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

Asset Stewardship Report 2014

Robert Lafferty

Approved By Richard Wakelen / Barry Hatton

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Document History

Version	Date	Details	Originator	Revision Class	Section Update
1.0	19/02/2014	Original Submission	N/A	N/A	N/A
1.1	19/02/2014	NAMP cost updates to Table 1, 2 and associated paragraphs. Tables Updated Appendix 5 updated	Robert Lafferty	Minor	Section 1 and 2, Appendix 5
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1.5	24/02/2014	Updated Appendix 5, HV Conductor Volumes, 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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					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
1.11	26/02/14	Updated as per Gold Check List v10, Table and Figure numbers checked and added to Appendices	Robert Lafferty	Minor	Appendix 8 header,
1.12	03/03/14	Appendix 11 moved to section 3 and commentary added. Appendix 12 removed, duplication of table 11. Added paragraph to bottom of section 1.3	Robert Lafferty	Minor	Appendix 11, 12 removed. Added to section 1.3
2.0	05/03/14	Approved by Barry Hatton	Robert Lafferty	Minor	Page 14 and Page 55

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 SPN Wood Poles and Conductors

1.1 Scope

This document details UK Power Networks' non-load replacement 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 107 poles on the 132kV network with an estimated Modern Equivalent Asset Value (MEAV) of £0.3m, and 10km of conductor with an estimated MEAV of £0.6m.

There are 11,751 poles on the 33kV network with an estimated MEAV of £28.4m, and 1,146km of conductor with an estimated MEAV of £37m. The proposed investment is £7m for the ED1 period, which equates to 10.7% of the MEAV for this asset category.

There are 68,022 poles on the HV network with an estimated MEAV of £118.1m and 5,553km of conductor with an estimated MEAV of £140.3m. The proposed investment is £40.5m for the ED1 period, which equates to 15.6% of the MEAV for this asset category.

There are 126,175 poles on the LV network with an estimated MEAV of £179.1, and 4,543km of conductor with an estimated MEAV of £61.6m. The proposed investment is £23.4m for the ED1 period, which equates to 10.1% of the MEAV for this asset category.

Table 1 shows there is no investment for 132kV wood poles planned 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	£12.6m	1.44.01	Additions CV3 Row 8 – LV poles Removals CV3 Row 136 – LV poles
	HV wood pole replacement	£7.6m	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	£2.1m	1.09.04	Additions CV3 Row 53 – 33kV Pole Removals CV3 Row 181– 33kV Pole
Conductor replacement	LV overhead line Renewal	£10.8m	1.41.03	Additions CV3 Row 6 – LV main (OHL) conductor Removals CV3 Row 134 – LV main (OHL) conductor
	HV conductor replacement	£32.9m	1.32.19 1.32.13	Additions CV3 Row 23, 24 – HV OHL conductor Removals CV3 Row 151 - HV OHL conductor
	33kV overhead Renewal	£4.5m	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
	33kV Overhead Refurbishment	£0.4m	1.09.05	CV5 Row 28 – Refurbishment

				33kv Pole

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

The investment strategy for wood poles at all voltages is that the number of HI4 and HI5 assets will be the same at the end of ED1 as it was 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 strategy. This is referred to in section 6.3.

Further intervention, such as boron rods, that 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.

1.2 ED1 Proposals

The proposed investment level for the replacement of LV, HV and 33kV wood poles and conductors in SPN is £71m, 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 33kV and LV poles as detailed in the 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
SPN	Wood pole	LV wood pole	1.44.01	Replace LV wood poles ('D' condition)	1,577	1,577	1,577	1,577	1,577	1,577	1,577	1,577
			1.41.03	LV overhead line refurbishment (including ABC)	1,356	1,356	1,356	1,356	1,356	1,356	1,356	1,356
		HV wood pole	1.19.12	Replace HV wood poles	946	946	946	946	946	946	946	946
			1.32.17	HV OHL Renewal	1201	1201	1201	1201	1201	1201	1201	1201
		HV OHL conductor	1.32.19	Replace 0.025 11KV conductor	2,915	2,915	2,915	2,915	2,915	2,915	2,915	2,915
		33kV wood pole	1.09.04	Replace 33kV wood poles	230	230	230	230	230	230	230	230
			1.09.01	33kV wood pole OHL Renewal	760	1692	154	360	291	466	817	193
			1.09.05	33kV Wood Pole Refurbishment	54	54	54	54	54	54	54	54
		Total (£k)			9,039	9,971	8,433	8,639	8,570	8,745	9,096	8,472

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 **7%** 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.

1.3 Innovation

Innovative ideas planned for introduction are:

- 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 or damage has been found to a certain part of the pole at base level.

- Boron rods – Solid rods of high-strength boron 173 that protect wooden poles that are constantly or occasionally damp.

1.4 Risks and Opportunities

	Description of similarly likely opportunities or risks arising in ED1 period	Uncertainties
Opportunity	Pole support system for woodpecker attack 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	Micro-bore pressure sensing drill in trial advised that 70% of 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. There is much more analysis required before re-categorisation can be realised to the level anticipated.

Table 3 – Risks and opportunities arising in ED1

2.0 Description of Wood Poles and Conductors

2.1 132kV Wood Poles and Conductors

There are 107 poles on the 132kV network and approximately 10km of conductor. The OHL conductor on this circuit is 175mm² Aluminium Conductor Steel Reinforced (ACSR).

There is one 132kV circuit, which was constructed in 1984 (SPN Hub 2 Sussex Coast). The conductor age is the same as the poles.

There are no plans to refurbish or replace this OHL, because the circuit is in 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.

2.2 33kV Wood Poles and Conductors

There are 11,751 poles on the 33kV network and approximately 1,146km of conductor. The majority of OHL conductors at this voltage are copper.

It can be seen from the age profile in Figure 1 that there was significant investment in the 1950s and 1960s, resulting in an ageing wood pole asset; the average age is approximately 45 years.

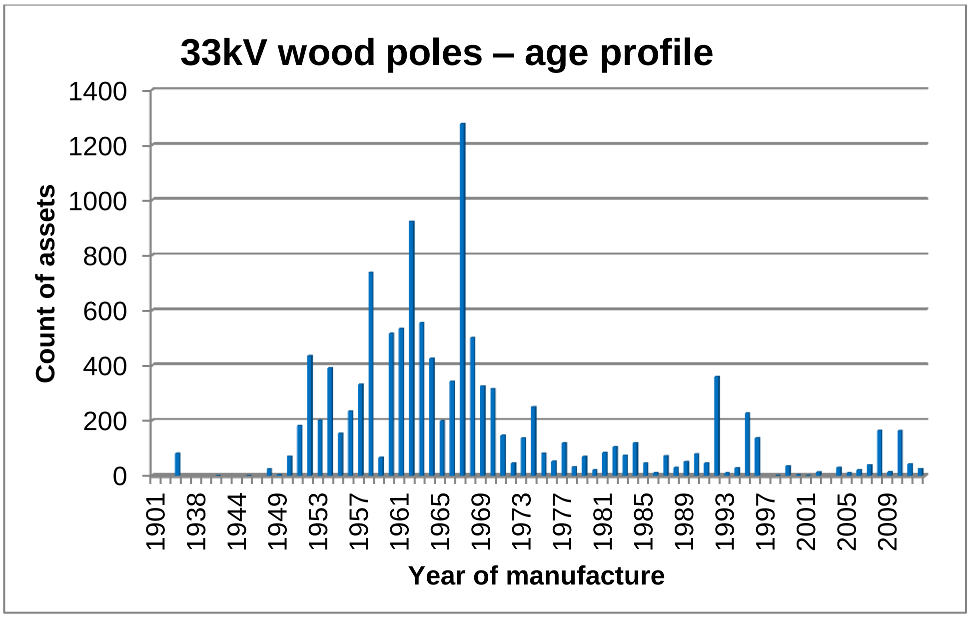

Figure 1 – Age profile of 33kV wood poles

(Source – RIGS 2012 CV3 Table V5)

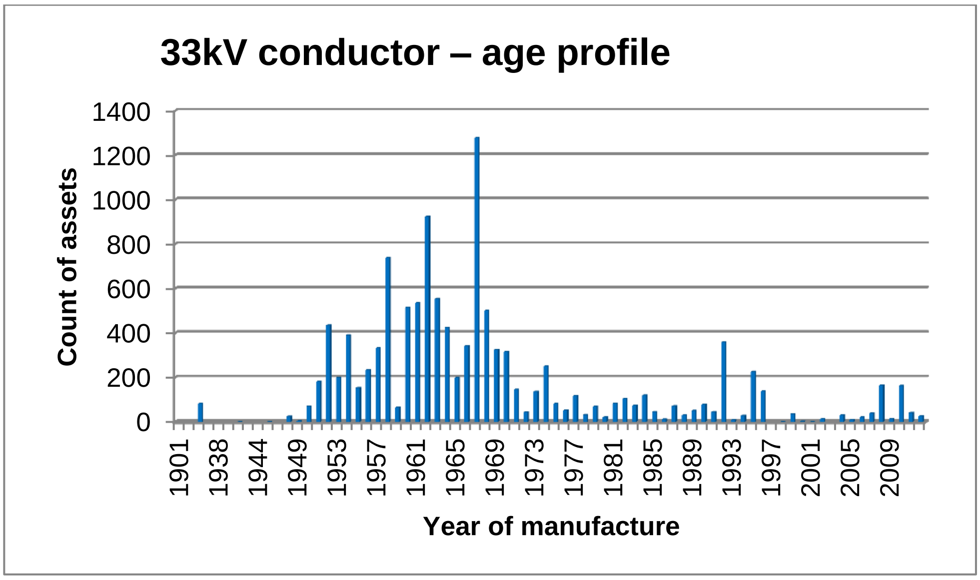

Figure 2 – Age profile of 33kV conductors

(Source – RIGS 2012 CV3 Table V5)

Ref NAMP Line: 1.09.01, 1.09.04 and 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.HV Wood Poles and Conductors

There are 68,022 poles on the HV network and approximately 5,553km of conductor. The majority of OHL conductors at this voltage are copper.

It can be seen from the age profile in Figure 3 that there was significant investment in the 1950s and 1960s and then again in the late 1970s, resulting in an ageing wood pole asset; the average age is approximately 42 years.

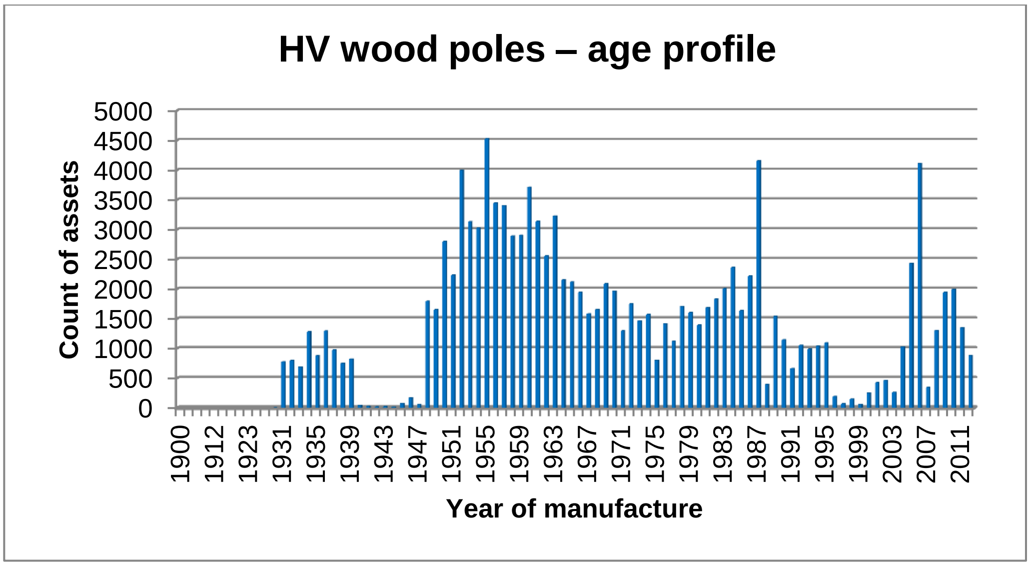

Figure 3 – Age profile for HV wood poles

(Source – RIGS 2012 CV3 Table V5)

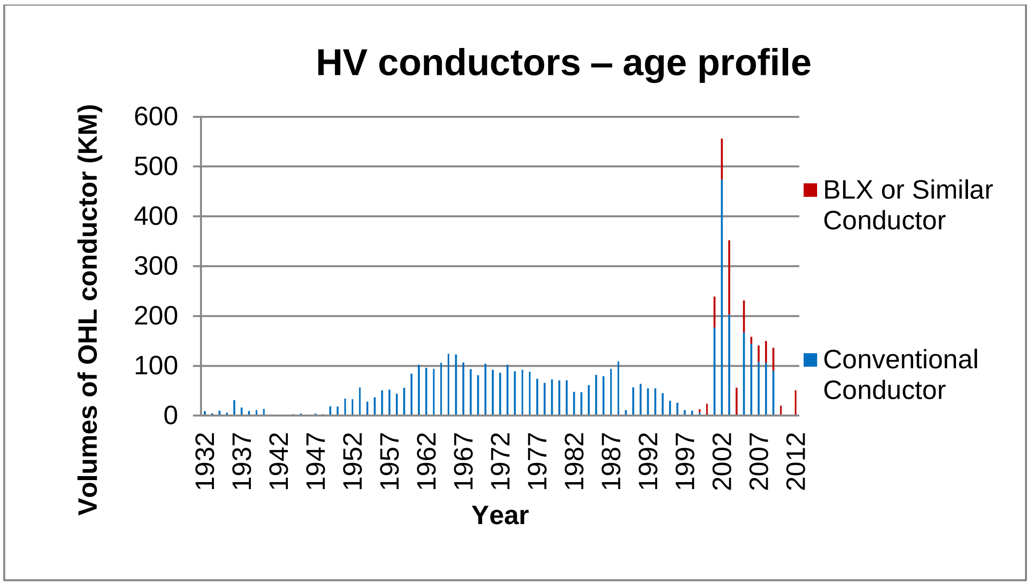

Figure 4 – Age profile for HV conductors

(Source – RIGS 2012 CV3 Table V5)

Ref NAMP Lines: 1.19.12, 1.32.13 and 1.32.19

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

2.3 LV Wood Poles and Conductors

There are 126,175 poles on the LV network and approximately 4,543km of conductor.

It can be seen from the age profile in Figure 5 that there was significant investment in the 1950s and 1960s, resulting in an ageing wood pole asset; the average age is approximately 42 years.

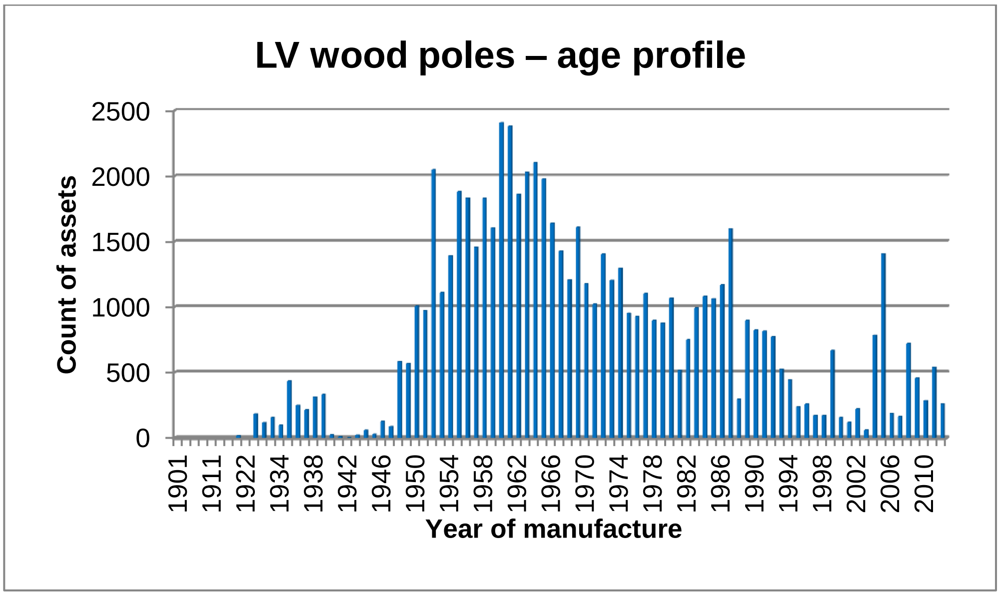

Figure 5 – Age profile for LV wood poles

(Source – RIGS 2012 CV3 Table V5)

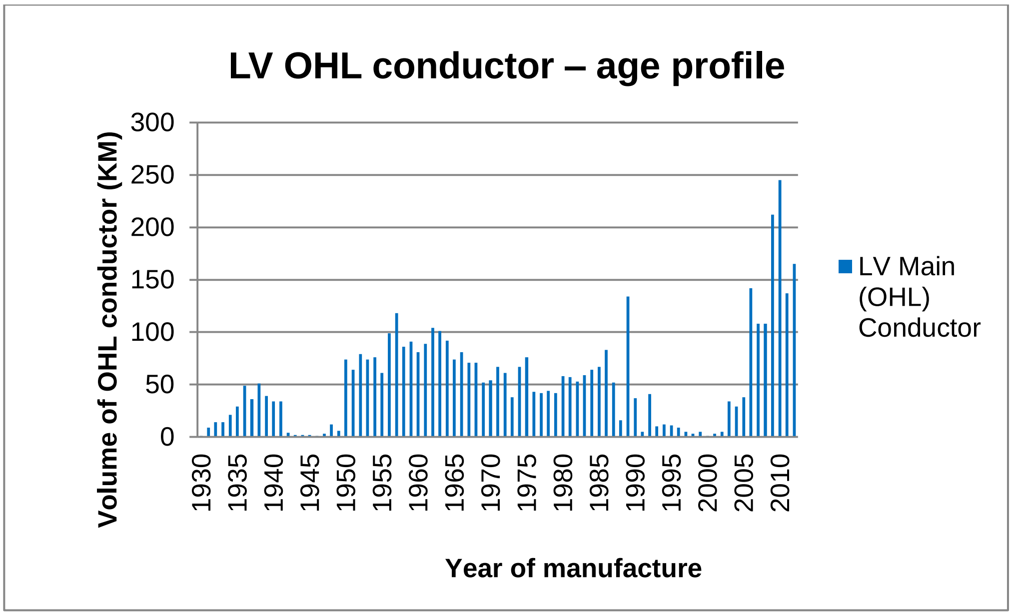

Figure 6 – Age profile for LV conductors on wood poles

(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 Continuity (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 Continuity Regulations 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 assessment of a wood pole overhead line's condition is based on a number of condition-assessment measures and defects, collected during routine inspections. ESQCR compliance condition / defects , 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 is 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, PURL tests, auger tests and the resistograph, which are used to 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; climbable tree; condition of anti-climbing device

Table 4 – Condition measures and defects

Condition Ratings (CR) 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 model and are defined in EMS-10-0001, *Maintenance and Inspection Overview*. 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 7 – Woodpecker damage

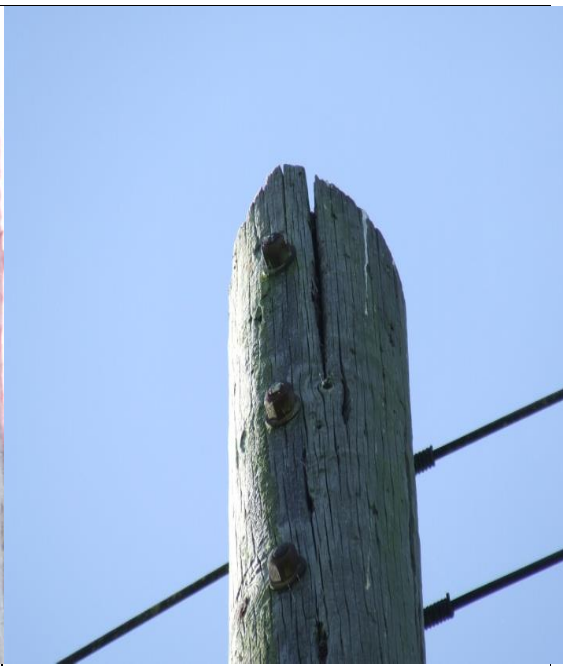

Figure 8 – Pole top rotting

Figure 9 – Pole base rotting

Figure 10 – Conductor damage

Woodpecker damage – The damage caused by woodpeckers on wooden poles affects the maximum loading of the pole at the point of woodpecker attack. By considering the geometry of the entry hole and nesting hole, it is possible to establish the minimum height from ground level where the holes have no effect on 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, if a light pole has a nesting cavity greater than 110mm diameter, the pole shall be changed; for a medium pole, it's 130mm; and for a stout pole it's 150mm. So 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 and rain coupled with 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, with the only evidence of attack, if any, being a slight or marked colour change from the normal. This is known as the 'incipient' or 'initial' stage. In some cases, there is no indication of incipient decay, hyphae (fungus) 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, in which the strength of the wood is so reduced that it can be crumbled between the fingers or easily broken (refer to Figure 9).

