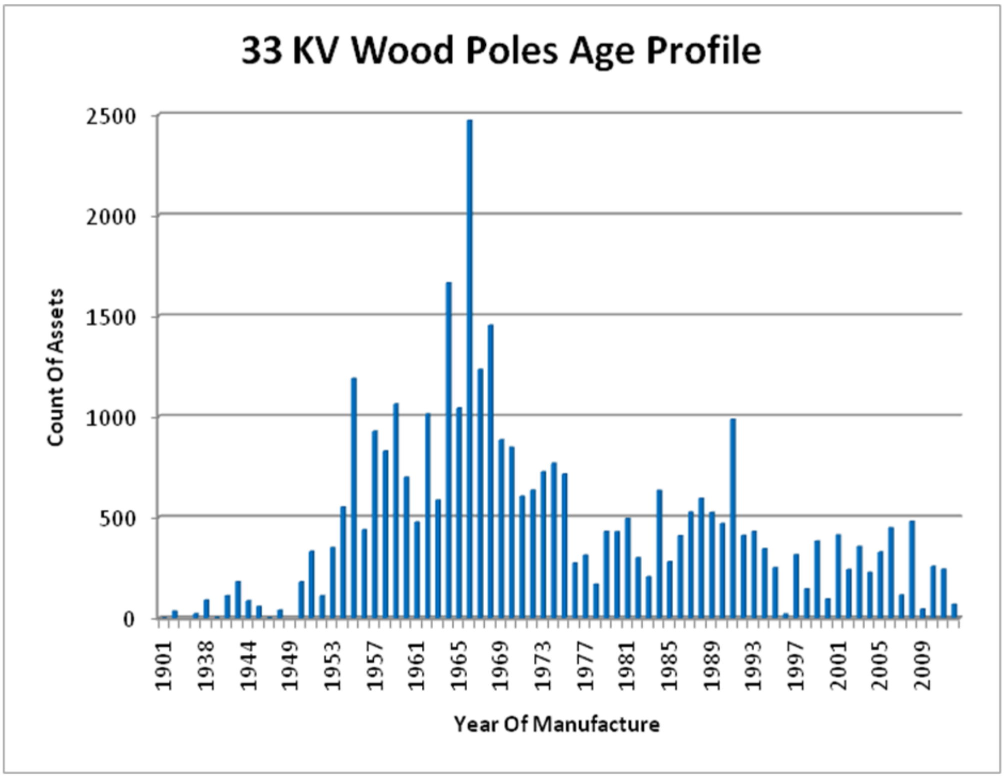


Figure 53 – 33kV(EHV) Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

(Source – RIGS 2012 CV3 Table V5)

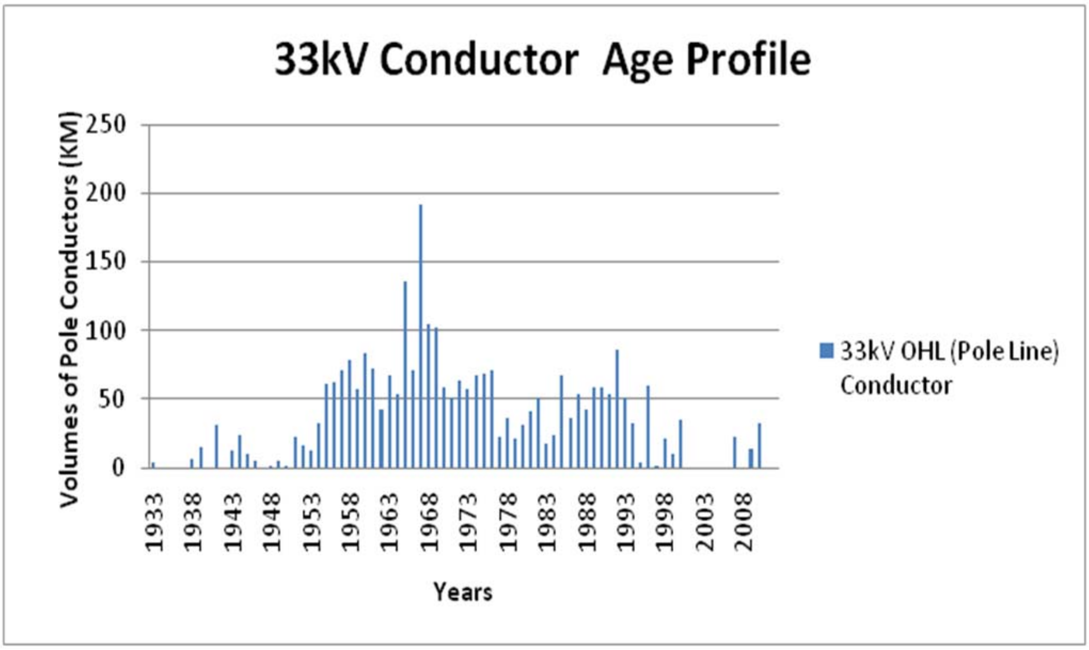


Figure 54 – 33kV(EHV) Conductor Age Profile

(Source – RIGS 2012 CV3 Table V5)