Fungi require oxygen, moisture and a substrate to feed on. It tends to be 'light-shy', 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
- Degradation of steel wires
- Sulphur corrosion of aluminium strands
- Falling trees
- Fatigue on high tower lines
- Small section conductors
- Lightning.

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 11, 12 and 13 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)

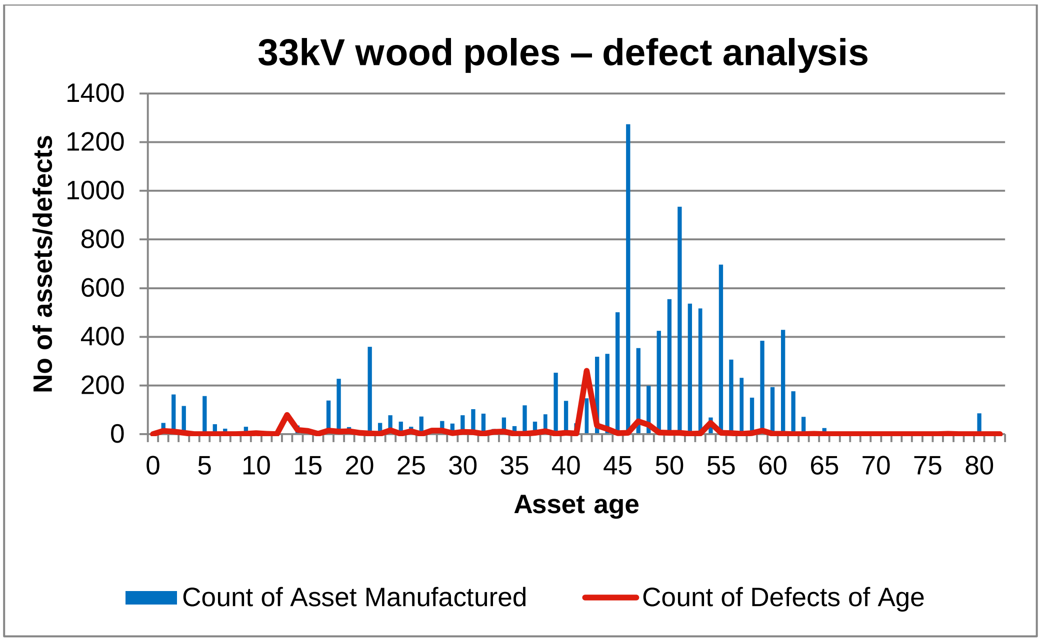

Figure 11 - Correlation between Defects and Asset Age

Two observations can be made from Figure 11;

1. The number of defects is low in the 33kV population due to the high importance of maintaing 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.

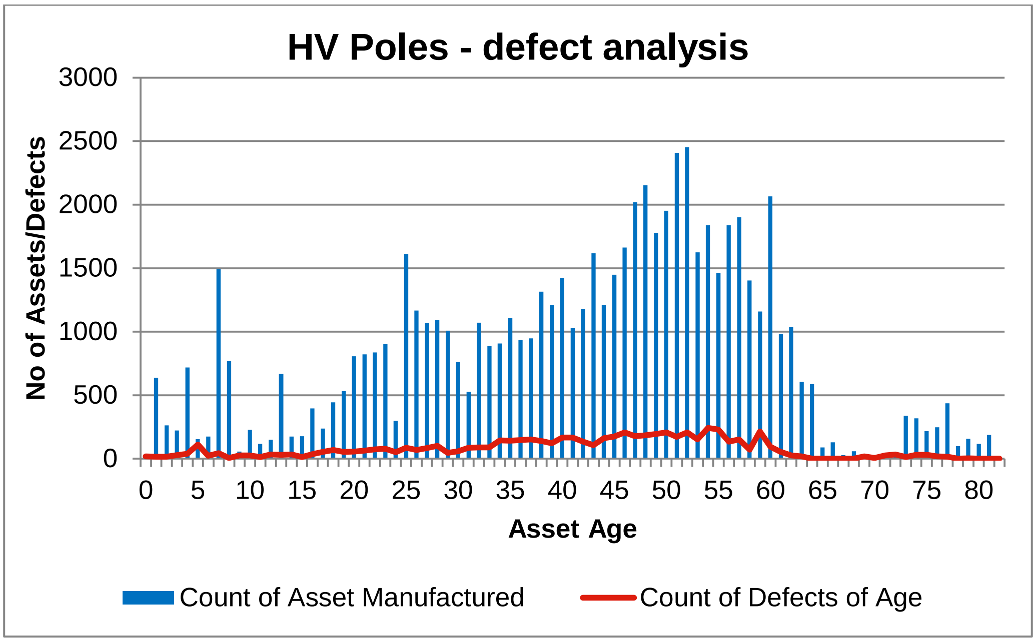

Figure 12 - Correlation between Defects and Asset Age

Three observations can be made from Figure 12;

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 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/reduced.

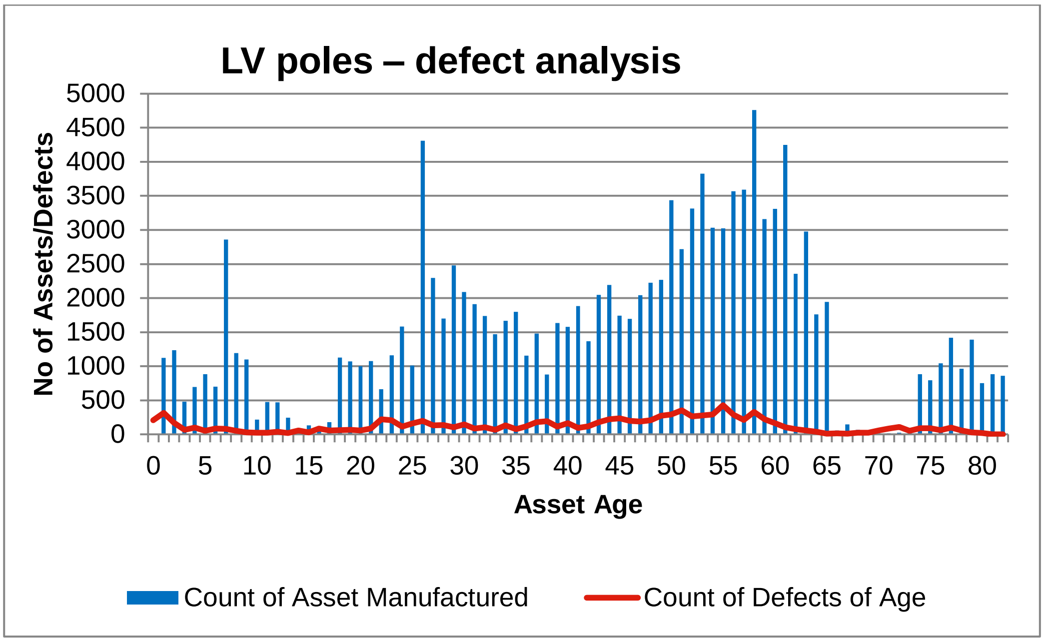

Figure 13 - Correlation between Defects and Asset Age

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 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 LV, HV and 33kV wood pole health indices against the age is shown in Figures 14, 15 and 16. These indicate the percentage of assets with HI4 and HI5 indices.

The trend shows the greatest number of assets (HI4 and HI5) is within the age band 61–80 for the HV poles, as the poles and associated conductors are replaced by 70 years . For LV poles, the trend is rising with the most HI4s and HI5s in the age band 61–90. For the 33kV poles, the trend appears to have the same % of HI 4 & HI5 under the age band 41- 60 and no assets with the age band 70-90.

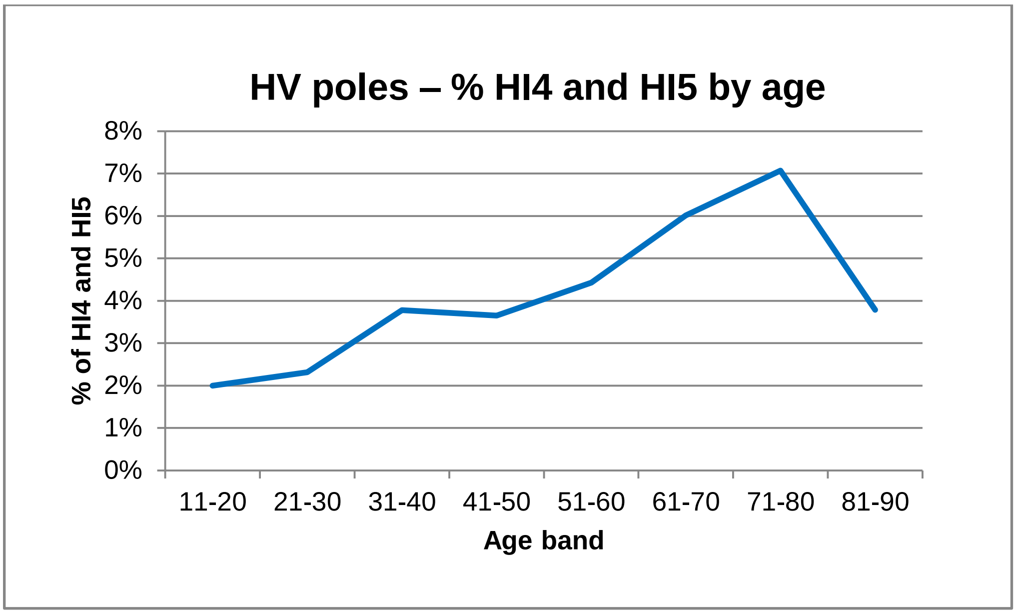

Figure 14 – HI profile of HV poles by age

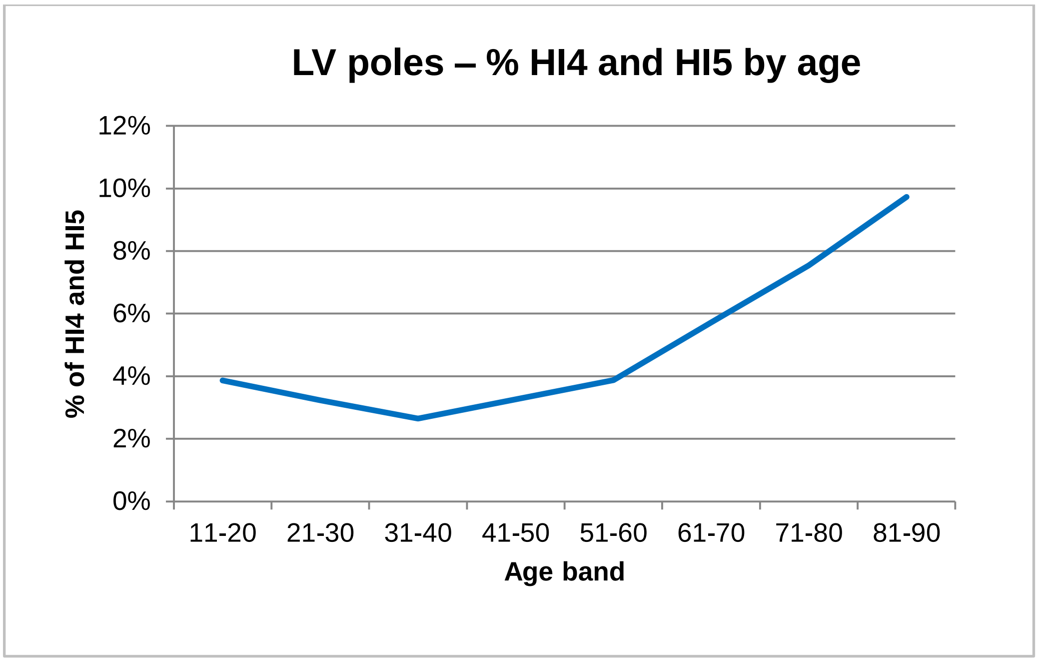

Figure 15 – HI profile of LV poles by age

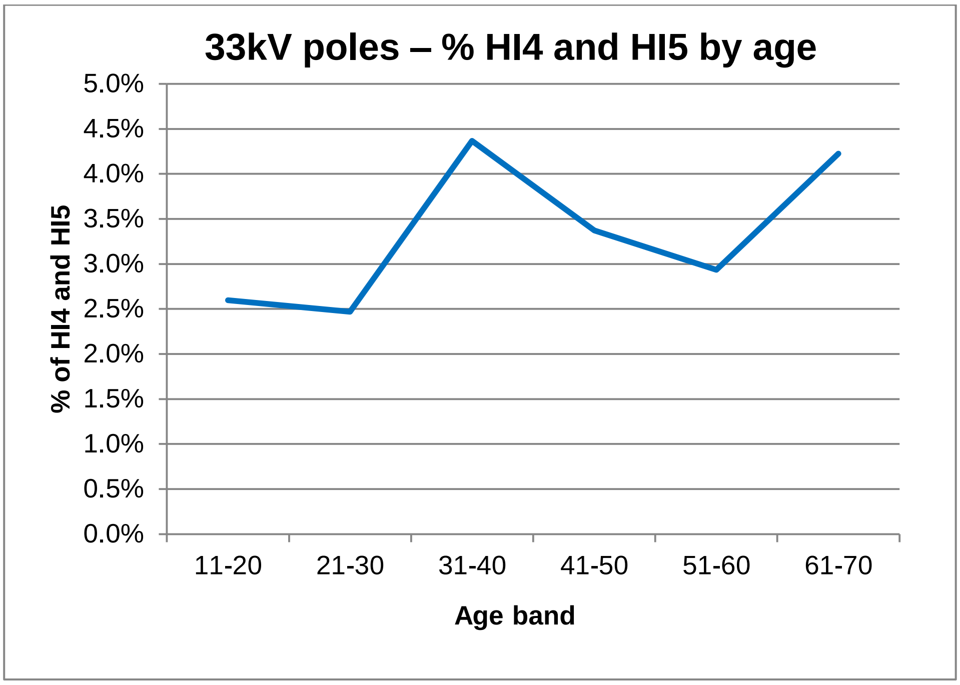

Figure 16 – HI profile of 33kV poles by age

3.2.5 Fault Rate

The five-year fault rate trends for 132kV, 33kV, HV and LV OHL conductors are shown in Figures 17, 18, 19 and 20. 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, weather.

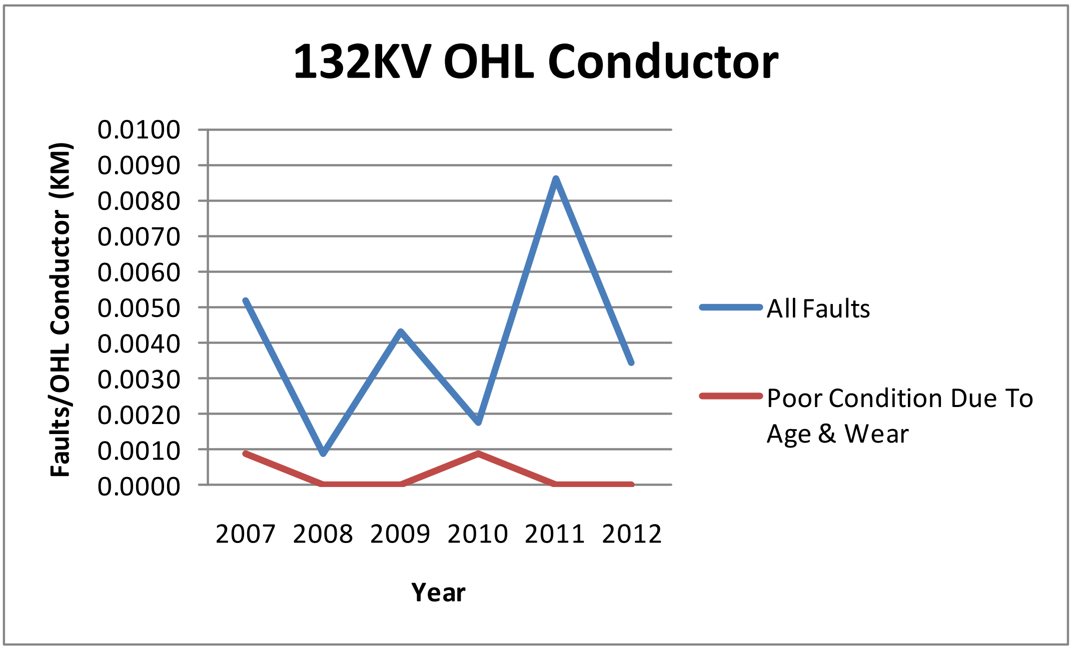

Figure 17 – 132kV OHL conductor fault rate

(Source - UKPN Fault Cube)

The fault trend appears to be rising over the whole time period for 132kV OHL conductor. A further breakdown of fault causes shows that a small proportion of these faults are due to poor condition (age or wear), there is a single fault in 2010, which is related specifically to the condition.

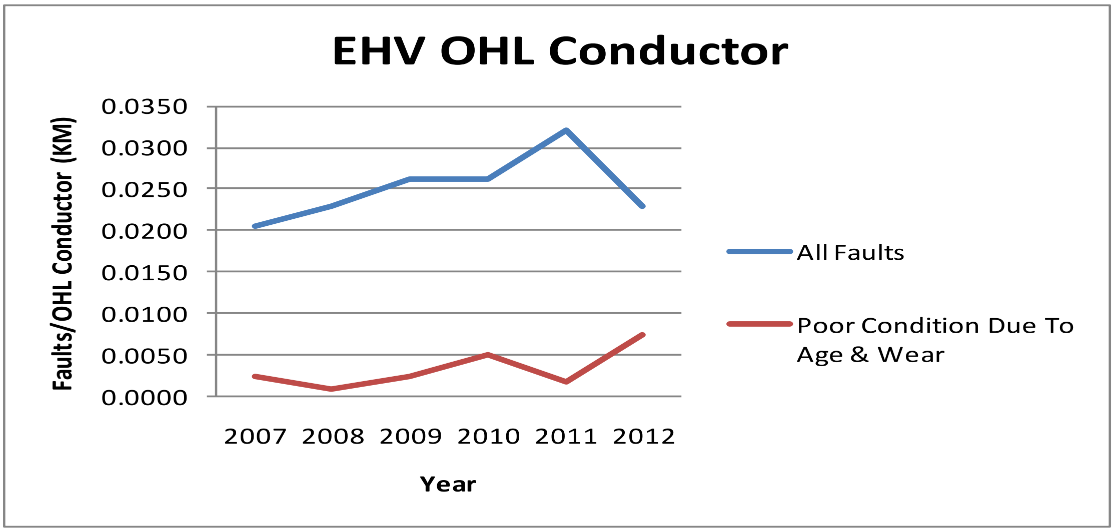

Figure 18 – EHV OHL conductor fault rate

(Source - UKPN Fault Cube)

The fault trend appears to be rising for 33kV pole conductors. A further breakdown of fault causes shows that significant numbers of faults are due to poor condition (age or wear) and, furthermore, there is a peak increase in faults in 2011 specifically related to the condition.