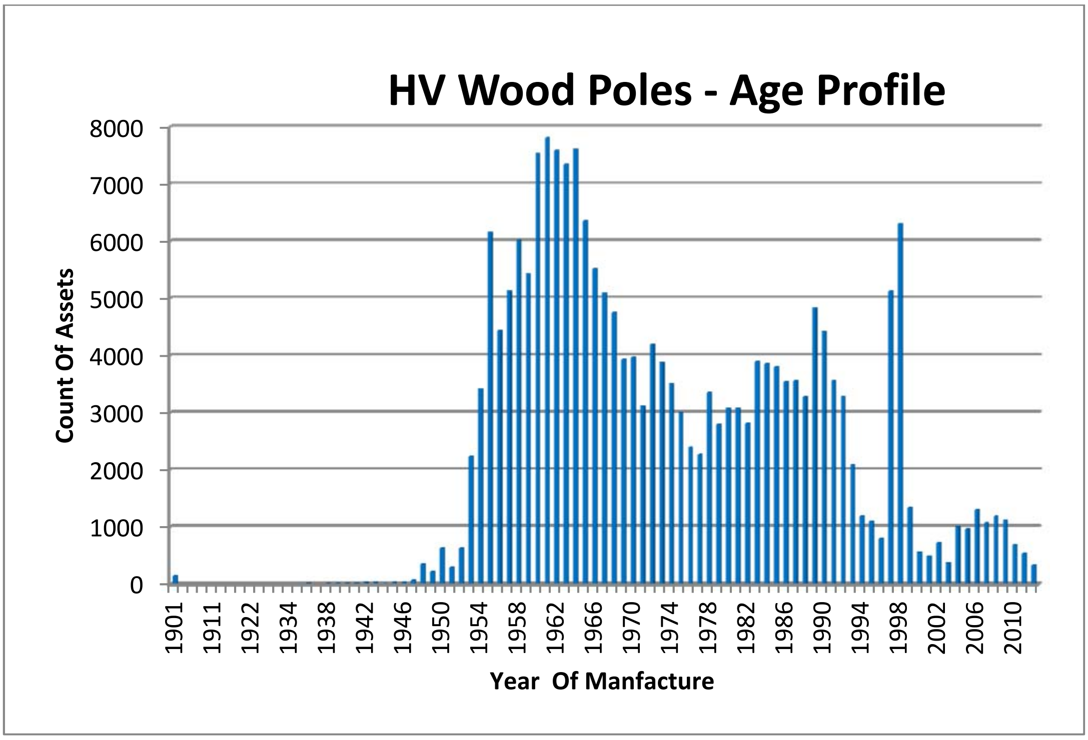


Figure 55 – HV Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

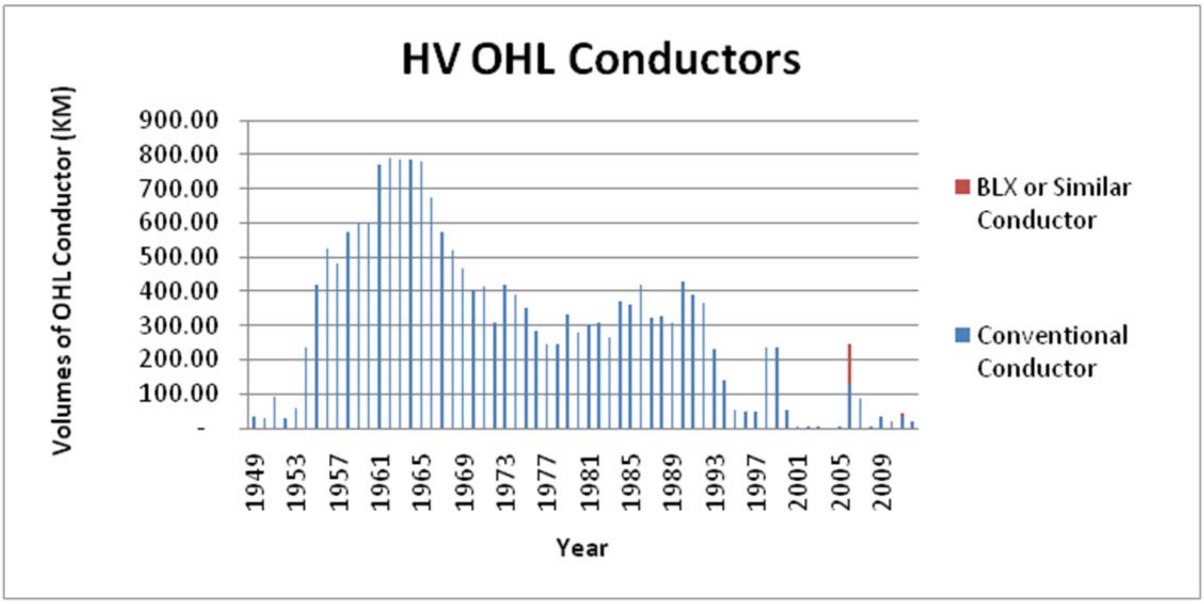


Figure 56 – HV Conductor Age Profile

(Source – RIGS 2012 CV3 Table V5)