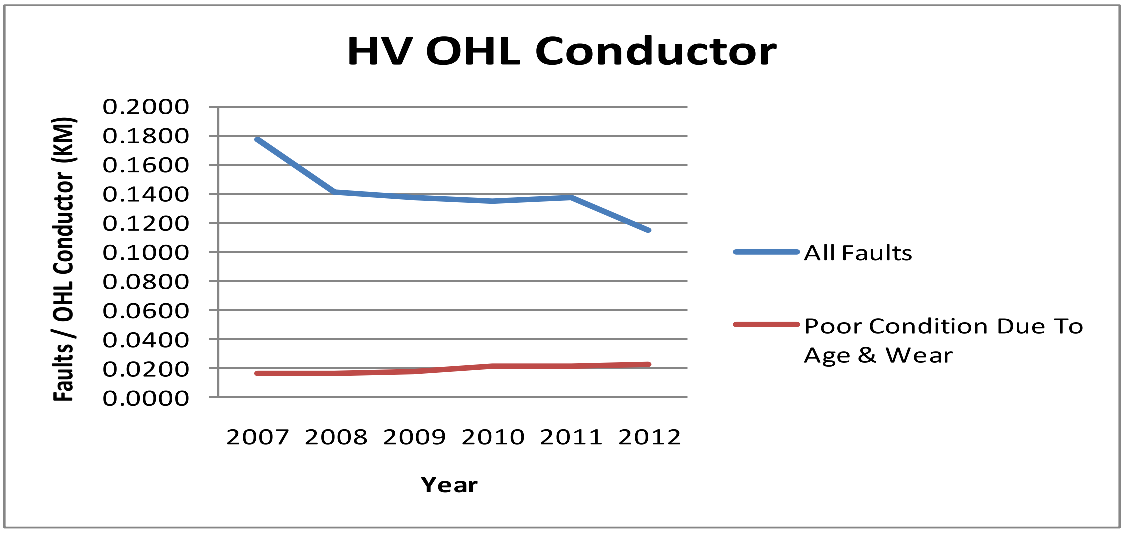

Figure 19 – HV OHL conductor fault rate

(Source - UKPN Fault Cube)

The fault trend has been falling over the past six years for HV pole conductors. A further breakdown of fault causes shows that a small proportion of these faults are due to poor condition (age or wear).

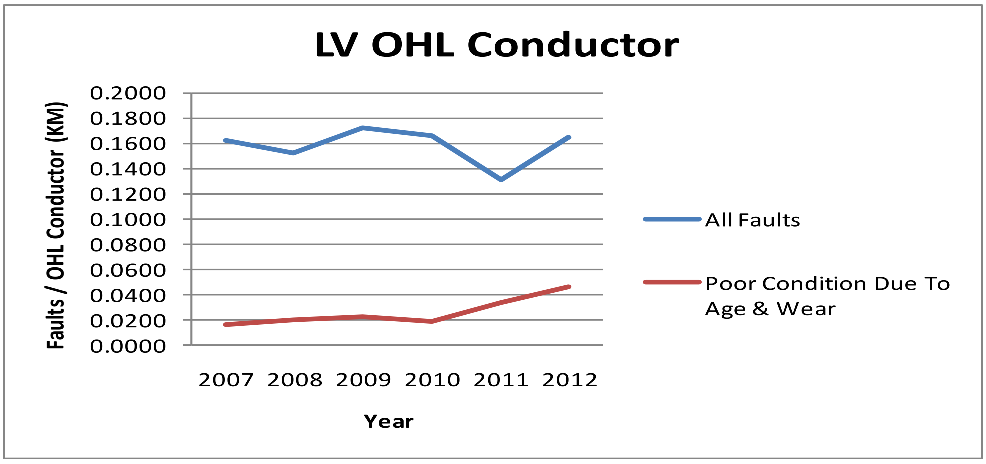

Figure 20 – LV OHL conductor fault rate

(Source - UKPN Fault Cube)

The fault trend has been falling for LV OHL conductors. A further breakdown of fault causes shows that a small proportion of these faults are due to poor condition (age or wear). Furthermore, there is a peak increase in faults in 2009 specifically related to the condition.

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.
- There has been a slight increase in tree fault rate over the five-year period for LV, HV and EHV, with an even greater increase in the past two years.

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 on HV and LV overhead lines to clear faults is expected to reduce during the ED1 period because of planned improvements and efficiencies in the management, control and scope of tree-cutting and surveys, the replacement of small section conductors, and the replacement of bare LV overhead conductors with aerial-bundled conductors (ABC).

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. Every 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.

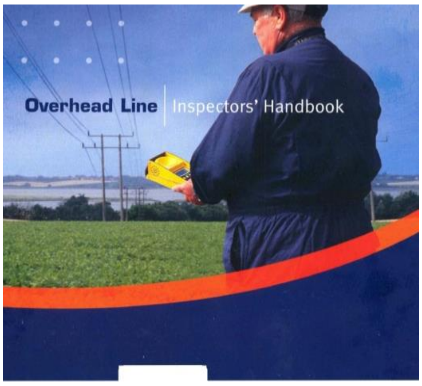

Figure 21 – Example of a handheld device and inspection manual

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 use 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 can reliably perform their function 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 used for the basis of Residual Strength Value (RSV) in UK Power Networks are based on values from BS 1990 Part 1: 1984.

A trained craftsman assesses the condition of a wood pole 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 and 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 have to be arranged using one of the following methods.

The PURL ultra-sonic tester – EA Technology makes the pole ultra-sonic rot locator (PURL). It is operated at several points along a circumferential line around the pole and the readings obtained are then 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 into 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. An assessment of the internal wood density will determine the condition of the pole and its serviceability.

3.3.4 Pole condition based on Health Index

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

The revised and consolidated pole condition score will then give an HI rating for the pole. The process is shown in Figure 19, taken from ARP tool.

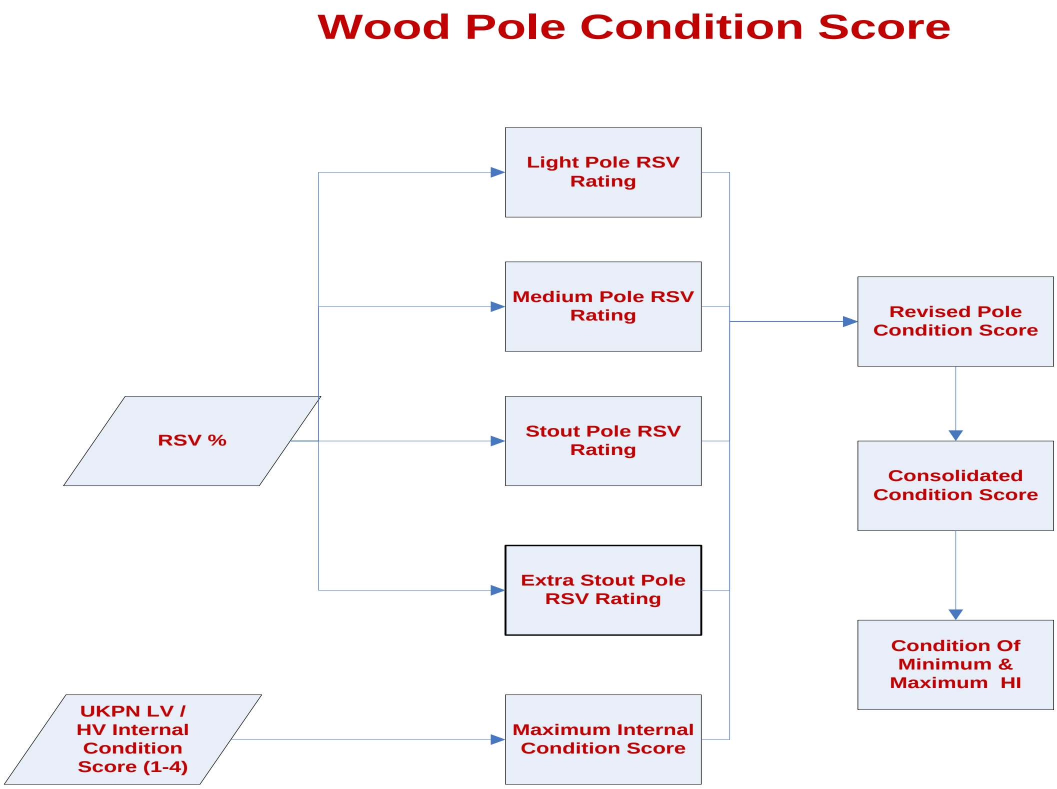

Figure 22 – Pole condition based on HI

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 calculated based on the year of manufacture and expected average life. The environmental factors considered include the distance from 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 is assigns 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

- 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 the 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, the 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 after 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, allowing 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. The results for the data used in the wood poles are given in Table 7.

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Asset category	Completeness	Timeliness	CAT score
33kV pole	60%	46%	56%
HV pole	60%	45%	56%
LV pole	61%	51%	58%

Table 7 – CAT scoring analysis

Data Source: ARP Wood pole data quality report 08_02_2013

The completeness score for wood poles is a combination of nameplate and condition data. Although the overall completeness of data is 60%. The main drivers for this asset group are inspector training courses and cyclic inspection schedules, which will improve this data over the next few 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 DPCR5 HI Profiles – With and Without Investment

Figures 20–22 shows 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.

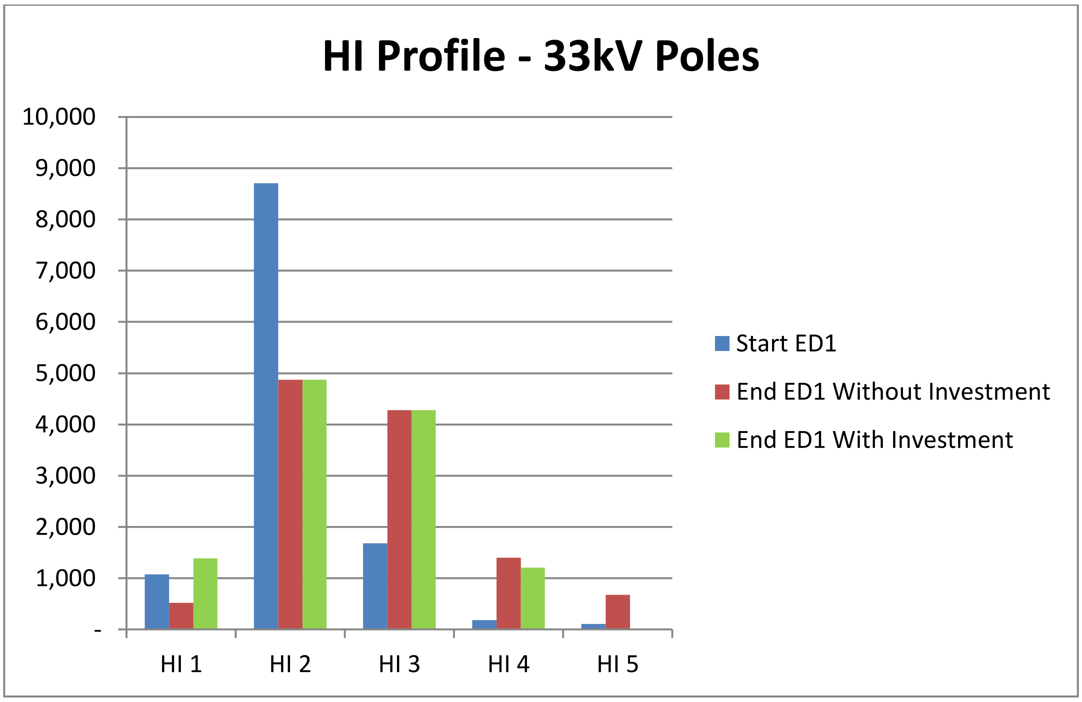


Figure 23 – HI profile for 33kV poles

(Source:ARP: 25July 2012)

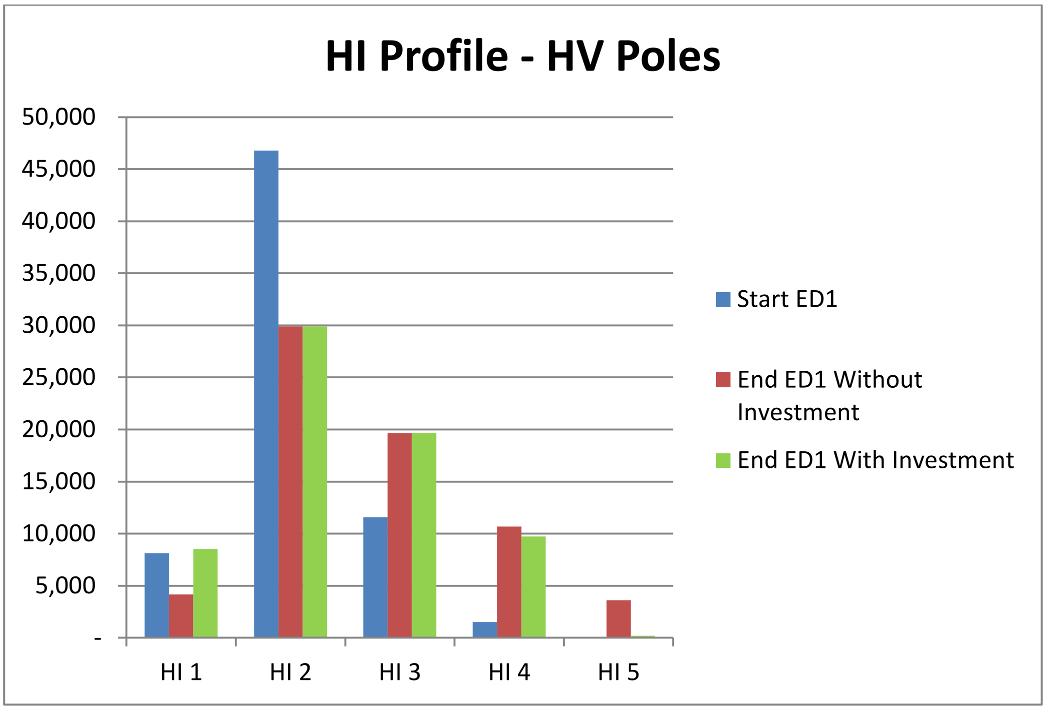


Figure 24 – HI profile for HV poles

(Source:ARP: 25July 2012)

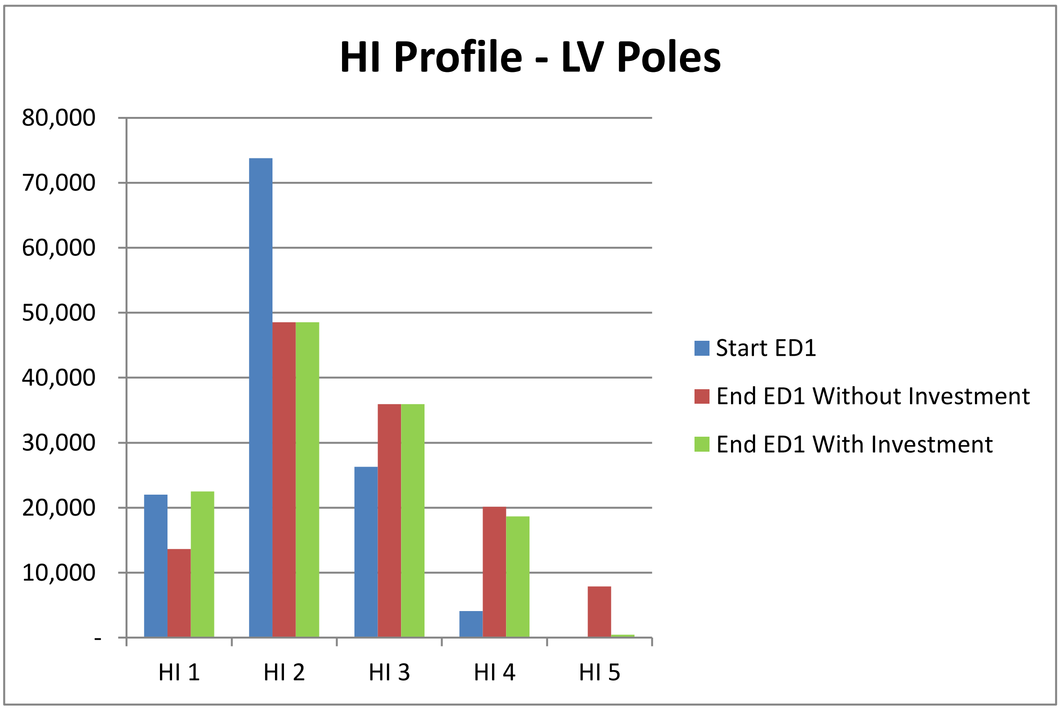


Figure 25 – HI profile for LV poles

(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:

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

5.1.1 Overhead line rebuilds and refurbishments

The overhead line shall be considered for rebuilding either when 60% of the overhead line supports have a condition rating of 4; or if the fault performance of the overhead line is unacceptable, based on CIs/CML, and is therefore driving the installation of covered conductors where repeat faults are experienced. This will result in either the entire overhead line or manageable sections of the overhead line being rebuilt.

The 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, 1.32.17, 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) – Four 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 where 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 by 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 as shown in Figure 28 of section 6.3. This is a moisture barrier wrap installed at ground level on new poles. One long-term benefit is that it improves the life of the 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, something that typically takes 20-25 years from new. By installing the boron rods, the life of the pole is extended by 8–10 years. Is it the case that only poles of condition 1 (or 2) between 25 and 58 years old are considered for treatment. The upper age limit is simply to be efficient by not installing Boron rods in poles that are due for replacement in ED1 and ED2 anyway. 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, making the replacement programme feasible, cost efficient and low risk.

The benefits of boron rod installation, based on the condition data taken from the 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 the benefits of boron rods

Pole support system – Installed adjacent to a pole that has minor rot on a certain part 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 subjected to rot, ultimately extending its life.

5.2 Proposed expenditure by interventions

The proposed volumes 'with intervention' and 'without interventions' for ED1 period is shown below for comparison. The potential saving with various intervention options per year during the ED1 period is detailed in section 6, £1.3m for LV poles and £1.2m for the HV poles.

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.

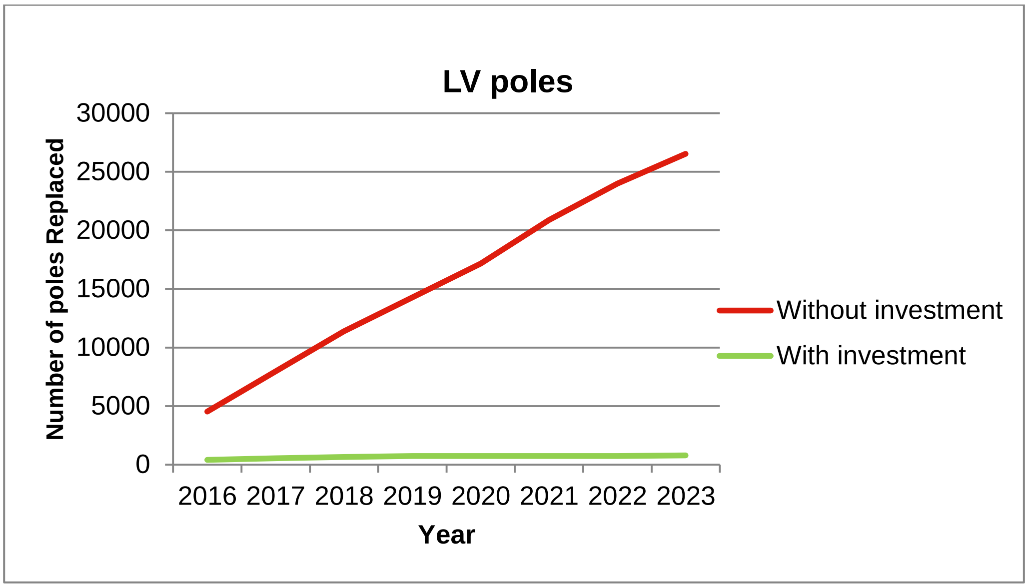


Figure 26 – Investment analysis for LV poles

(source; 19th February 2014 NAMP Table O)

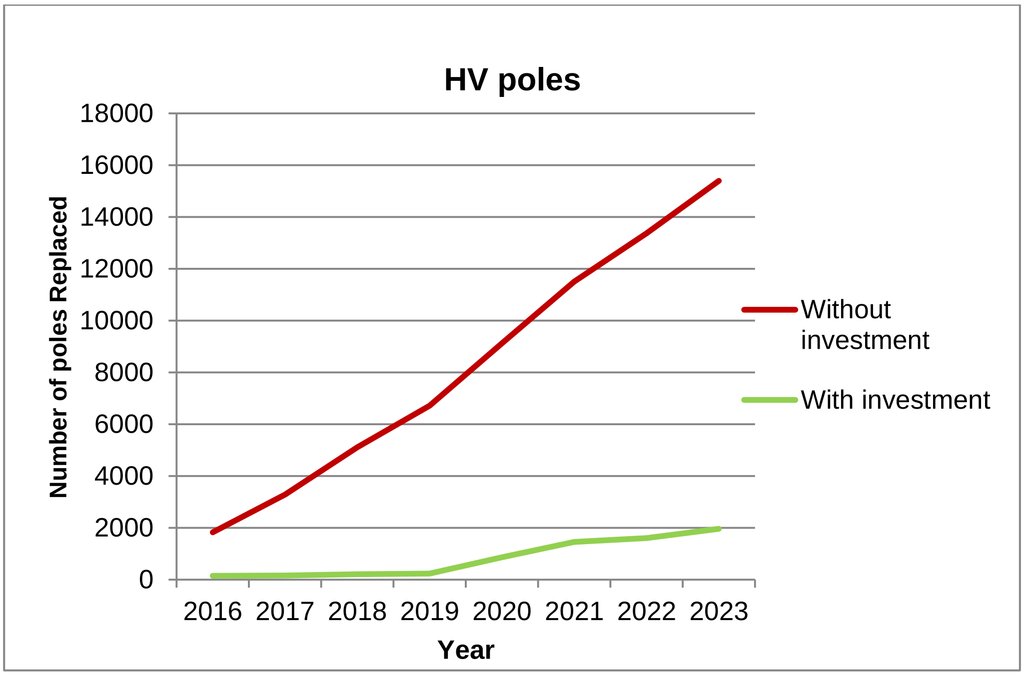


Figure 27 – Investment analysis for HV poles

(source; 19th February 2014 NAMP Table O)

5.3 Policies: Selecting Preferred Interventions

Preferred interventions for each asset and justification for selection

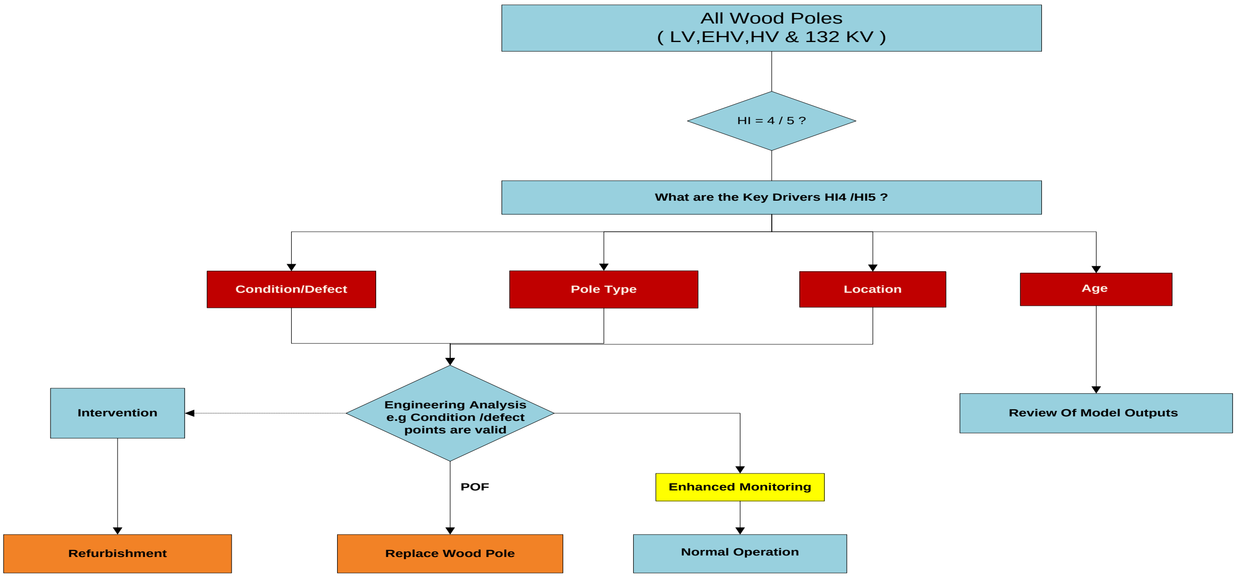


Figure 28 – Intervention decision flow chart

6.0 Innovation

6.1 Boron Rods

Figure 29 – 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 and fit into a 10mm diameter holes. Plastic bang-in caps are used to cover the holes.

Wooden poles 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 30), 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.

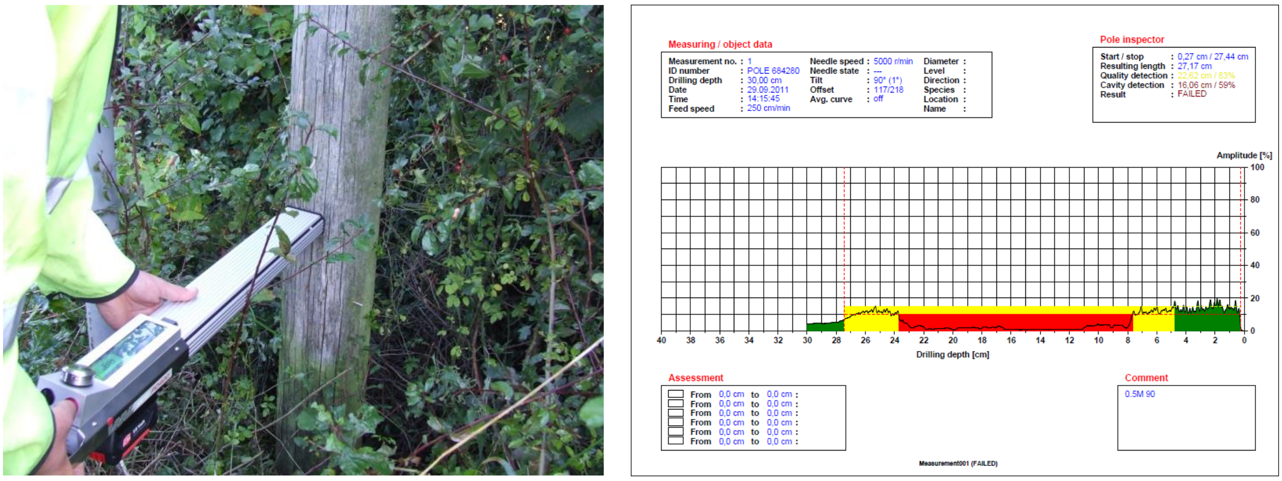


Figure 30 – Micro-bore pressure sensing drill in use and output information

6.3 Pole Saver

This is a wood pole rot mitigation application, as shown in Figure 31, 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 the AC500 preservative (used on green poles) beyond that of the traditional creosoted option.

Figure 31 – 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 and this type of mitigation is intended to provide additional support, not residual strength.

Figure 32 – Pole brace installed

6.5 Composite Poles

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

Figure 33 – 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. There is also some thought that the woodpeckers are attracted to certain poles because they vibrate at a frequency similar to where mites nest. Where this occurs, the previously mentioned composite pole may prove to be the mitigation.

Figure 34 – Woodpecker damage on a HV wooden pole

The potential saving with various intervention options per year during the ED1 period is shown below, £1.3m for LV poles and £1.2m 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	2,000	544	1.088
	Boron rods	30	7,586	0.227
	Pole-support systems	250	33	0.008
Total expenditure				**1.32**
HV poles	Micro- bore pressure sensing drill	2,000	537.5	1.075
	Boron rods	30	4,081	0.122
	Pole-support systems	250	18	0.004
Total expenditure				**1.20**

Table 10 – Innovation Costs

7.0 ED1 Expenditure Requirements for Wood Poles and Conductors

7.1 Method

Figure 35 shows an overview of the method used to construct the ED1 NLRE investment plans.

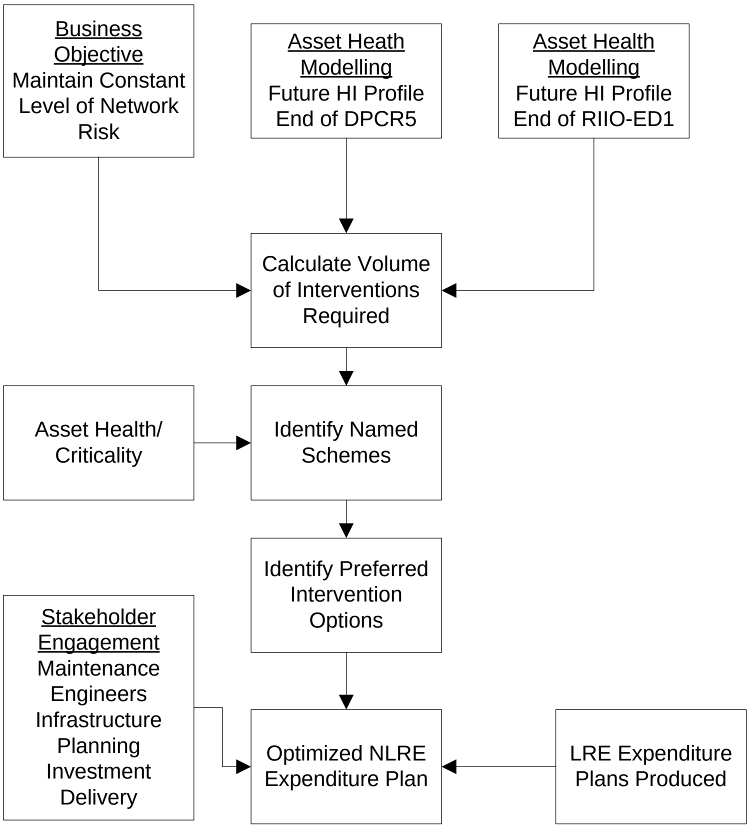


Figure 35 – Constructing the NLRE plan

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 condition. 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 the Figures 36-41, 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.

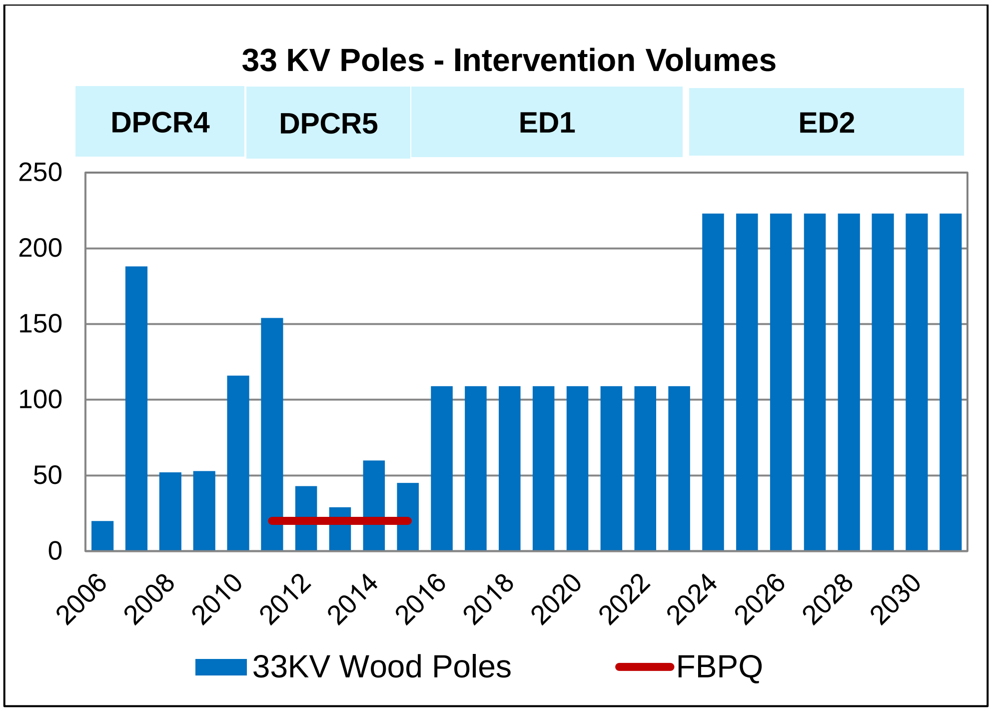


Figure 36 – 33kV wood poles intervention volumes

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 36 shows how the 33KV poles significantly increases over the ED2 period due to ageing population and the large number of decayed poles identified .There are currently 304 ‘D’ poles and 262 ‘S’ poles in SPN. We estimate that we will replace 223 poles per year are planned for replacement during the ED2 period.

It is expected that ED2 numbers will reduce by using the proposed interventions as shown in table 8.

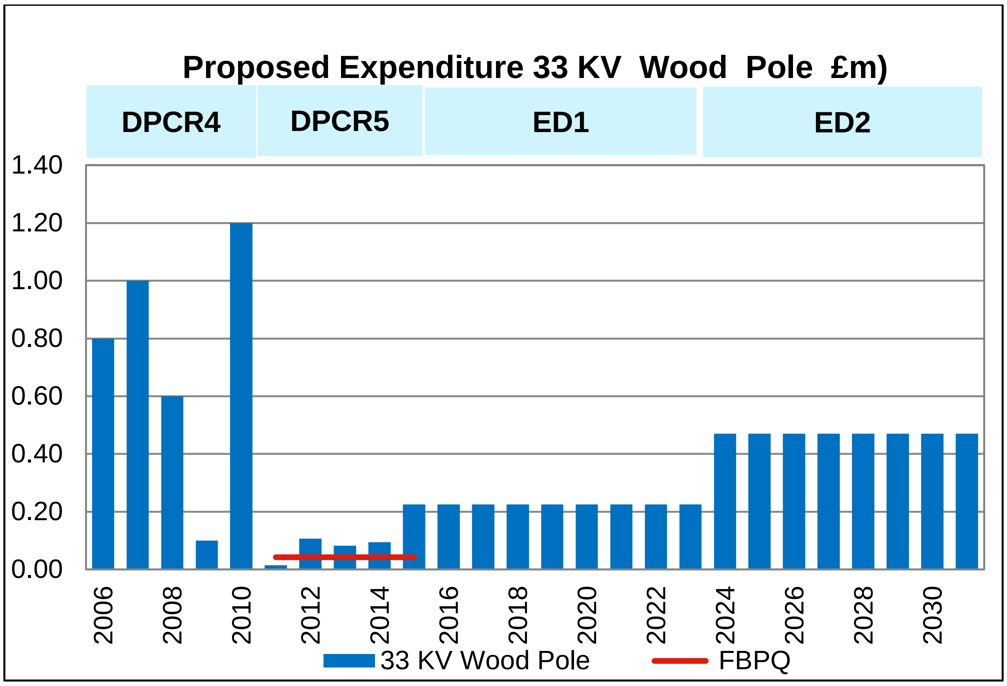


Figure 37 – Proposed expenditure for 33kV poles (£m)

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

As shown in Figure 37, the expenditure increases significantly over ED1. This is due to high numbers of poles commissioned during the period 1963 –1970 (as shown in Figure 1) of section 2 will reach their end of life by the end of ED1.

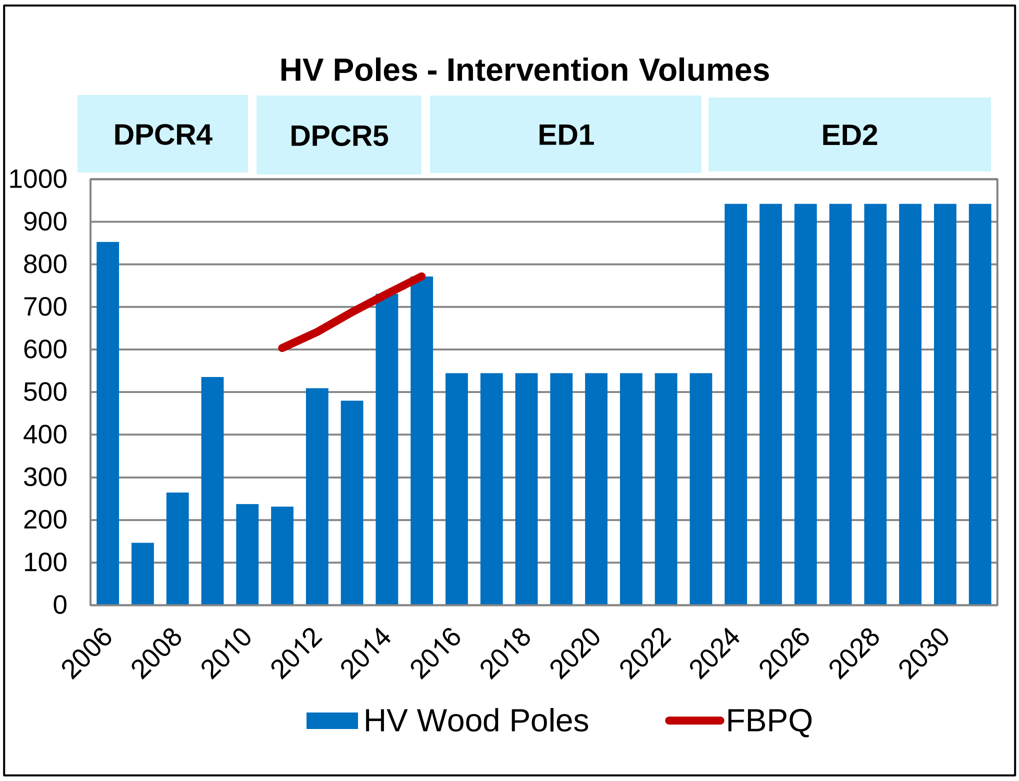


Figure 38 – Intervention volumes for HV wood poles

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

The trend shows HV pole volumes are high compared with historic achievement, resulting in a large step change into ED2. This is due to a number of 'D' and 'S' poles – shown in Table 10.There are currently 1,491 'D' poles and 1387 'S' poles in SPN ,ED2 volumes been (942) set to manage the outstanding 'D ' poles and emerging 'D ' poles in Ellipse.