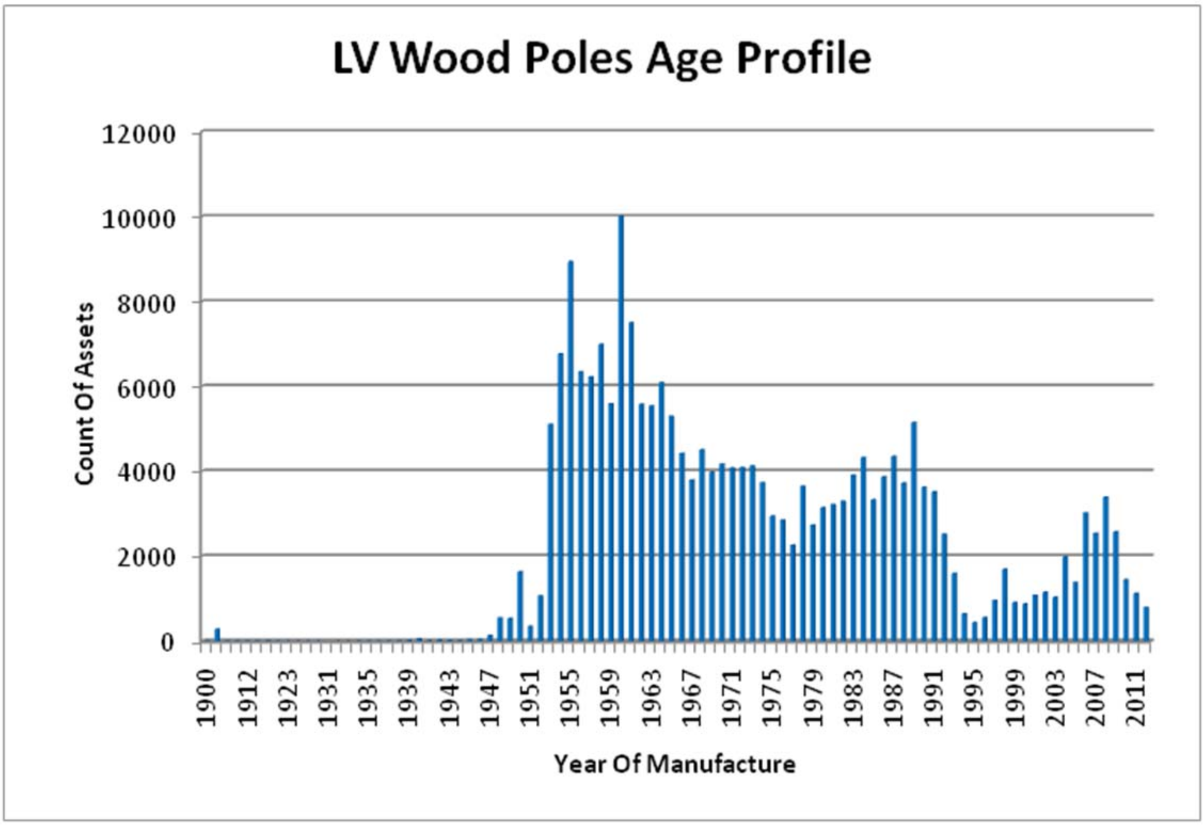


Figure 57 – LV Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

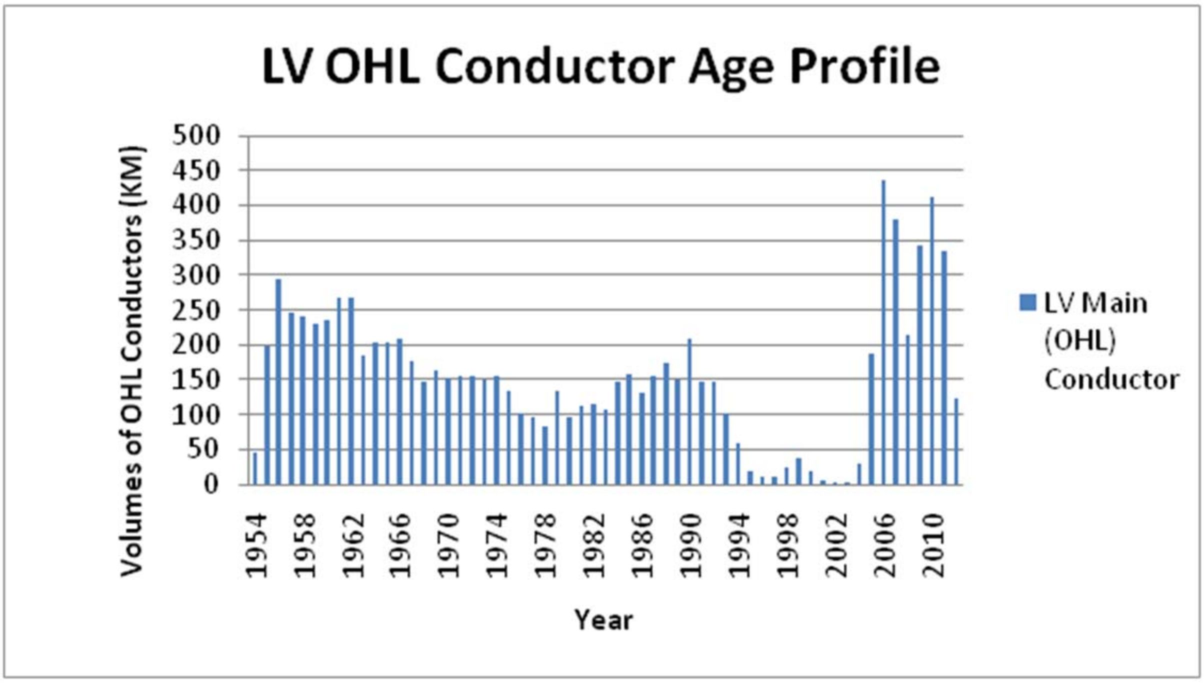


Figure 58 – LV Conductor Age Profile

(Source – RIGS 2012 CV3 Table V5)

Appendix 2 – HI and Criticality Profiles

33KV Poles :

Asset Health and Crticality 2015

Asset categories		Units	Estimated Asset Health and Criticality Profile 2015 with Interventions					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2015
33 KV Poles	Low	No. Assets	1181	5421	350	326	270	7548
	Average	No. Assets	4303	19734	1275	1189	982	27483
	High	No. Assets	0	0	0	0	0	0
	Very High	No. Assets	0	0	0	0	0	0

Table 21 - Asset Health and Criticality 2015

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

Asset Health and Crticality 2023

Asset categories		Units	Estimated Asset Health and Criticality Profile 2023 with Interventions					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2023
33 KV Poles	Low	No. Assets	1043	4922	1093	176	314	7548
	Average	No. Assets	3795	17922	3979	640	1147	27483
	High	No. Assets	0	0	0	0	0	0
	Very High	No. Assets	0	0	0	0	0	0

Table 22 - Asset Health and Criticality 2023

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

HV Poles :

Asset Health and Criticality 2015

Asset categories		Units	Estimated Asset Health and Criticality Profile 2015 with Interventions					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2015
HV Poles	Low	No. Assets	12	103	14	2	4	135
	Average	No. Assets	30344	147825	6695	6814	4848	196,526
	High	No. Assets	3370	13180	604	469	0	17,623
	Very High	No. Assets	14	38	1	6	0	59

Table 23 - Asset Health and Criticality 2015

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

Asset Health and Criticality 2023

Asset categories		Units	Estimated Asset Health and Criticality Profile 2023 with Interventions					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2023
HV Poles	Low	No. Assets	7	81	34	5	8	135
	Average	No. Assets	16643	117840	49495	7489	5059	196,526
	High	No. Assets	1712	10577	4441	664	229	17,623
	Very High	No. Assets	10	29	11	9	0	59

Table 24 - Asset Health and Criticality 2023

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

LV Poles :

Asset Health and Criticality 2015

Asset categories		Units	Estimated Asset Health and Criticality Profile 2015 with Interventions					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2015
LV Poles	Low	No. Assets	0	0	0	0	0	0
	Average	No. Assets	44138	179341	6435	8501	7691	246,106
	High	No. Assets	115	1016	14	62	48	1,255
	Very High	No. Assets	1	0	0	0	1	2

Table 25 - Asset Health and Criticality 2015

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

Asset Health and Criticality 2023

Asset categories		Units	Estimated Asset Health and Criticality Profile 2023 with Interventions					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2023
LV Poles	Low	No. Assets	0	0	0	0	0	0
	Average	No. Assets	37480	151153	47037	6192	4244	246,106
	High	No. Assets	183	771	240	32	29	1,255
	Very High	No. Assets	1	1	0	0	0	2

Table 26 - Asset Health and Criticality 2023

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

Appendix 3 – Fault Data

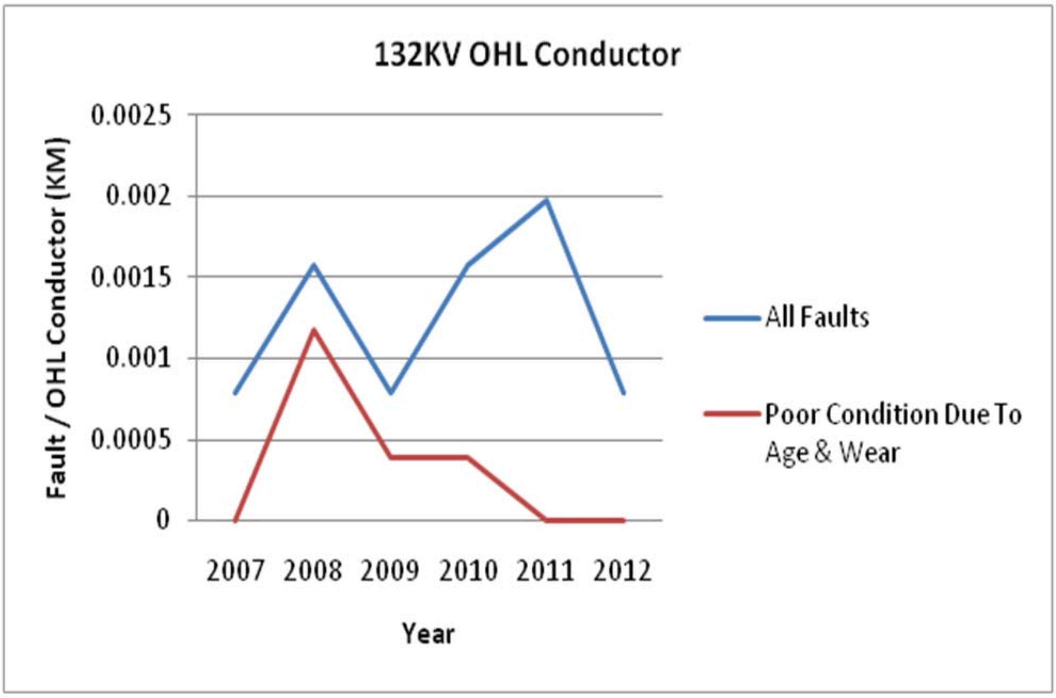


Figure 59 – Fault rate – 132kV OHL Conductor

(Source - UKPN Fault Cube)