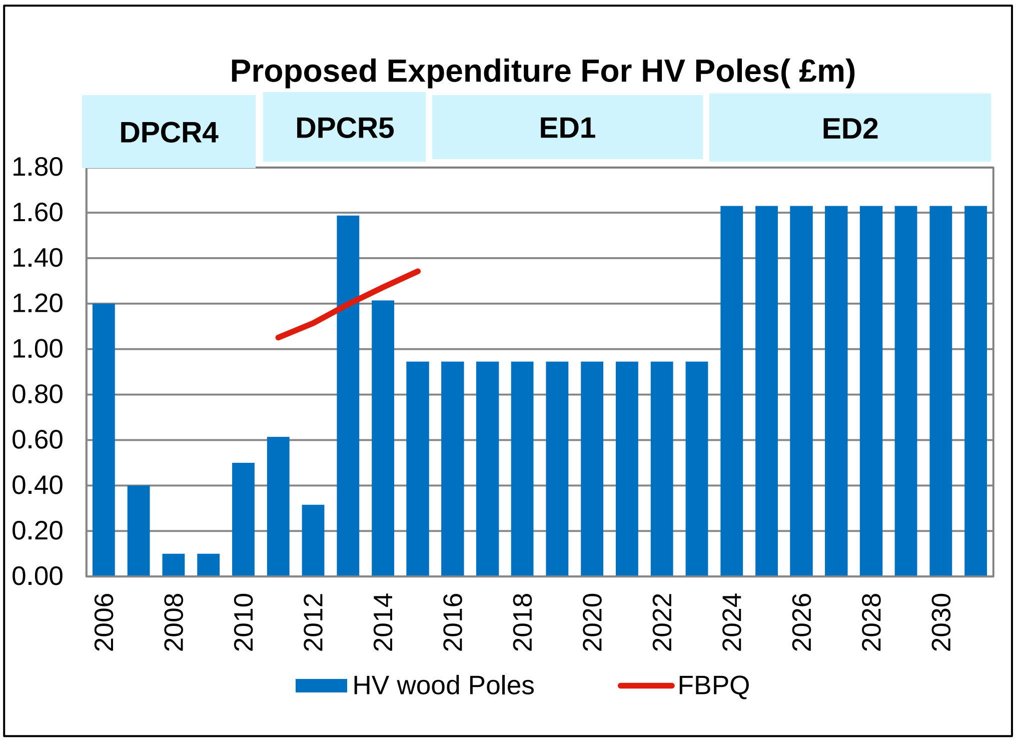


Figure 39 – Proposed expenditure for HV poles (£m)

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

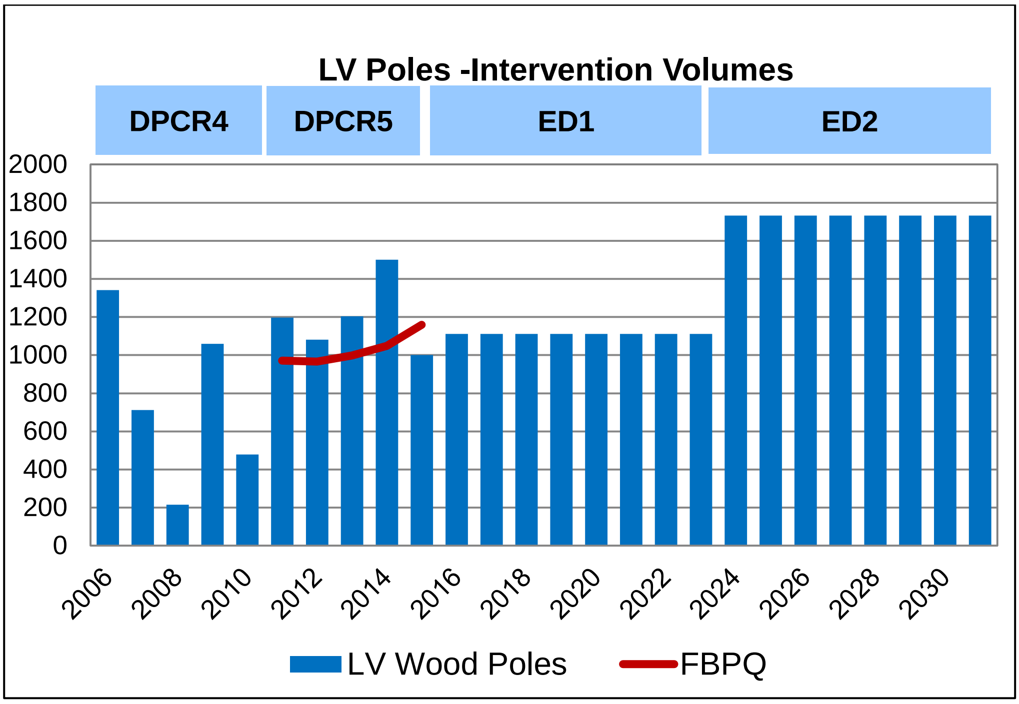


Figure 40 – Intervention volumes for LV wood poles

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 36 shows a rapid increase in volumes over the ED2 period for 33kV poles. There are currently 1590 ‘D’ poles and 2823 ‘S’ poles in SPN. We estimate that we will replace 223 poles per year during the ED2 period. It is expected that ED2 numbers will reduce by using the proposed interventions as shown in table 8.

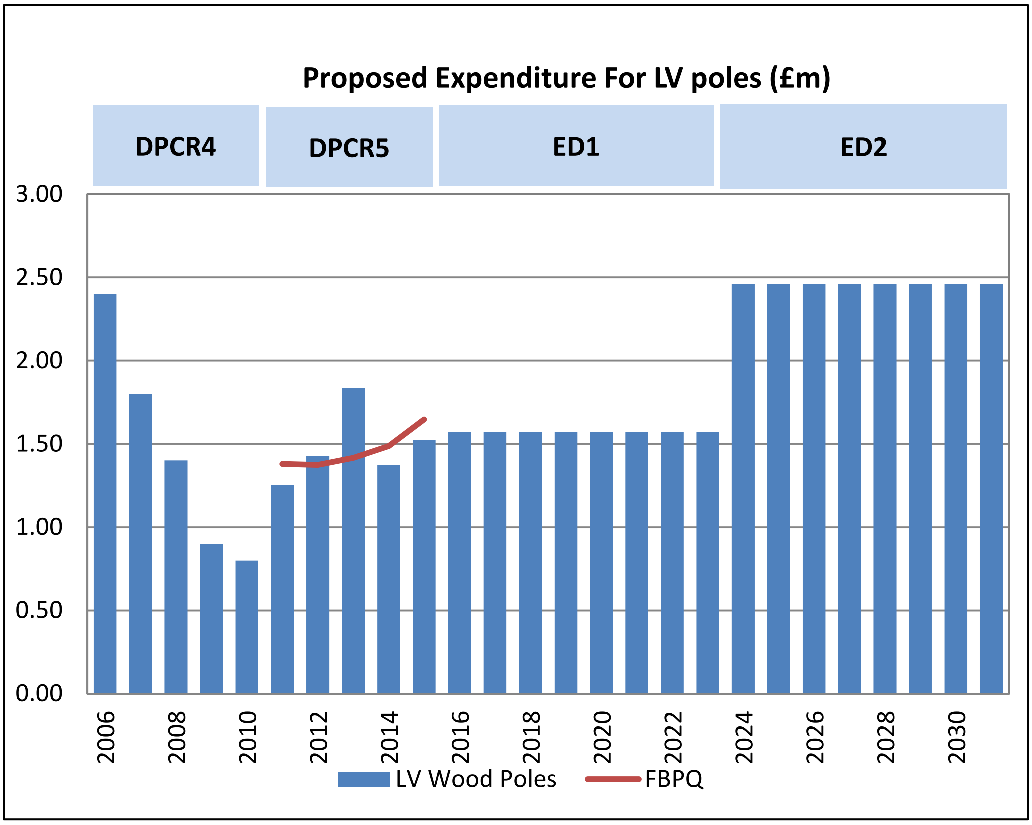


Figure 41 – Proposed expenditure for LV poles (£m)

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 pole volumes are high compared with historic achievement, resulting in a large step change into ED2. This is due to a number of ‘D’ and ‘S’ poles – shown in Table 10, as extracted from Ellipse in March 2013.

Asset Category	Number Of S Poles	Number Of D Poles	% Population	
			S poles	**D Poles**
33 KV Pole	262	304	2%	3%
HV Pole	1387	1491	2%	2%
LV Pole	2823	1590	2%	1%

Table 10 – Number of ‘D’ and ‘S’ poles, March 2013

The increased investment on the pole replacement in ED2 is due to the ageing population and the large number of decayed poles identified. There are around 1,590 LV ‘D’ poles and 2,823 ‘S’ poles. We estimate that we will replace 1,733 poles per year during the ED2 period. There are currently 1,491 ‘D’ HV poles and 1,387 ‘S’ HV poles in Ellipse; 942 poles per year are planned for replacement during the ED2 period. The ED1 volumes have been set to manage the number of outstanding ‘D’ poles, as well as the new emerging ‘D’ poles in Ellipse. The increase in volumes is due to the fact 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 ED2 numbers will reduce by using the proposed intervention options as detailed in section 6.

7.4.1 Proposed intervention volumes and expenditure for conductors

The proposed asset replacement volumes for the ED1 period shown in Figures 42, 44 and 46, along with the volumes for DPCR4 and DPCR5 and ED2 for comparison. It is estimated that 50% of the LV ABC scheme will have an impact on reducing ESQCR issues.

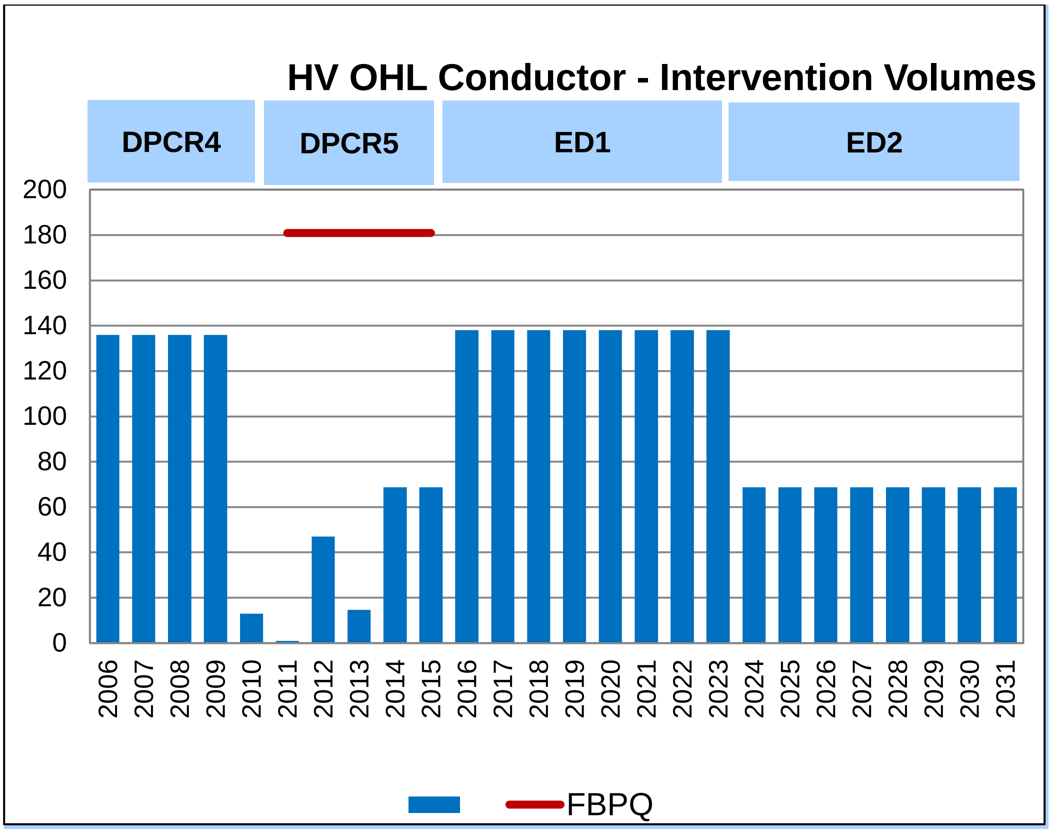


Figure 42 – Intervention volumes for HV OHL conductors

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

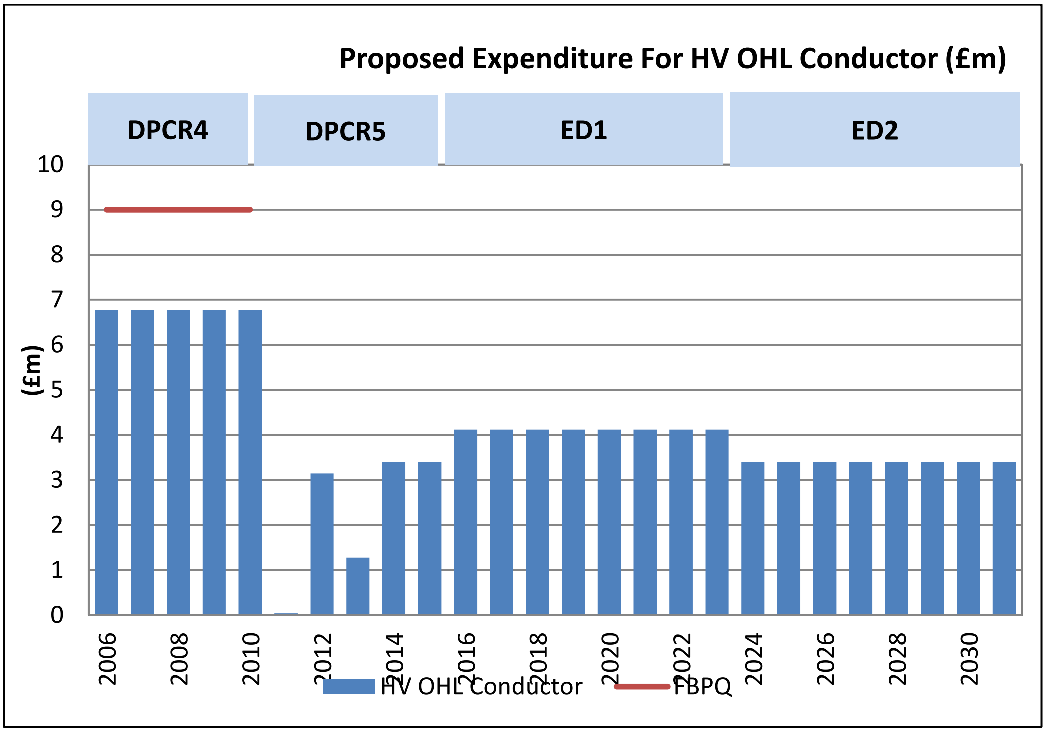


Figure 43 – Proposed expenditure for HV OHL conductors

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

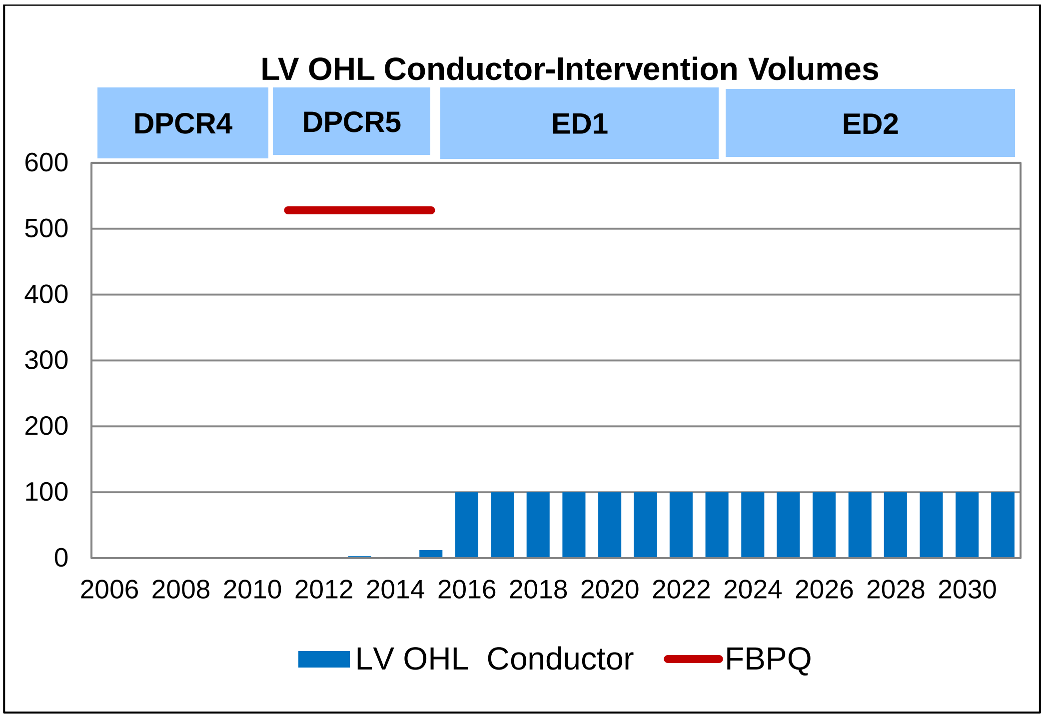


Figure 44 – Intervention volumes for LV OHL conductor

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

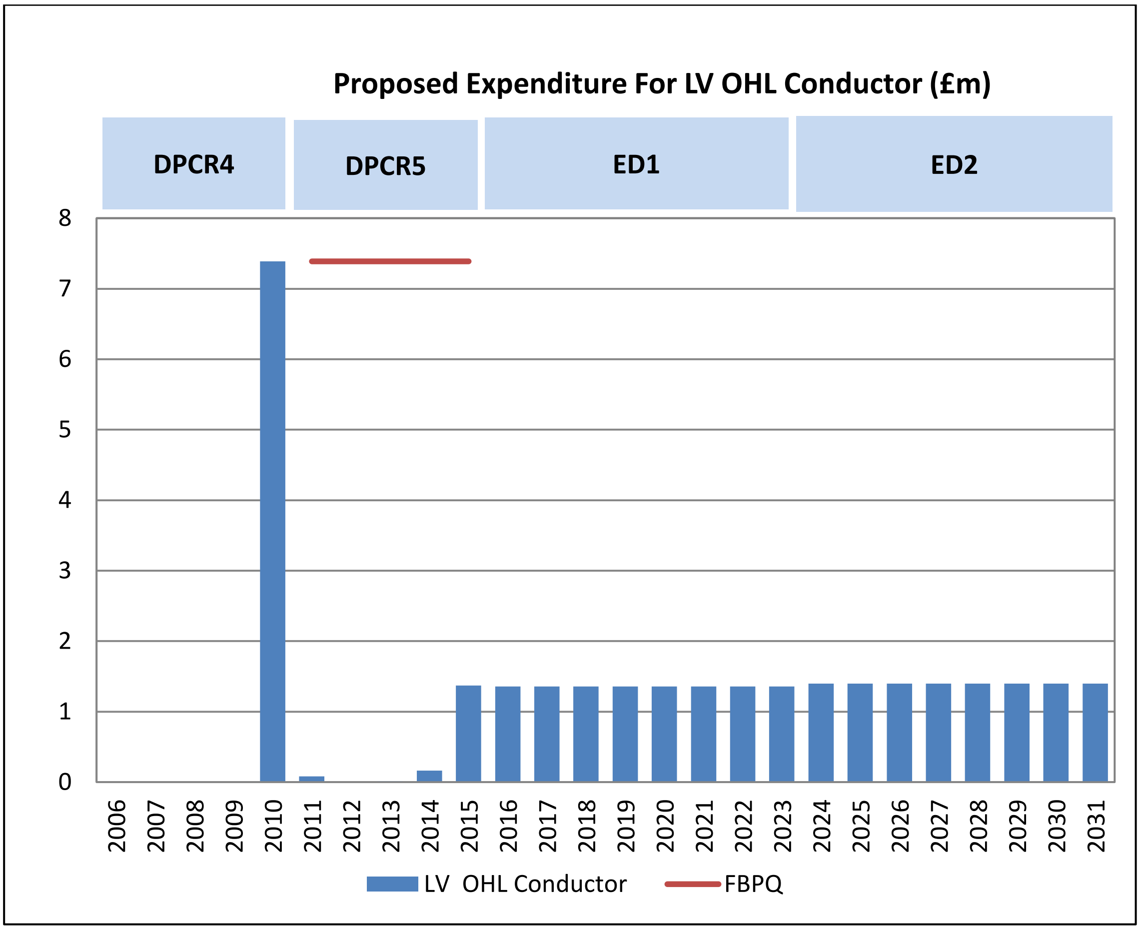


Figure 45 – Proposed expenditure for LV OHL conductors

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

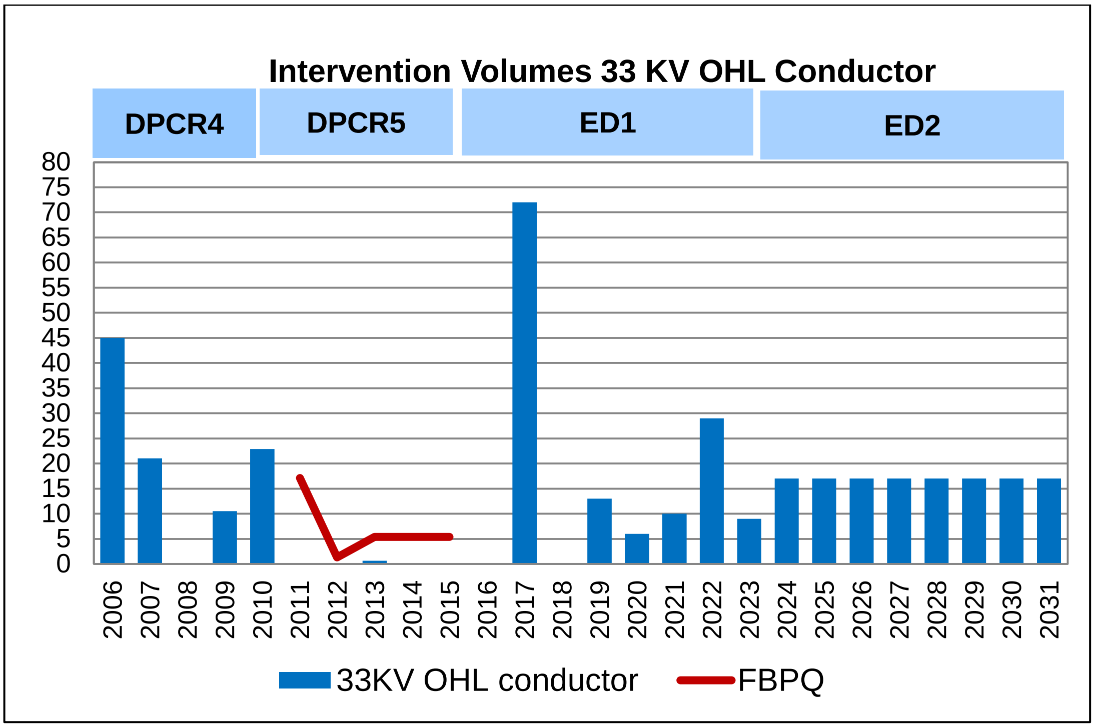


Figure 46 – Intervention volumes for 33kV OHL conductors

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

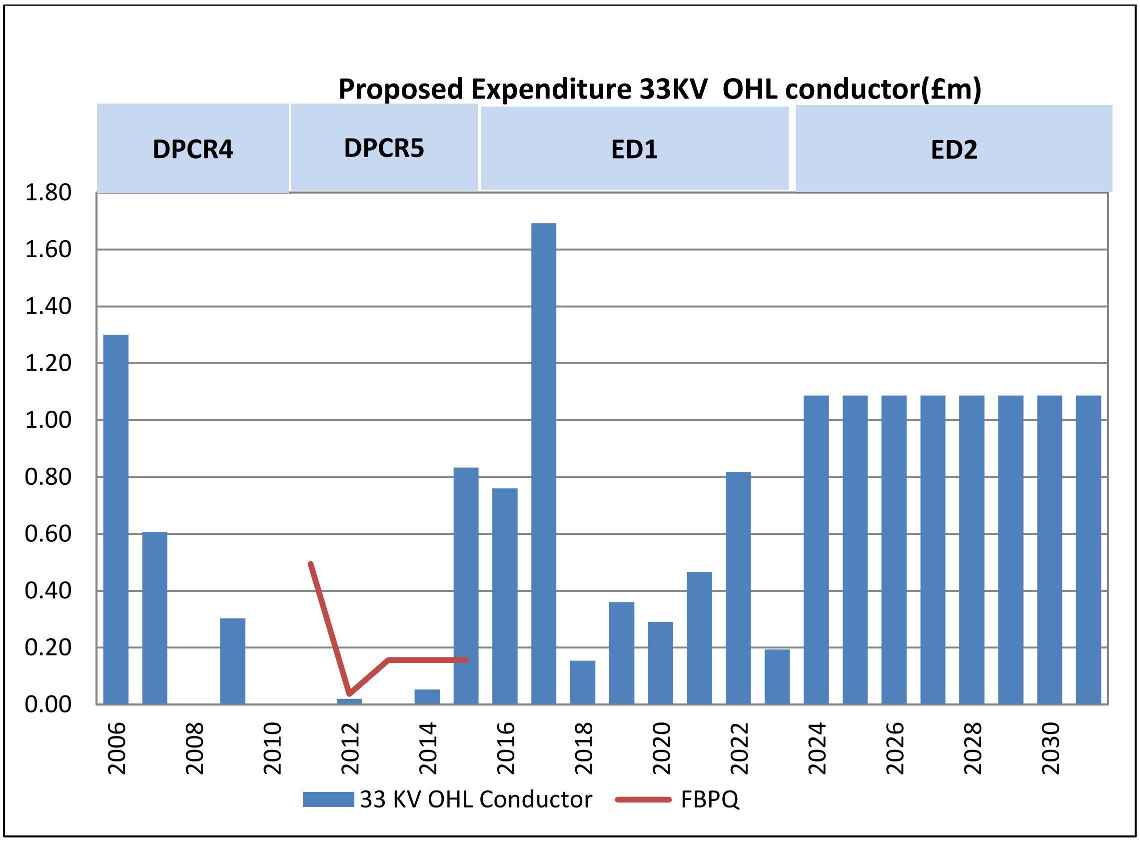


Figure 47 – Proposed expenditure for 33kV OHL conductors

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

The increase in spend during the DPCR5 period will allow 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. ED1 forecasts have been set to remove small section of the conductor and replace spans of conductors with multiple fault history. The ED1 volumes have been set to manage/achieve steady state forecast during the ED1 period.

7.5 Commentary

The proposed investment level in ED1 for the replacement of LV, HV and 33kV wood poles in SPN is £71m.

We are currently on target for achieving wood pole 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 (SAPs) for the remainder of DPCR5.

HV & LV Poles :

As detailed in the section 7.4 Figure 38 - 41 ,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 1,590 LV 'D' poles and 2,823 'S' poles. We estimate that we will replace 1,733 poles per year during the ED1 period. There are around 1,491 'D' HV poles and 1,387 'S' HV poles in Ellipse; 942 poles per year are planned for replacement during the ED2 period.

The ED1 volumes have been set to manage the number of outstanding 'D' poles, as well as the new emerging 'D' poles in Ellipse. The increase in volumes is due to the fact 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 36 and Figure 37 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 1,3 and 5) of section 2 that will reach their end of life by the end of ED1.

This is the worst case scenario considered ,as it is expected that ED1 numbers will come down through the 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 the DPCR5 period , spend has been reallocated to resolve high risk ESQCR issues as shown in Figure 44 and 45 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, it is extracted from ARP as based on the 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 their average life does not turn out as predicted. All results are shown below 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	7.1	65.9	22.2	3.8	0.9
-2	7.1	73.0	15.5	3.4	0.9
-1	9.1	73.1	14.4	2.4	0.9
0	9.1	74.1	14.3	1.5	0.9
1	9.3	76.2	12.0	1.5	0.9
2	10.3	76.2	11.1	1.5	0.9
4	10.4	79.6	8.0	1.1	0.9

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	12.4	46.3	31.8	9.5	0.0
-2	12.4	52.0	30.8	4.9	0.0
-1	12.6	54.9	28.4	4.1	0.0
0	12.6	57.8	25.5	4.0	0.0
1	12.7	62.2	21.3	3.9	0.0
2	12.7	65.3	19.7	2.3	0.0
4	12.7	70.9	16.0	0.4	0.0

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.

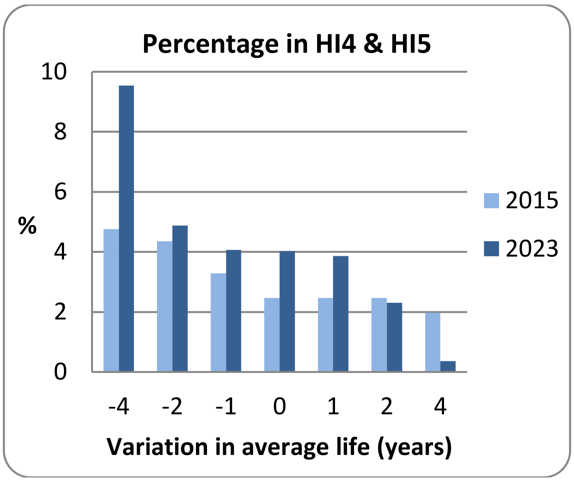


Figure 48 – Effect of average life variation on volumes of HI4 and HI5

Figure 48 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	11.4	61.9	23.3	3.3	0.1
-2	11.4	66.1	19.8	2.6	0.0
-1	11.9	67.4	18.3	2.4	0.0
0	11.9	68.9	17.0	2.2	0.0
1	12.2	70.4	15.2	2.2	0.0
2	12.5	72.1	13.5	2.0	0.0
4	13.2	73.1	12.2	1.5	0.0

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	14.0	45.6	28.5	10.6	1.3
-2	14.2	50.9	26.9	7.3	0.7
-1	14.2	53.2	25.4	6.9	0.2
0	14.2	55.1	24.6	6.1	0.0
1	14.6	57.2	22.4	5.8	0.0
2	14.8	59.8	20.1	5.3	0.0
4	15.2	64.4	16.7	3.8	0.0

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.

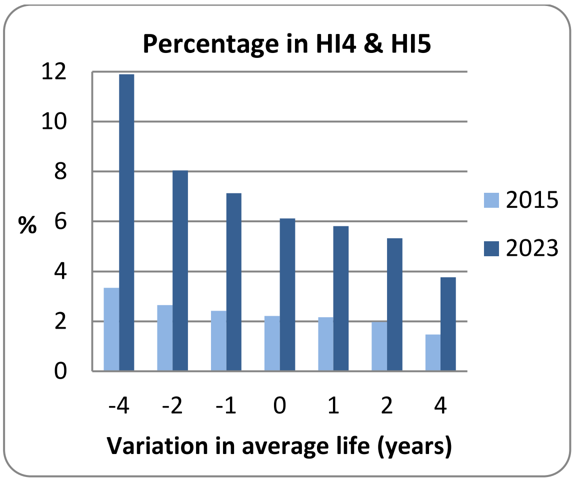


Figure 49 – Effect of average life variation on volumes of HI4 and HI5

7.6.3 LV wood poles

Average life change	2015 percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	16.2	52.7	26.8	4.3	0.0
-2	17.1	55.7	23.4	3.8	0.0
-1	17.4	57.2	21.8	3.6	0.0
0	17.4	58.5	20.8	3.2	0.0
1	19.1	58.4	19.3	3.2	0.0
2	19.4	59.9	17.7	3.0	0.0
4	20.1	61.3	16.6	2.0	0.0

Average life change	2023 percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	19.6	39.8	28.4	12.2	0.0
-2	20.1	42.4	28.5	8.9	0.0
-1	20.6	44.6	26.7	8.1	0.0
0	20.7	47.4	25.0	7.0	0.0
1	21.1	48.9	23.2	6.7	0.0
2	21.2	51.9	20.8	6.1	0.0
4	21.4	55.0	18.4	5.2	0.0

Table 14 – Results of sensitivity analysis for LV poles

In Table 14, 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.

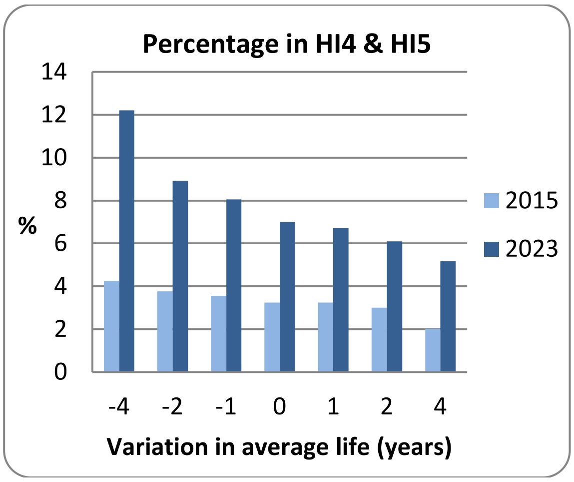


Figure 50 – Effect of average life variation on volumes of HI4s and HI5s

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 mimicked 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, this is a new concept and the methodology is under development. The criticality index can be used with the health index to give an indication of the level of risk that can be seen on the network. Table below shows the health and criticality matrix for 2015 and 2023 with investment.

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.

33 KV Poles :

Asset categories		Units	Estimated Asset Health and Criticality Profile 2015 with Investment					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2015
33 KV Poles	Low	No. Assets	61	499	96	11	6	673
	Average	No. Assets	3	37	3	0	0	43
	High	No. Assets	952	7695	1492	161	97	10,397
	Very High	No. Assets	58	473	91	10	6	638

Table 13: 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	69	279	245	80	0	673
	Average	No. Assets	3	19	16	5	0	43
	High	No. Assets	1247	4313	3785	1052	0	10,397
	Very High	No. Assets	73	264	232	69	0	638

Table 14: 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	742	7231	1620	179	0	**9,772**
	Average	No. Assets	4761	27072	6789	938	0	**39,560**
	High	No. Assets	2618	12458	3162	391	0	**18,629**
	Very High	No. Assets	2	39	0	0	0	**41**

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
HV Poles	Low	No. Assets	928	4298	2825	1534	187	**9,772**
	Average	No. Assets	4522	17389	11440	6209	0	**39,560**
	High	No. Assets	3068	8194	5385	1982	0	**18,629**
	Very High	No. Assets	5	18	12	6	0	**41**

Table 16: 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	**-**
	Average	No. Assets	21863	72930	26079	4097	0	**124,969**
	High	No. Assets	143	852	189	0	0	**1,184**
	Very High	No. Assets	0	1	1	0	0	**2**

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 Intervention					Asset Register
			Asset health index					
			HI1	HI2	HI3	HI4	HI5	2023
LV Poles	Low	No. Assets	0	0	0	0	0	**-**
	Average	No. Assets	22294	48074	35619	18524	458	**124,969**
	High	No. Assets	230	456	337	161	0	**1,184**
	Very High	No. Assets	0	1	1	0	0	**2**

Table 18: Asset Health and Criticality 2023 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, and so 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 into the existing resource (inspectors), and 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, but where this is not possible, a financial provision has been created.

Appendix 1 – Age Profiles

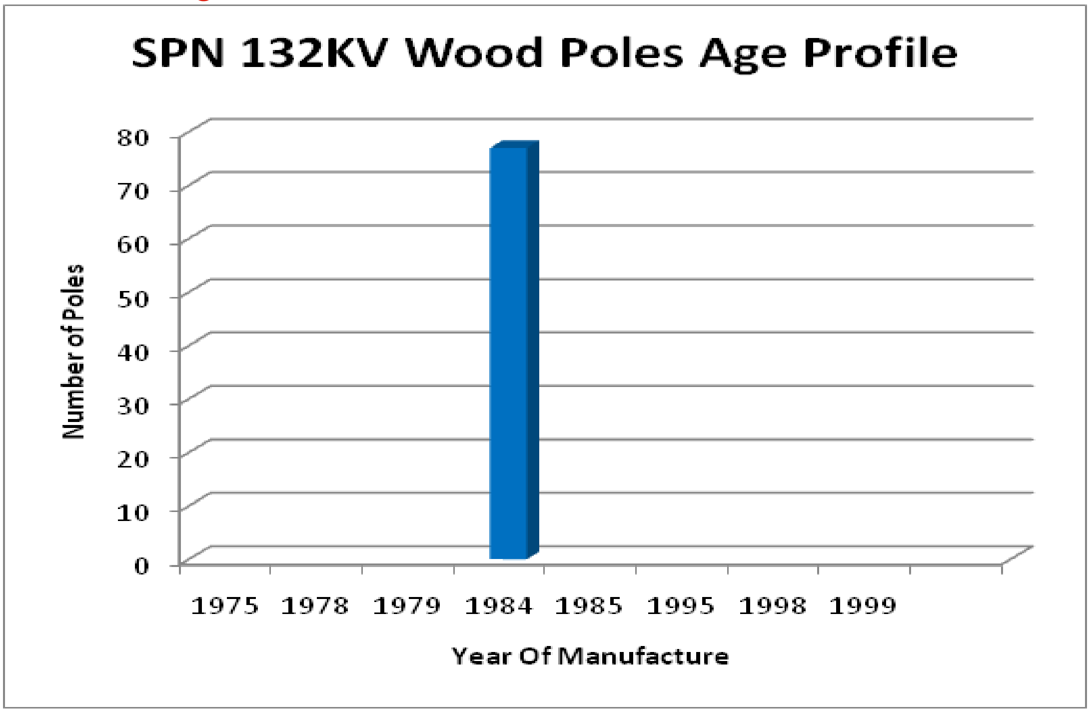


Figure 51 – 132kV Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

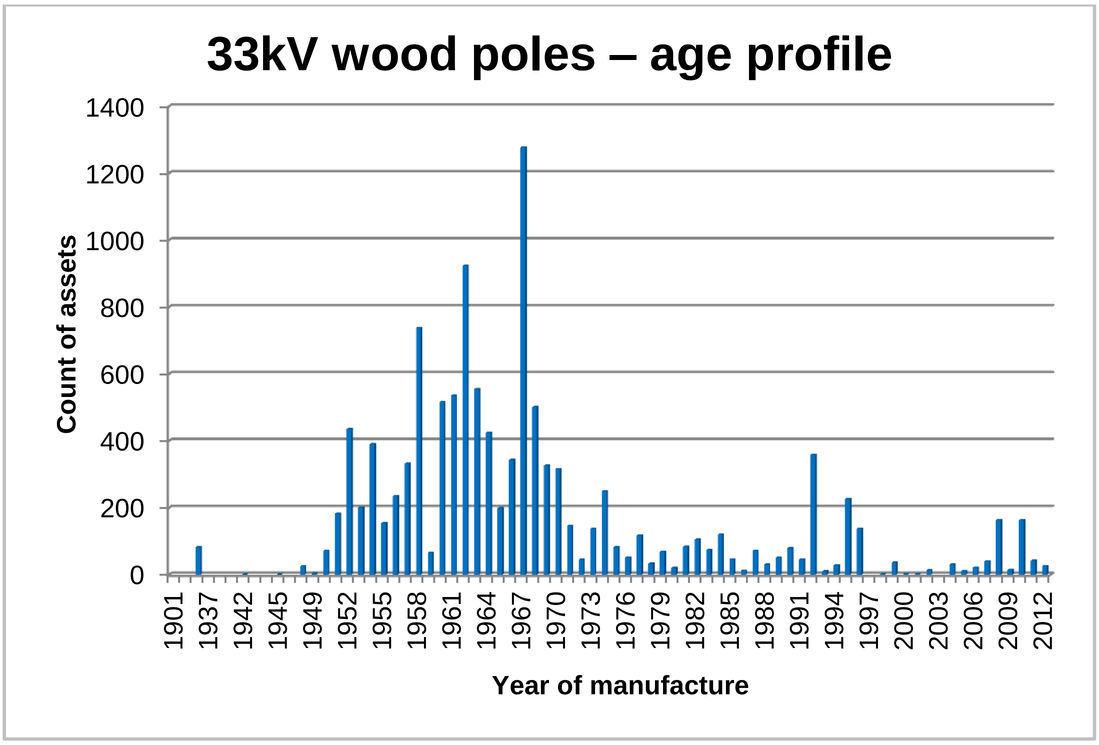


Figure 52 – 33kV(EHV) Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

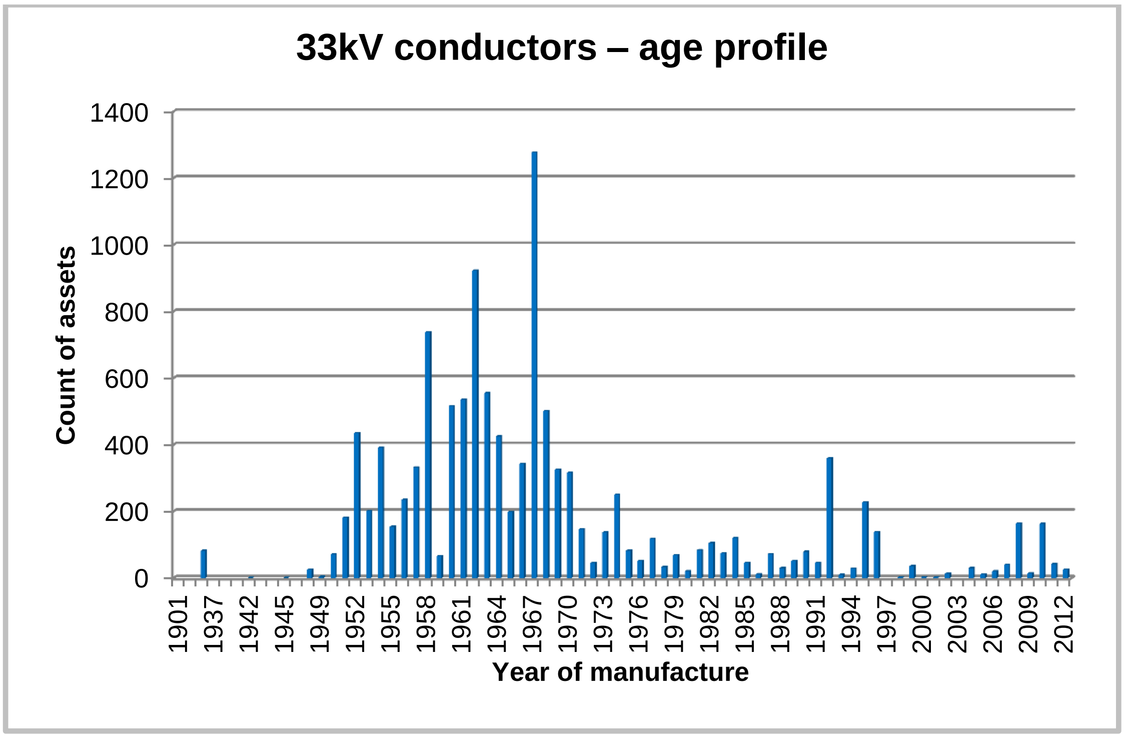


Figure 53 – 33kV(EHV) Conductor Age Profile

(Source – RIGS 2012 CV3 Table V5)