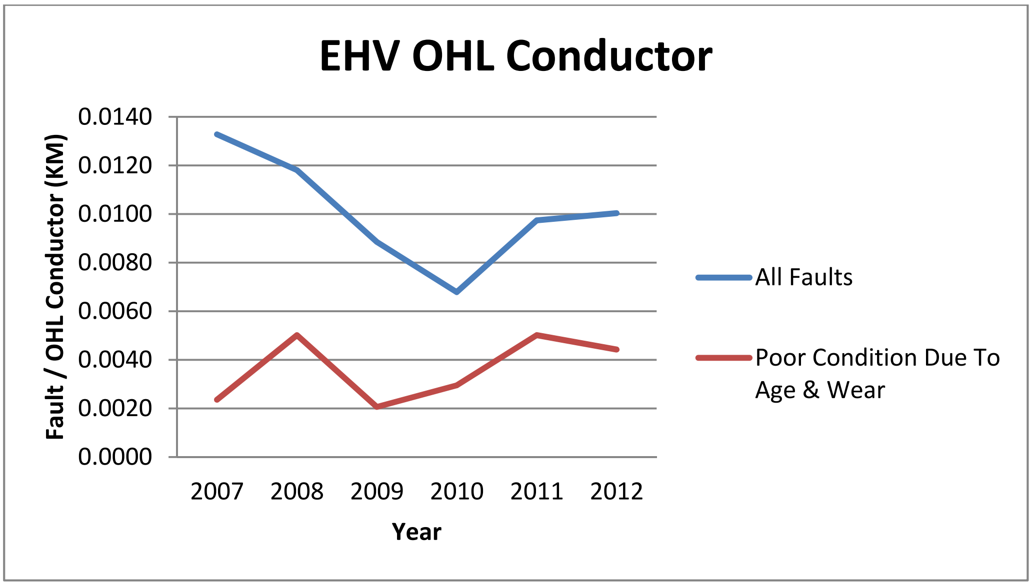


Figure 60 – Fault rate – EHV(33kV) OHL Conductor

(Source - UKPN Fault Cube)

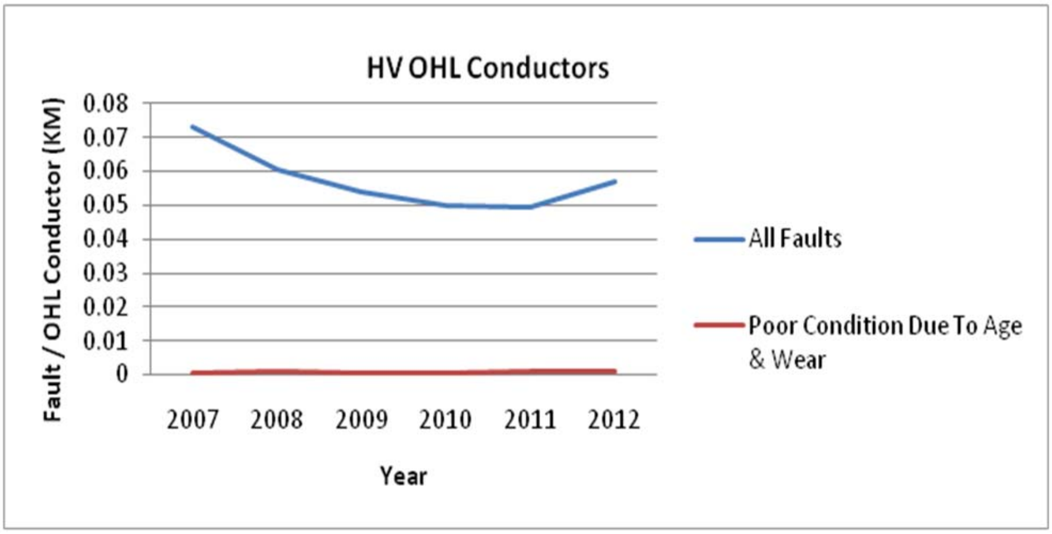


Figure 61 – Fault rate – HV OHL Conductor

(Source - UKPN Fault Cube)

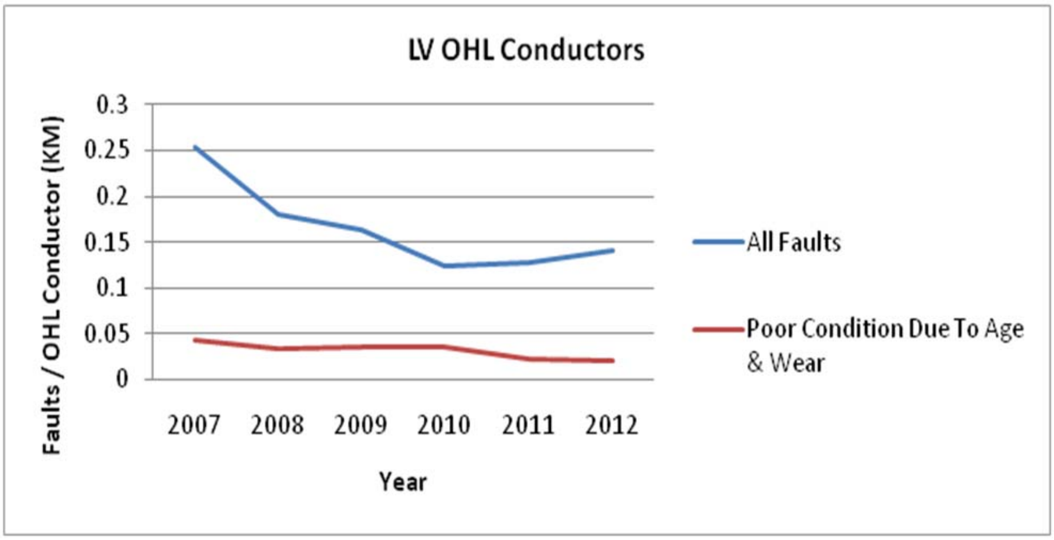


Figure 62 – Fault rate – LV OHL Conductor

(Source - UKPN Fault Cube)

Appendix 4 – WLC and other Case Studies

Not relevant: intentionally left blank

Appendix 5 – NLRE Expenditure Plan

		Sub-category	NAMP line(s)	NAMP description	2015 /2016	2016 /2017	2017 /2018	2018 /2019	2019 /2020	2020 /2021	2021 /2022	2022 /2023
EPN	Wood pole	LV wood pole	1.44.01	Replace LV wood poles ('D' condition)	2659	2659	2659	2659	2659	2659	2659	2659
			1.41	LV overhead line Renewal (including ABC)	2,024	2024	2024	2024	2024	2024	2024	2024
		HV wood pole	1.19.12	Replace HV wood poles	1,736	1,736	1,736	1,736	1,736	1,736	1,736	1,736
			1.32.17	HV OHL Renewal	1420	1420	1420	1420	1420	1420	1420	1420
		HV Conductor Replacement	1.32.19	Replace 0.025 11KV conductor	2914	2914	2914	2914	2914	2914	2914	2914
		33kV wood pole	1.09.04	Replace 33 KV wood poles	389	389	389	389	389	389	389	389
			1.09.01	33kV wood pole OHL Renewal	348	1534	3090	3021	2512	907	1148	1984
			1.09.05	33kV Wood Pole Refurbishment	57	57	57	57	57	57	57	57
		Total (£k)			11,547	12,733	14,289	14,220	13,711	12,106	12,347	13,183

Table 27 - Wood Pole expenditure plan

(Source – 19th February 2014 NAMP Table J Less Indirect)

Intervention Volumes for the OHL Support Poles

LV Poles – Intervention Volumes								
DPCR4	1527	1733	1566	914	1017			
FBBQ	1001	1115	1115	1154	1267			
DPCR5	789	393	2408	2000	1800			
ED1	1788	1788	1788	1788	1788	1788	1788	1788
ED2	1841	1841	1841	1841	1841	1841	1841	1841

Table 28 - Wood Pole forecast replacement volumes LV Poles

HV Poles – Intervention Volumes								
DPCR4	383	506	710	727	752			
FBBQ	728	728	717	641	641			
DPCR5	440	271	616	1023	871			
ED1	1000	1000	1000	1000	1000	1000	1000	1000
ED2	1054	1054	1054	1054	1054	1054	1054	1054