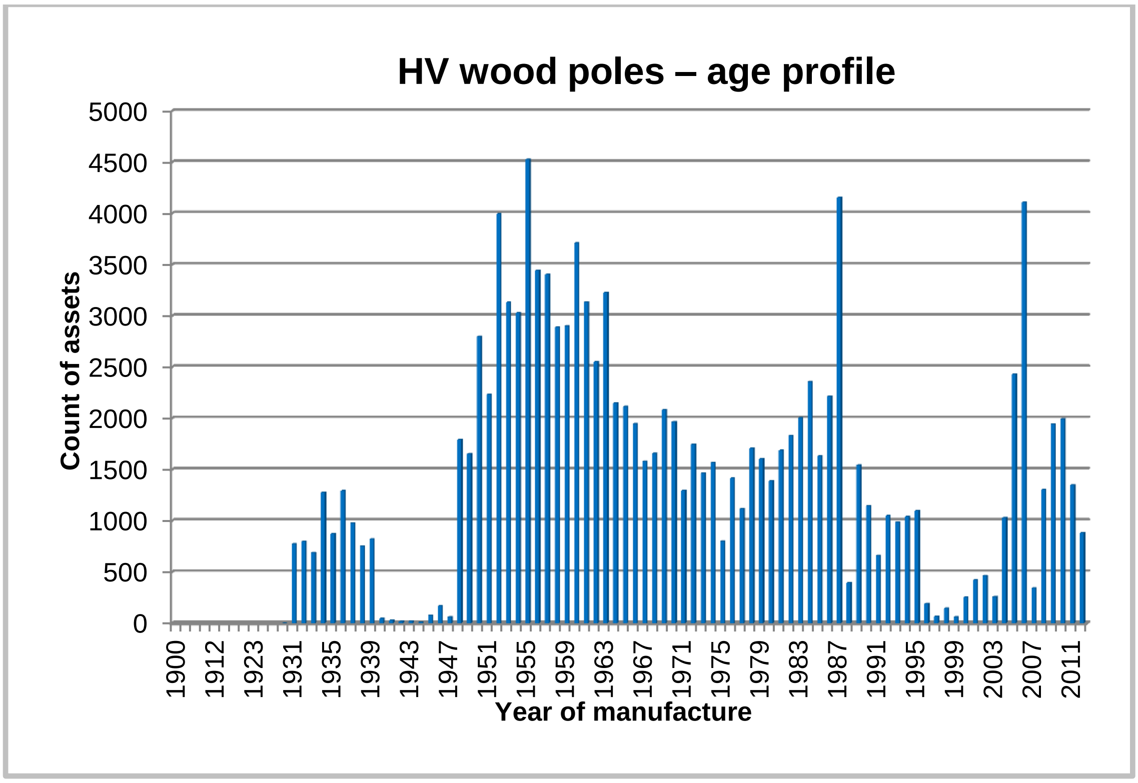


Figure 54 – HV Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

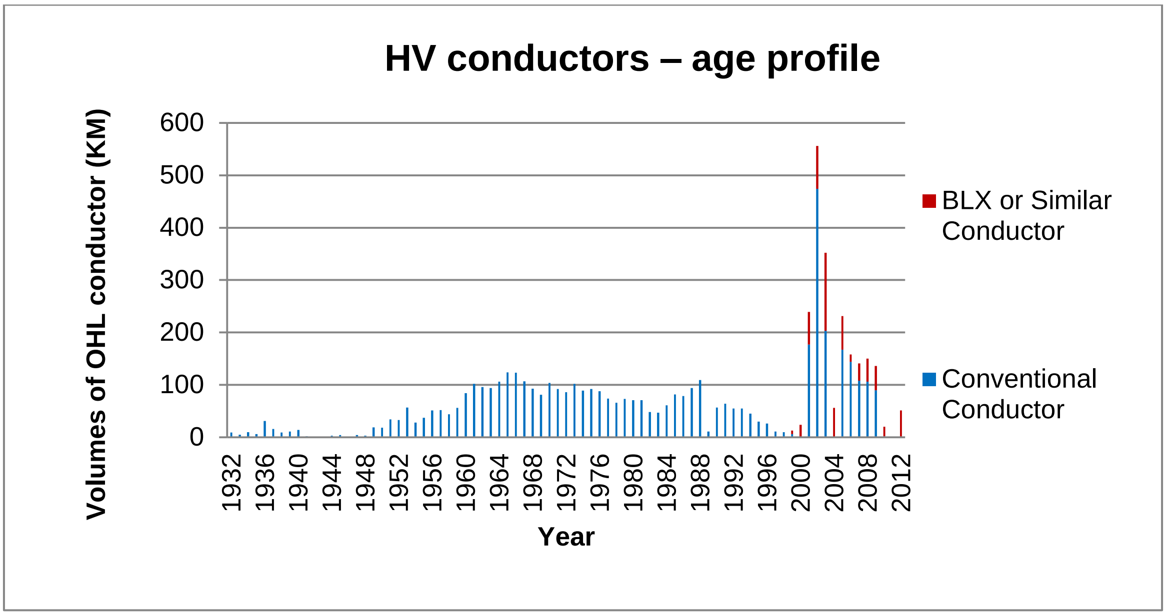


Figure 55 – HV Conductor Age Profile

(Source – RIGS 2012 CV3 Table V5)

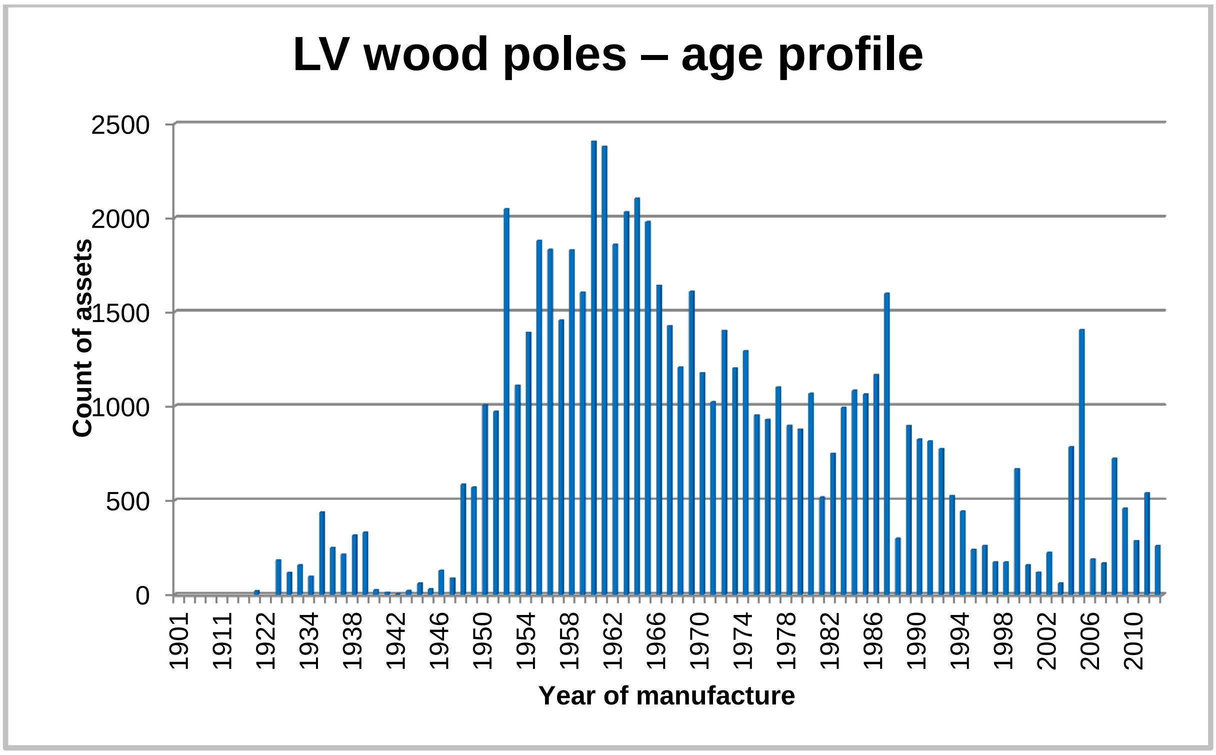


Figure 56 – LV Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

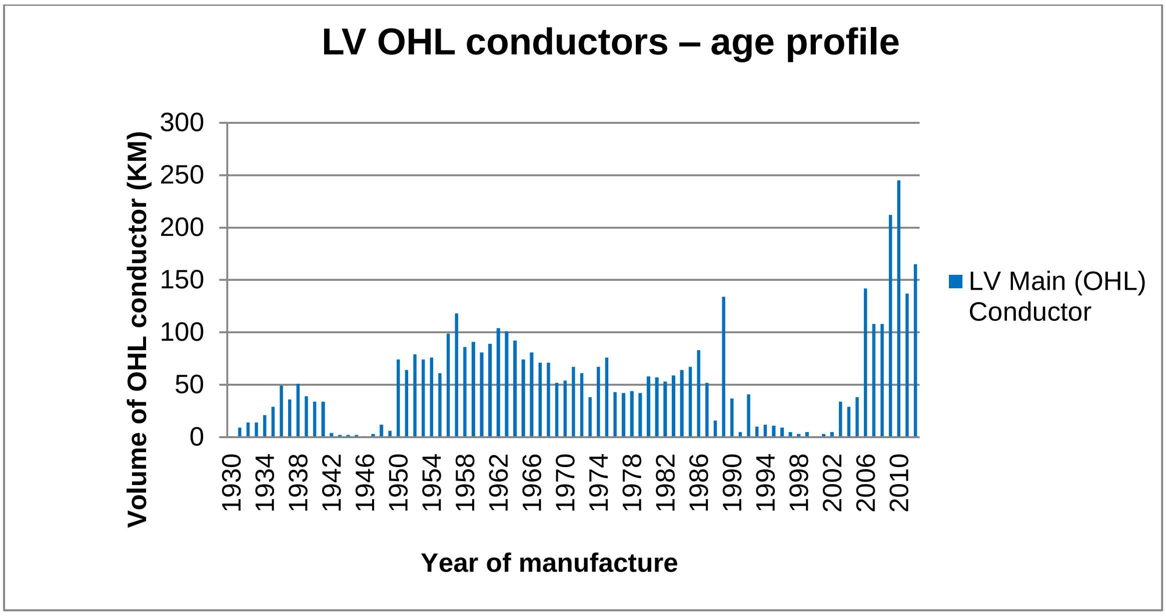


Figure 57 – LV Wood Pole Age Profile

(Source – RIGS 2012 CV3 Table V5)

Appendix 2 – HI and Criticality Profiles

33KV Poles :

Asset Health and Criticality 2015

Asset categories		Units	Estimated Asset Health and Criticality Profile 2015 with Interventions – Asset health index					Asset Register
			HI1	HI2	HI3	HI4	HI5	2015
33 KV Poles	Low	No. Assets	61	499	96	11	6	673
	Average	No. Assets	3	37	3	0	0	43
	High	No. Assets	952	7695	1492	161	97	10,397
	Very High	No. Assets	58	473	91	10	6	638

Table 19 - 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 2023with Interventions – Asset health index					Asset Register
			HI1	HI2	HI3	HI4	HI5	2023
33 KV Poles	Low	No. Assets	69	279	245	80	0	673
	Average	No. Assets	3	19	16	5	0	43
	High	No. Assets	1247	4313	3785	1052	0	10,397
	Very High	No. Assets	73	264	232	69	0	638

Table 20 - 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	742	7231	1620	179	0	9,772
	Average	No. Assets	4761	27072	6789	938	0	39,560
	High	No. Assets	2618	12458	3162	391	0	18,629
	Very High	No. Assets	2	39	0	0	0	41

Table 21 - 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	928	4298	2,825	1534	187	9,772
	Average	No. Assets	4522	17389	11,440	6209	0	39,560
	High	No. Assets	3068	8194	5,385	1982	0	18,629
	Very High	No. Assets	5	18	12	6	0	41

Table 22 - 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	-
	Average	No. Assets	21863	72930	26079	4097	0	124,969
	High	No. Assets	143	852	189	0	0	1,184
	Very High	No. Assets	0	1	1	0	0	2

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
LV Poles	Low	No. Assets	0	0	0	0	0	-
	Average	No. Assets	22294	48074	35619	18524	458	124,969
	High	No. Assets	230	456	337	161	0	1,184
	Very High	No. Assets	0	1	1	0	0	2

Table 24 - Asset Health and Criticality 2023

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

Appendix 3 – Fault Data

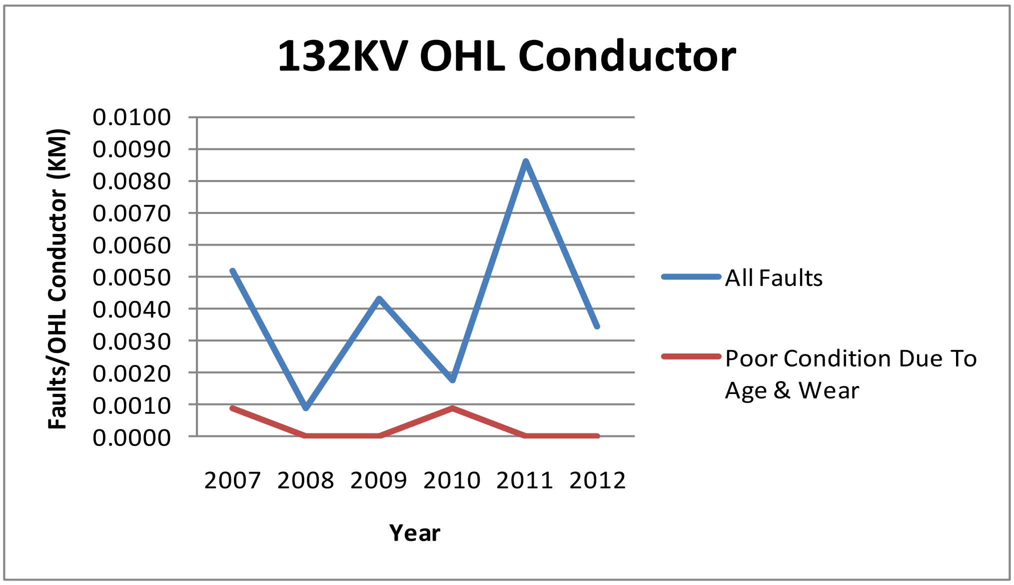


Figure 58 – Fault rate – 132kV OHL Conductor

(Source - UKPN Fault Cube)

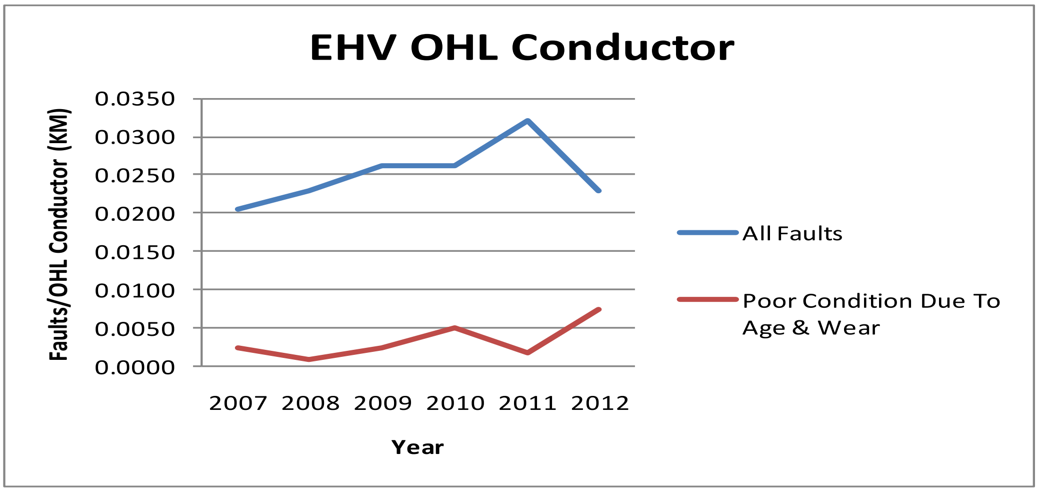


Figure 59 – Fault rate – EHV(33kV) OHL Conductor

(Source - UKPN Fault Cube)

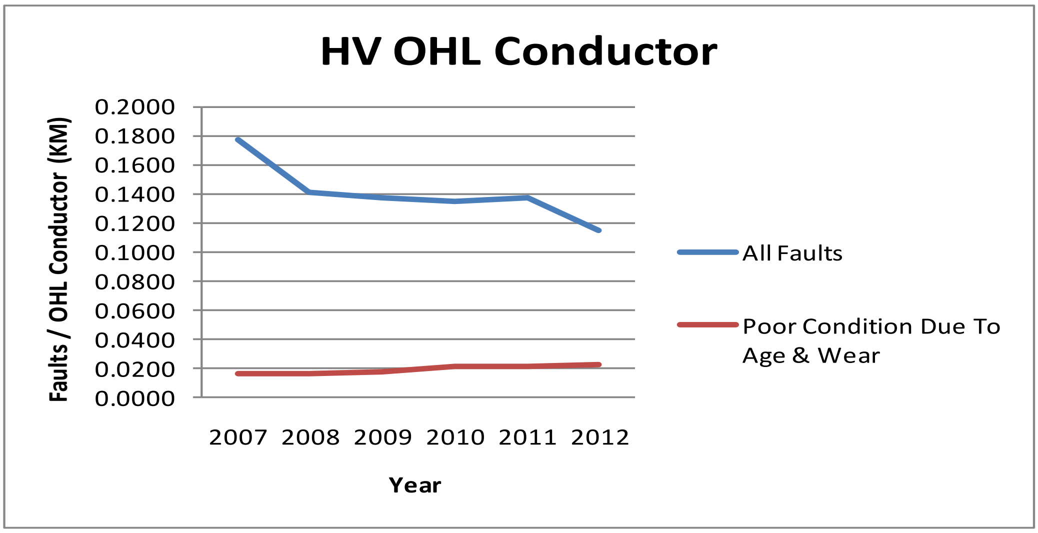


Figure 60 – Fault rate – HV OHL Conductor

(Source - UKPN Fault Cube)