Table 29 - Wood Pole forecast replacement volumes HV Poles

33KV Poles – Intervention Volumes								
DPCR4	68	357	37	45	10			
FBBQ	51	60	60	60	50			
DPCR5	201	13	551	180	137			
ED1	184	184	184	184	184	184	184	184
ED2	181	181	181	181	181	181	181	181

Table 30 - Wood Pole forecast replacement volumes 33kV Poles

(Source – 19th February 2014 NAMP Table O)

Proposed Expenditure for the OHL Support Poles

Proposed Expenditure - LV Poles								
DPCR4	1.8	6.1	3.3	3	1			
FBBQ	1.49	1.66	1.66	1.72	1.89			
DPCR5	1.84	1.20	3.13	2.58	2.56			
ED1	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66
ED2	2.74	2.74	2.74	2.74	2.74	2.74	2.74	2.74

Table 31 - Wood Pole expenditure plan LV Poles

Proposed Expenditure - HV Poles								
DPCR4	0.5	1.5	0.9	3.7	2			
FBBQ	1.27	1.27	1.25	1.12	1.12			
DPCR5	1.50	1.07	1.19	1.51	1.74			
ED1	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74
ED2	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83

Table 32 - Wood Pole expenditure plan HV Poles

Proposed Expenditure – 33KV Poles								
DPCR4	0.16	0.86	0.09	0.11	0.11			
FBBQ	0.11	0.13	0.13	0.13	0.11			
DPCR5	0.69	0.19	1.25	0.29	0.39			
ED1	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
ED2	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38

Table 33 - Wood Pole expenditure plan 33kV Poles

(Source – 19th February 2014 NAMP Table J Less Indirect)

Intervention Volumes for the OHL Conductors

LV OHL Conductor - Intervention Volumes								
DPCR4	675	400	400	400	400			
FBBQ	400	400	400	392	353			
DPCR5	0	0	0.987	3	19			
ED1	150	150	150	150	150	150	150	150
ED2	150	150	150	150	150	150	150	150

Table 34 - Wood Pole forecast replacement volumes LV Conductor

HV OHL Conductor - Intervention Volumes								
DPCR4	153	89	2	17	17			
FBBQ	108.3	108.3	108.3	108.3	108.3			
DPCR5	37	8	21.05	68.72	68.72			
ED1	138	138	138	138	138	138	138	138
ED2	68.72	68.72	68.72	68.72	68.72	68.72	68.72	68.72

Table 35 - Wood Pole forecast replacement volumes HV Conductor

33 KV OHL Conductor - Intervention Volumes								
DPCR4	0	31	0	14.1	84			
FBBQ	21.7	26.5	34.9	10.5	20			
DPCR5	22	0	7	76.3	0			
ED1	0	17	48	59	48	16	15	35
ED2	29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.7

Table 36 - Wood Pole forecast replacement volumes 33kV Conductor

(Source – 19th February 2014 NAMP Table O)

Proposed Expenditure for the OHL Conductor

Proposed Expenditure - LV OHL Conductor								
DPCR4	9.41	5.58	5.58	5.58	5.58			
FBBQ	5.58	5.58	5.58	5.46	4.92			
DPCR5	0.01	0	0.04	0.26	2.05			
ED1	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
ED2	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09

Table 37 - Wood Pole expenditure plan HV Conductor

Proposed Expenditure - HV OHL Conductor								
DPCR4	5.69	3.31	0.07	0.63	5.39			
FBBQ	5.39	5.39	5.39	5.39	5.39			
DPCR5	1.12	1	0.68	3.42	3.42			
ED1	4.34	4.34	4.34	4.34	4.34	4.34	4.34	4.34
ED2	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42

Table 38 - Wood Pole expenditure plan HV Conductor

Proposed Expenditure – 33 KV OHL Conductor								
DPCR4	0.00	2.39	0.00	1.09	4.26			
FBBQ	1.67	2.04	2.69	0.81	1.54			
DPCR5	0.85	0.02	0.63	0.00	0.71			
ED1	0.33	1.44	2.90	2.84	2.36	0.85	1.08	1.72
ED2	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29

Table 39 - Wood Pole expenditure plan 33kV Conductor

(Source – 19th February 2014 NAMP Table J Less Indirect)

Appendix 6 – Sensitivity Analysis

Sensitivity Analysis:

Asset Risk and Prioritisation Model for EPN EHV OHL Support (Poles) (written by Decision Lab)

Introduction

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

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

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

The Asset Risk and Prioritisation Model

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

Sensitivity Analysis

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

Standard average asset lives are used in the ARP model. For wood poles, this is 60 years. This study covered the full population of EPN EHV OHL support (poles).

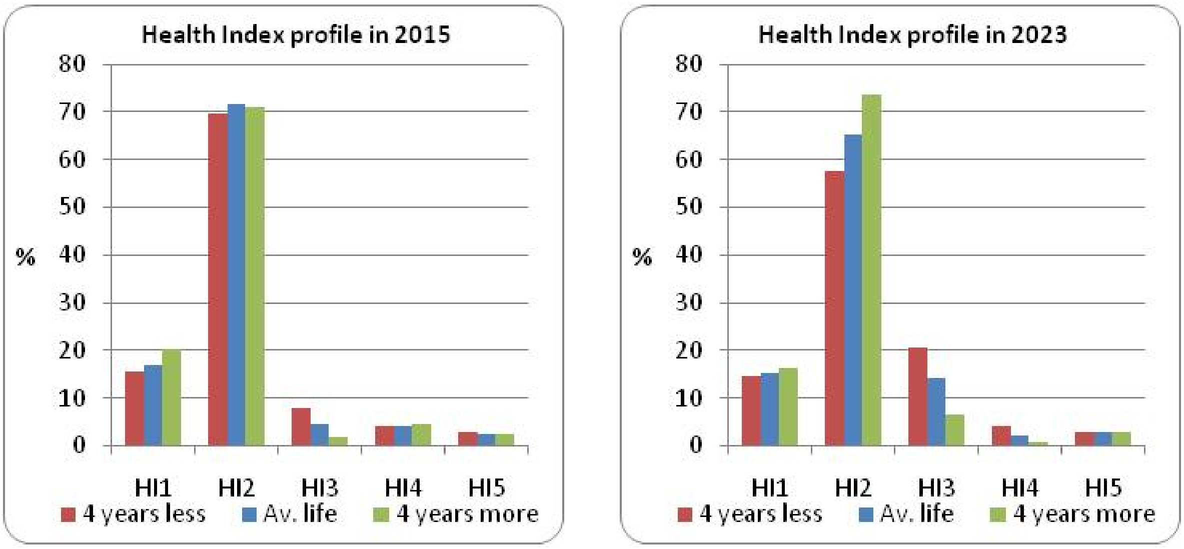
Using 2012 asset data and the replacement plans up to 2023, the ARP model was used to predict the Health Index of each asset at the beginning and end of ED1. This was then repeated, varying each current average asset life by +/- 1, 2 and 4 years.

All results are shown below as the	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	15.7	69.6	7.7	4.1	2.8
-2	15.7	71.6	5.8	4.1	2.8
-1	16.8	70.9	5.4	4.1	2.8
0	16.8	71.7	4.6	4.3	2.6
1	19.0	71.0	3.1	4.3	2.6
2	19.0	71.5	2.6	4.4	2.5
4	20.2	70.9	2.0	4.4	2.5

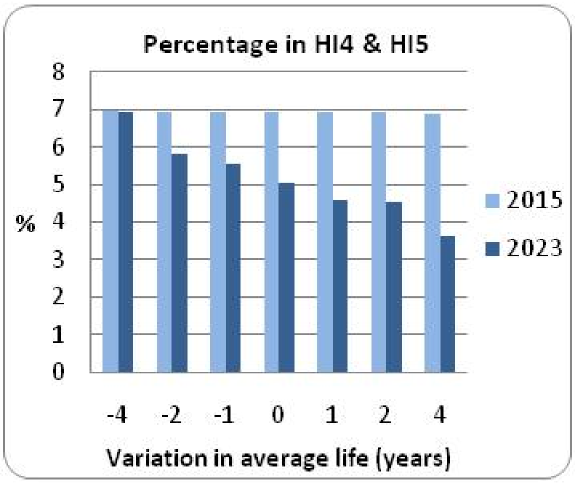
Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	14.7	57.7	20.7	4.1	2.8
-2	15.1	61.3	17.8	3.0	2.8
-1	15.1	63.0	16.3	2.8	2.8
0	15.1	65.4	14.4	2.3	2.7
1	16.0	66.3	13.1	1.8	2.7
2	16.1	68.3	11.1	1.8	2.7
4	16.1	73.6	6.6	0.9	2.7

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

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



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



The results show:

- In 2015, a variation in average life of four years will not affect the proportion of HI4 and HI5 assets, which will remain at 6.9%.
- In 2023, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 5.0% to 3.6%; if four years shorter, it will increase to 6.9%.

Conclusion

The ED1 replacement plan for EPN EHV OHL support (poles) is mildly sensitive to a variation in average asset life of up to four years.

Sensitivity Analysis:

Asset Risk and Prioritisation Model for EPN HV OHL Support (Poles) (Written by Decision Lab)

Introduction

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

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

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

The Asset Risk and Prioritisation Model

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

Sensitivity Analysis

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

Standard average asset lives are used in the ARP model. For wood poles, this is 60 years. This study covered the full population of EPN HV OHL support (poles).

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

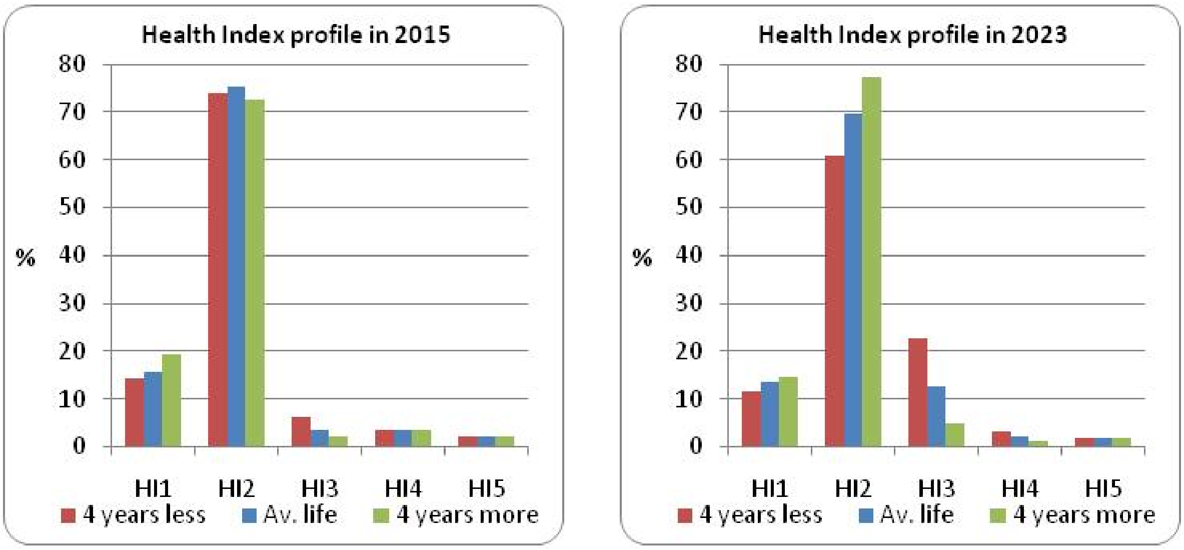
All results are shown below as the percentages of the population.

Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	14.2	73.9	6.1	3.4	2.3
-2	14.2	75.4	4.6	3.4	2.3
-1	15.7	74.5	4.1	3.4	2.3
0	15.7	75.2	3.4	3.4	2.3
1	17.4	74.0	2.9	3.4	2.2
2	17.4	74.3	2.6	3.4	2.2
4	19.2	72.8	2.3	3.4	2.2

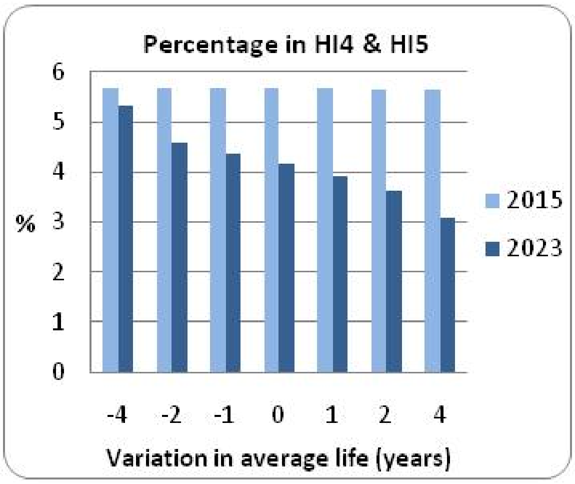
Average life change	2023 percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	11.4	60.8	22.5	3.3	2.0
-2	13.6	64.8	17.0	2.6	2.0
-1	13.6	67.1	14.9	2.4	1.9
0	13.6	69.5	12.7	2.2	1.9
1	14.1	71.5	10.5	2.0	1.9
2	14.1	73.5	8.8	1.7	1.9
4	14.7	77.5	4.8	1.2	1.9

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

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



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



The results show:

- A variation in average asset life will affect the proportion of HI4 and HI5 assets in 2023 and possibly also in 2015.
- In 2015, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 5.7% to 5.6%; if four years shorter, it will remain at 5.7%.
- In 2023, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 4.1% to 3.1%; if four years shorter, it will increase to 5.3%.

Conclusion

The ED1 replacement plan for EPN HV OHL support (poles) is mildly sensitive to a variation in average asset life of up to four years.

Sensitivity Analysis:

Asset Risk and Prioritisation Model for EPN LV OHL Support (Poles) (written by Decision Lab)

Introduction

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

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

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

The Asset Risk and Prioritisation Model

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

Sensitivity Analysis

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

Standard average asset lives are used in the ARP model. For wood poles, this is 60 years. This study covered the full population of EPN LV OHL support (poles).

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

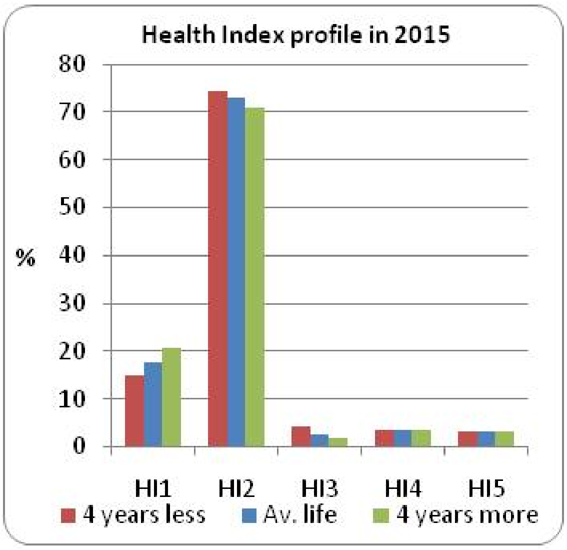
All results are shown below as the percentages of the population.

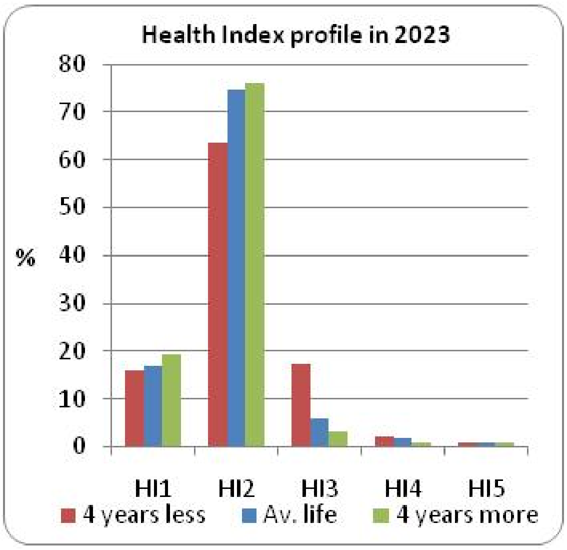
Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	14.8	74.3	4.3	3.4	3.1
-2	16.5	73.7	3.2	3.4	3.1
-1	17.8	72.8	2.9	3.4	3.1
0	17.8	73.1	2.6	3.4	3.1
1	19.3	71.8	2.3	3.4	3.1
2	19.3	72.0	2.2	3.5	3.1
4	20.6	71.1	1.8	3.5	3.0

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	16.0	63.6	17.3	2.3	0.8
-2	16.4	67.7	13.1	2.0	0.8
-1	17.0	69.4	10.9	1.8	0.8
0	17.0	74.6	5.8	1.7	0.8
1	18.0	75.5	4.2	1.5	0.8
2	18.0	76.2	3.8	1.2	0.8
4	19.2	75.9	3.3	0.8	0.8

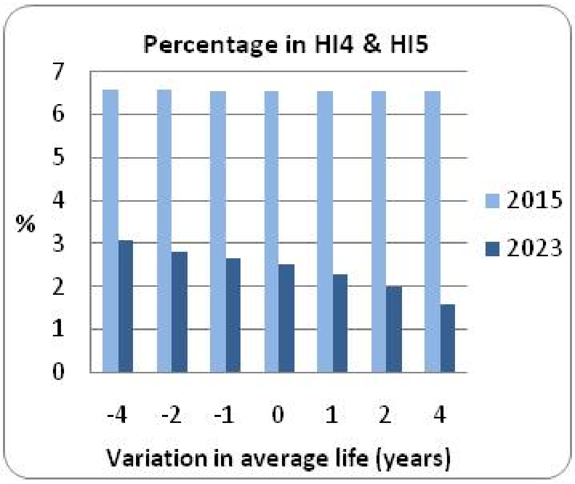
As the percentages above are rounded, the sum of a row may be 0.2% above or below 100%.

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





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



The results show:

- A variation in average asset life will affect the proportions of HI4 and HI5 assets in 2023, but not in 2015.
- In 2023, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 2.5% to 1.6%; if four years shorter, it will increase to 3.1%.

Conclusion

The ED1 replacement plan for EPN LV OHL support (poles) is mildly sensitive to a variation in average asset life of up to four years.

Appendix 7 – Named Schemes

The following tables show the planned replacement/refurbishment projects for ED1 and their main driver(s) for intervention.

33kV OHL Replacements			
Route	Asset	Replacement driver	Scheme Paper
Tilbury/Shell/Coryton	33kV OHL Conductor	Asset Health	No
Braintree Grid/Coggeshall	33kV OHL Conductor	Asset Health	No
Braintree Grid/Witham	33kV OHL Conductor	Asset Health	No
Diss/Kenninghall	33kV OHL Conductor	Asset Health	Yes
Stow/Debenham	33kV OHL Conductor	Asset Health	No
Stow/Manor Rd	33kV OHL Conductor	Asset Health	No
Wickham Market/Melton Tee	33kV OHL Conductor	Asset Health	No
Wymondham/Dereham	33kV OHL Conductor	Asset Health	No
Brimsdown/Cuffley No.2	33kV OHL Conductor	Asset Health	No
Fleethall - Burnham P1 - P49	33kV OHL Conductor	Asset Health	No
Letchworth Grid/North Hitchin	33kV OHL Conductor	Asset Health	No
Hatfield Grid/Welwyn Tunnel No.4	33kV OHL Conductor	Asset Health	No
Swaffham Grid Local T2 - Hempton Grid	33kV OHL Conductor	Asset Health	No
Hatfield Grid/West Potters Bar	33kV OHL Conductor	Asset Health	No
South Chelmsford	33kV OHL Conductor	Asset Health	No
Tilbury Compact Grid/Mucking Generator/Shell Grid	33kV OHL Conductor	Asset Health	No
Aylesbury East Waddesdon/Buckinghamshire Rd 1	33kV OHL Conductor	Asset Health	No
Wymondley Grid/North Hitchin	33kV OHL Conductor	Asset Health	No
BishopsStortfordGrid/Thorley MuchHadham	33kV OHL Conductor	Asset Health	No

Rye House Grid/North Harlow	33kV OHL Conductor	Asset Health	No
(P23-P149) and (P10-P23) Braintree Local/Dunmow	33kV OHL Conductor	Asset Health	No
Bishops Stortford Grid (Thorley)/North Harlow	33kV OHL Conductor	Asset Health	No
Rye House Grid (Ware) / Much Hadham	33kV OHL Conductor	Asset Health	No
Braintree Grid/Lake&Elliot	33kV OHL Conductor	Asset Health	No
Bata / Leemans	33kV OHL Conductor	Asset Health	No
Rye House to Turnford 3 and The Cross 3	33kV OHL Conductor	Asset Health	No

Table 40 – Named Schemes *(Source – 19th February 2014 NAMP Table J Less Indirect)*

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

	VOLUMES																				
Outputs	**Asset Stewardship reports**										**RIG Table**										
	NAMP Line	2015/6	2016/7	2017/8	2018/9	2019/20	2020/21	2021/22	2022/23	**Total**	RIG Table	RIG Row	2015/6	2016/7	2017/8	2018/9	2019/20	2020/21	2021/22	2022/23	**Total**
Wood Pole Replacement																					
LV Wood Pole	1.44.01	1,788	1,788	1,788	1,788	1,788	1,788	1,788	1,788	**14,304**	CV3	8	1,788	1,788	1,788	1,788	1,788	1,788	1,788	1,788	**14,304**
HV Wood Pole	1.19.12	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	**8,000**	CV3	27	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	**8,000**
33kV Wood Pole	1.09.04	184	184	184	184	184	184	184	184	**1,472**	CV3	53	184	184	184	184	184	184	184	184	**1,472**
Conductor Replacement																					
LV Overhead Line Renewal	1.41.03	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	**1,200.0**	CV3	6	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	**1,200.0**
HV Conductor Renewal	1.32.13	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	**640.0**	CV3	23	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	**640.0**
HV Conductor (0.025)	1.32.19	68.7	68.7	68.7	68.7	68.7	68.7	68.7	68.7	**549.8**	CV3	24	68.7	68.7	68.7	68.7	68.7	68.7	68.7	68.7	**549.8**
33kV Overhead Renewals	1.09.01	0.0	17.0	48.0	59.0	48.0	16.0	15.0	35.0	**238.0**	CV3	52	0.0	17.0	48.0	59.0	48.0	16.0	15.0	35.0	**238.0**
Wood Pole Refurbishment																					
33kV Refurbishment	1.09.05	355.0	355.0	355.0	355.0	355.0	354.0	354.0	354.0	**2,837**	CV5	28	355.0	355.0	355.0	355.0	355.0	354.0	354.0	354.0	**2,837**
Total		**3,625.72**	**3,642.72**	**3,673.72**	**3,684.72**	**3,673.72**	**3,640.72**	**3,639.72**	**3,659.72**	**29,240.76**			**3,625.72**	**3,642.72**	**3,673.72**	**3,684.72**	**3,673.72**	**3,640.72**	**3,639.72**	**3,659.72**	**29,240.76**

[Source: 19th February 2014 Namp Table O/21st February 2014 ED1 RIGs]

Appendix 9 – Efficiency benchmarking with other DNO’s

The investment plan has been developed in accordance with this strategy and by making use of the Asset Risk and Prioritisation (ARP) model to assess all asset data available in order to determine asset health, criticality and consequence of failure. This has enabled the construction of a well-justified plan based on detailed knowledge of individual assets rather than age or statistical modelling approaches.

The investment strategy for wood poles at all voltages is that they should have the same Health Index references of HI4 or HI5 at the end of ED1 as they do at the start.

Any new pole installed on the network should have a ‘pole saver’ fitted that will extend the life of a wooden pole; this strategy is referred to in section 6.3.

Further intervention, such as boron rods, which can delay or defer a replacement on suitable poles, will be installed throughout ED1; this strategy is referred to in section 6.1.

Benchmarking

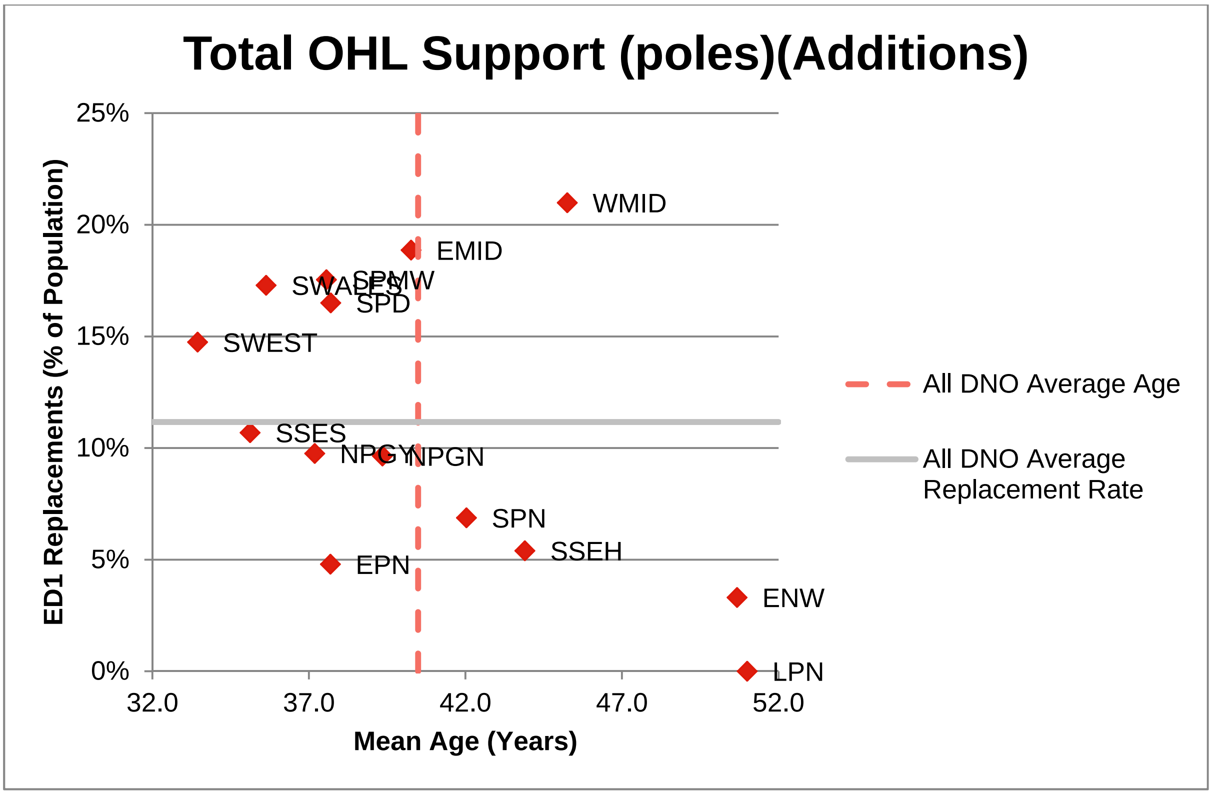


Figure 63 - Levels of proposed asset replacement in ED1 as a percentage of installed network

The graph shows that EPN’s proposed % replacement volumes are the one of the lowest in the industry.

Appendix 10 – Material changes since the July 2013 ED1 submission

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

Asset type	Action	Change type	2013 Submission	2014 Submission	Difference	Comment
6.6/11kV Poles (EPN) CV3	Replace	Volume km (Conventional Conductor) Row 23	549.76	640	+90.24	CV5 to CV3 change equates to adding 640km conductor to CV3. 549.76km in 2013 moved to CV3 24
		UCI (£k)	49.8	22	-27.8	UCI reduced as poles replaced will be on the D pole line CV3 27
		Investment (£m) Row 23	27.4	14.1	-13.3	-
	Replace	Volume km (BLX Conductor) Row 24	0	549.76	+549.76	Movement of +549.76km from CV3 23 to CV3 24
		UCI (£k)	0	37.4	-	Cost/Volumes moved from CV3 23 and UCI reduced to correct costs. Higher than normal as BLX (Covered Conductor costs more per km)
		Investment (£m) Row 24	0	20.6	+20.6	-
	TOTAL	**Investment Row 23 and 24 (£m)**	**27.4**	**34.7**	**+7.3**	**-**

Table 41 – Material Changes to July ED1 Submission (CV3)

[Source: Final EPN Business Plan Data Tables following the OFGEM Question and Answer Process / 21st February 2014 ED1 Business Plan Data Tables]

Asset type	Action	Change type	2013 Submission	2014 Resubmission	Difference	Comment
6.6/11kV Poles (EPN) V4a	Replace	Volume (Poles)	376	6562	+6,186	+5,498 Poles have been moved from CV3 however only cost were present in 2013 submission. Costs for these poles are associated to the project mapping to CV3 row 24.
		UCI (£k)	N/A	N/A	N/A	No costs in V4a

Table 42 – Material Changes to July ED1 Submission (V4a)

[Source: Final EPN Business Plan Data Tables following the OFGEM Question and Answer Process / 21st February 2014 ED1 Business Plan Data Tables]

Poles

Asset replacement of HV OHL was incorrectly mapped to CV5 (OHL refurbishment). It has been moved to CV3 23 (Conventional conductor replacement) and CV3 27 (pole replacement). In monetary terms this means there was a movement of £19.08m out of CV5, the UCI was reduced and moved into CV3. The number of poles being replaced overall has increased but only in V4a increasing the number of HV pole replacements over ED1.

Overall there was a net increase to CV3 costs of £7.3m and net increase of HV OHL conductor of 640km.