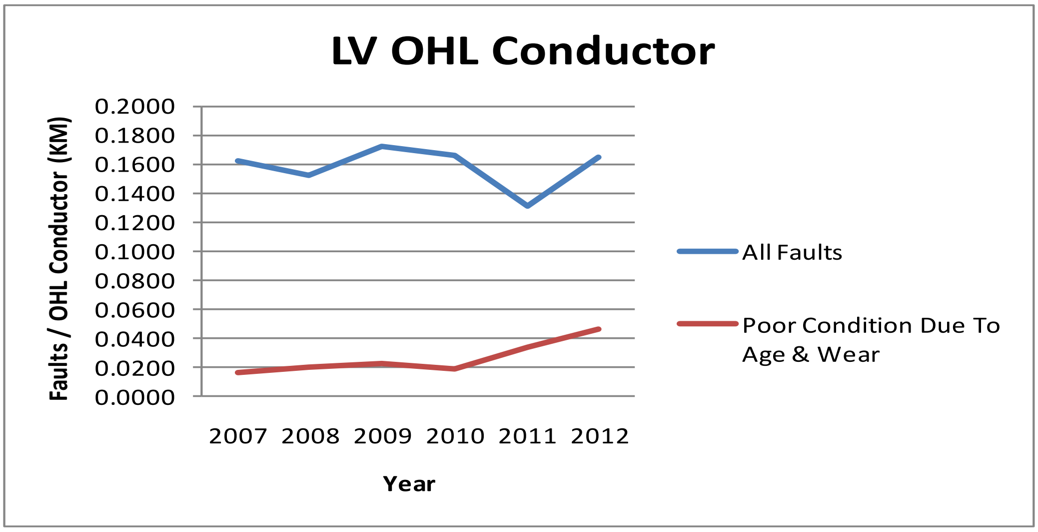


Figure 61 – Fault rate – LV OHL Conductor

(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
SPN	**Wood pole**	*LV wood pole*	*1.44.01*	*Replace LV wood poles ('D' condition)*	*1,577*	*1,577*	*1,577*	*1,577*	*1,577*	*1,577*	*1,577*	*1,577*
			1.41.03	*LV overhead line refurbishment (including ABC)*	*1,356*	*1,356*	*1,356*	*1,356*	*1,356*	*1,356*	*1,356*	*1,356*
		HV wood pole	*1.19.12*	*Replace HV wood poles*	*946*	*946*	*946*	*946*	*946*	*946*	*946*	*946*
			1.32.17	*HV OHL Renewal*	*1201*	*1201*	*1201*	*1201*	*1201*	*1201*	*1201*	*1201*
		HV OHL conductor	*1.32.19*	*Replace 0.025 11KV conductor*	*2,915*	*2,915*	*2,915*	*2,915*	*2,915*	*2,915*	*2,915*	*2,915*
		33kV wood pole	*1.09.04*	*Replace 33kV wood poles*	*230*	*230*	*230*	*230*	*230*	*230*	*230*	*230*
			1.09.01	*33kV wood pole OHL Renewal*	*1045*	*1977*	*439*	*645*	*575*	*750*	*1102*	*478*
			1.09.05	*33kV Wood Pole Refurbishment*	*54*	*54*	*54*	*54*	*54*	*54*	*54*	*54*
		Total (£k)			***9,324***	***10,256***	***8,718***	***8,924***	***8,854***	***9,029***	***9,381***	***8,757***

Table 25 - Wood Pole expenditure plan

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

Intervention Volumes for the OHL Support Poles

LV OHL Support Poles – Intervention Volumes								
DPCR4	1342	712	215	1059	972			
FBBQ	972	967	998	1048	1160			
DPCR5	1188	1049	1216	1500	1000			
ED1	1111	1111	1111	1111	1111	1111	1111	1111
ED2	1733	1733	1733	1733	1733	1733	1733	1733

Table 26 - Wood Pole forecast replacement volumes LV Poles

HV OHL Support Poles – Intervention Volumes								
DPCR4	853	146	264	536	154			
FBBQ	604	641	688	731	772			
DPCR5	231	507	480	731	700			
ED1	545	545	545	545	545	545	545	545
ED2	942	942	942	942	942	942	942	942

Table 27 - Wood Pole forecast replacement volumes HV Poles

EHV OHL Support Poles – Intervention Volumes								
DPCR4	20	188	52	53	20			
FBBQ	20	20	20	20	20			
DPCR5	156	42	29	60	45			
ED1	109	109	109	109	109	109	109	109
ED2	223	223	223	223	223	223	223	223

Table 28 - Wood Pole forecast replacement volumes 33kV Poles

(Source – 19th February 2014 NAMP Table O)

Proposed Expenditure for the OHL Support Poles

LV OHL Support Poles – Proposed Expenditures								
DPCR4	2.4	1.8	1.4	0.9	0.8			
FBBQ	1.38	1.37	1.42	1.49	1.65			
DPCR5	1.25	1.43	1.84	1.37	1.52			
ED1	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57
ED2	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46

Table 29 - Wood Pole expenditure plan LV Poles

HV OHL Support Poles – Proposed Expenditures								
DPCR4	1.2	0.4	0.1	0.1	0.5			
FBBQ	1.05	1.12	1.20	1.27	1.34			
DPCR5	0.61	0.32	1.59	1.22	0.95			
ED1	0.946	0.946	0.946	0.946	0.946	0.946	0.946	0.946
ED2	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63

Table 30 - Wood Pole expenditure plan HV Poles

EHV OHL Support Poles – Proposed Expenditures								
DPCR4	0.8	1	0.6	0.1	1.2			
FBBQ	0.04	0.04	0.04	0.04	0.04			
DPCR5	0.02	0.11	0.08	0.10	0.23			
ED1	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
ED2	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47

Table 31 - 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	0	0	0	0	0			
FBBQ	528	528	528	528	528			
DPCR5	0	0	2.645	1	12			
ED1	100	100	100	100	100	100	100	100
ED2	100	100	100	100	100	100	100	100

Table 32 - Wood Pole forecast replacement volumes LV Conductor

HV OHL Conductor - Intervention Volumes								
DPCR4	136	136	136	136	13			
FBBQ	180.9	180.9	180.9	180.9	180.9			
DPCR5	1	47	14.651	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 33 - Wood Pole forecast replacement volumes HV Conductor

EHV OHL Conductor - Intervention Volumes								
DPCR4	45	21	0	10.5	22.9			
FBBQ	17.1	1.3	5.4	5.4	5.4			
DPCR5	0	0	0.63	0.012	0			
ED1	0	72	0	13	6	10	29	9.004
ED2	17	17	17	17	17	17	17	17

Table 34 - Wood Pole forecast replacement volumes 33kV Conductor

(Source – 19th February 2014 NAMP Table O)

Proposed Expenditure for the OHL Conductors

LV OHL Conductor – Proposed Expenditures								
DPCR4	0	0	0	0	7.39			
FBBQ	7.39	7.39	7.39	7.39	7.39			
DPCR5	0.08	0.00	0.01	0.16	1.37			
ED1	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36
ED2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4

Table 35 - Wood Pole expenditure plan HV Conductor

HV OHL Conductor – Proposed Expenditures								
DPCR4	6.77	6.77	6.77	6.77	6.77			
FBBQ	9.00	9.00	9.00	9.00	9.00			
DPCR5	0.04	3.14	1.28	3.40	3.40			
ED1	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12
ED2	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4

Table 36 - Wood Pole expenditure plan HV Conductor

EHV OHL Conductor – Proposed Expenditures								
DPCR4	1.3005	0.6069	0	0.30345	0.66181			
FBBQ	0.49	0.04	0.16	0.16	0.16			
DPCR5	0	0.02	0	0.05	0.83			
ED1	0.76	1.69	0.15	0.36	0.29	0.47	0.82	0.19
ED2	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09

Table 37 - 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 SPN 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 SPN 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 SPN 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.

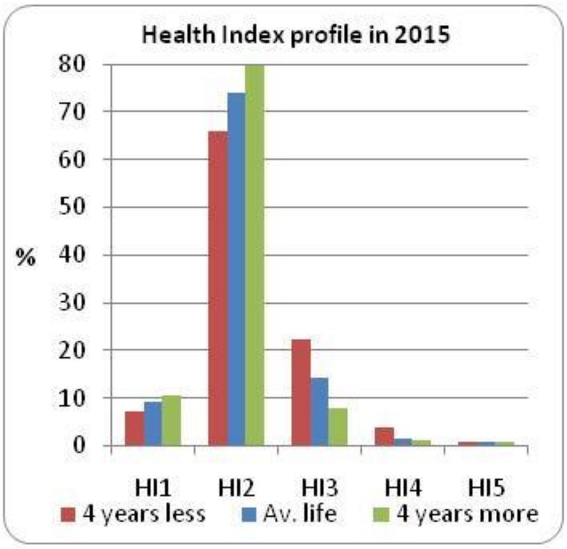
All results are shown below as the percentages of the population.

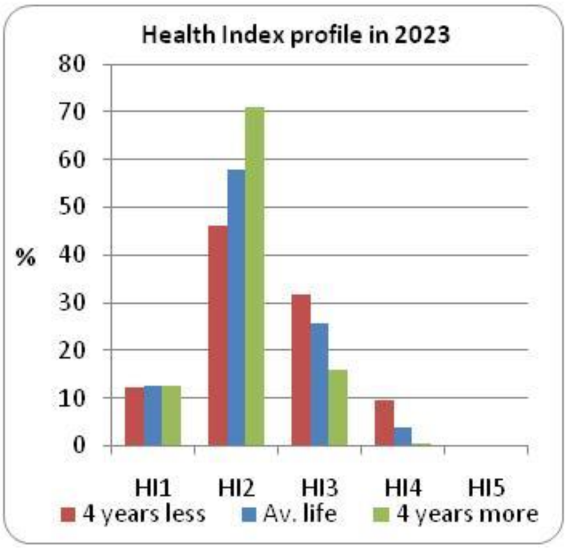
Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	7.1	65.9	22.2	3.8	0.9
-2	7.1	73.0	15.5	3.4	0.9
-1	9.1	73.1	14.4	2.4	0.9
0	9.1	74.1	14.3	1.5	0.9
1	9.3	76.2	12.0	1.5	0.9
2	10.3	76.2	11.1	1.5	0.9
4	10.4	79.6	8.0	1.1	0.9

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	12.4	46.3	31.8	9.5	0.0
-2	12.4	52.0	30.8	4.9	0.0
-1	12.6	54.9	28.4	4.1	0.0
0	12.6	57.8	25.5	4.0	0.0
1	12.7	62.2	21.3	3.9	0.0
2	12.7	65.3	19.7	2.3	0.0
4	12.7	70.9	16.0	0.4	0.0

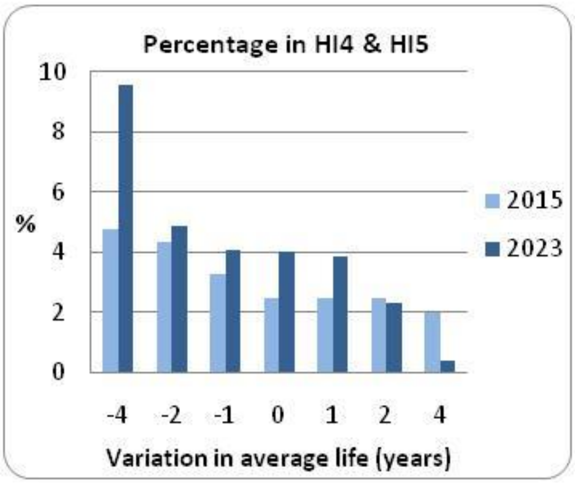
As the percentages above are rounded, the sum of a row may be 0.2% above or below 100%.

The upper and lower and current average 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 2015 and 2023.
- In 2015, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 2.4% to 2.0%; if four years shorter, it will increase to 4.7%.
- In 2023, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 4.0% to 0.4%; if four years shorter, it will increase to 9.5%.

Conclusion

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

Sensitivity Analysis

Asset Risk and Prioritisation Model for SPN 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 SPN 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 SPN 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.

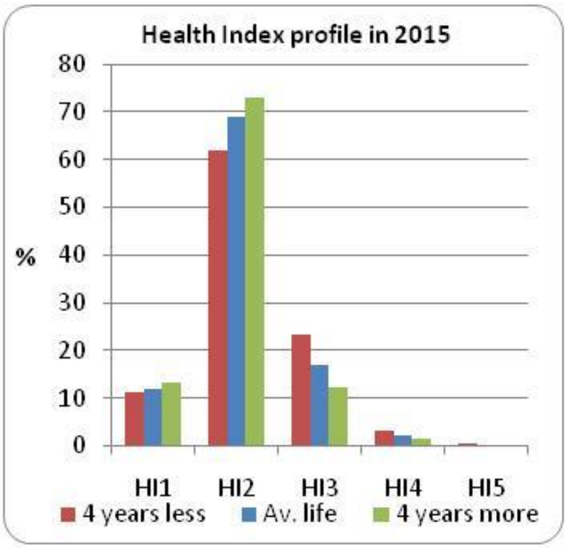
All results are shown below as the percentages of the population.

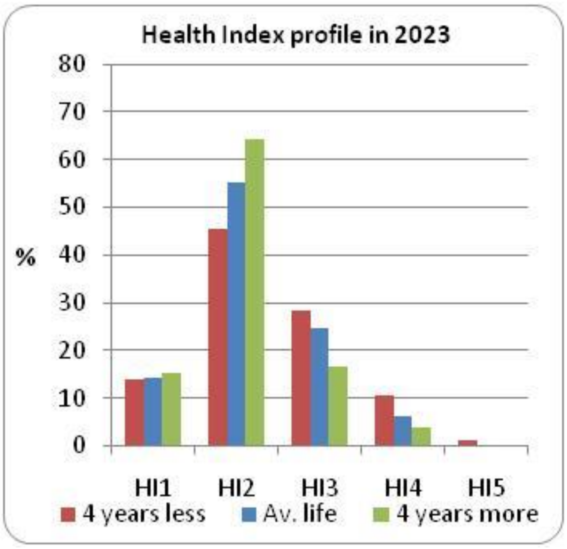
Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	11.4	61.9	23.3	3.3	0.1
-2	11.4	66.1	19.8	2.6	0.0
-1	11.9	67.4	18.3	2.4	0.0
0	11.9	68.9	17.0	2.2	0.0
1	12.2	70.4	15.2	2.2	0.0
2	12.5	72.1	13.5	2.0	0.0
4	13.2	73.1	12.2	1.5	0.0

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	14.0	45.6	28.5	10.6	1.3
-2	14.2	50.9	26.9	7.3	0.7
-1	14.2	53.2	25.4	6.9	0.2
0	14.2	55.1	24.6	6.1	0.0
1	14.6	57.2	22.4	5.8	0.0
2	14.8	59.8	20.1	5.3	0.0
4	15.2	64.4	16.7	3.8	0.0

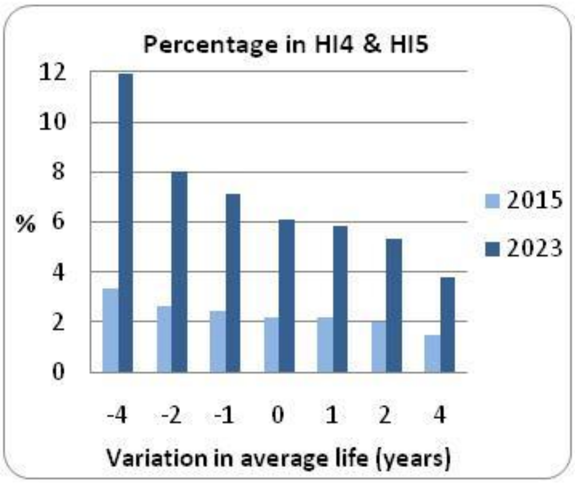
As the percentages above are rounded, the sum of a row may be 0.2% above or below 100%.

The upper and lower and current average 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 and possibly also in 2015.
- In 2015, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 2.2% to 1.5%; if four years shorter, it will remain at 3.4%.
- In 2023, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 6.1% to 3.8%; if four years shorter, it will increase to 11.9%.

Conclusion

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

Sensitivity Analysis:

Asset Risk and Prioritisation Model for SPN 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 SPN 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 SPN 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.

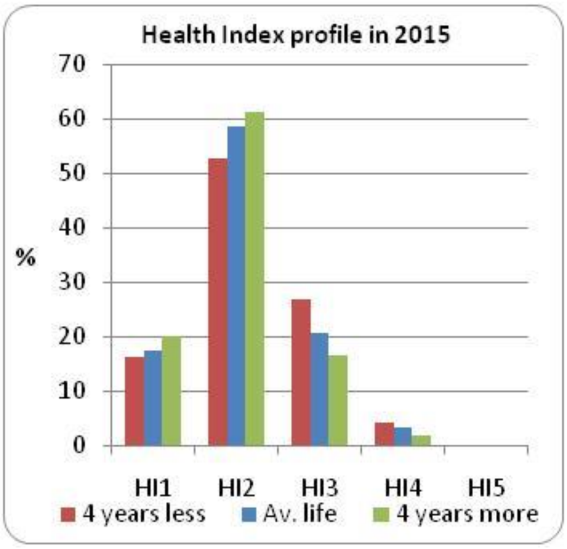
All results are shown below as the percentages of the population.

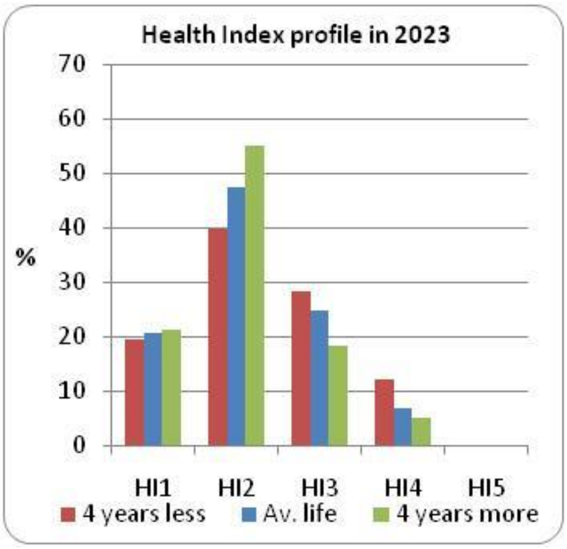
Average life change	**2015** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	16.2	52.7	26.8	4.3	0.0
-2	17.1	55.7	23.4	3.8	0.0
-1	17.4	57.2	21.8	3.6	0.0
0	17.4	58.5	20.8	3.2	0.0
1	19.1	58.4	19.3	3.2	0.0
2	19.4	59.9	17.7	3.0	0.0
4	20.1	61.3	16.6	2.0	0.0

Average life change	**2023** percentage HI profile				
	HI1	HI2	HI3	HI4	HI5
-4	19.6	39.8	28.4	12.2	0.0
-2	20.1	42.4	28.5	8.9	0.0
-1	20.6	44.6	26.7	8.1	0.0
0	20.7	47.4	25.0	7.0	0.0
1	21.1	48.9	23.2	6.7	0.0
2	21.2	51.9	20.8	6.1	0.0
4	21.4	55.0	18.4	5.2	0.0

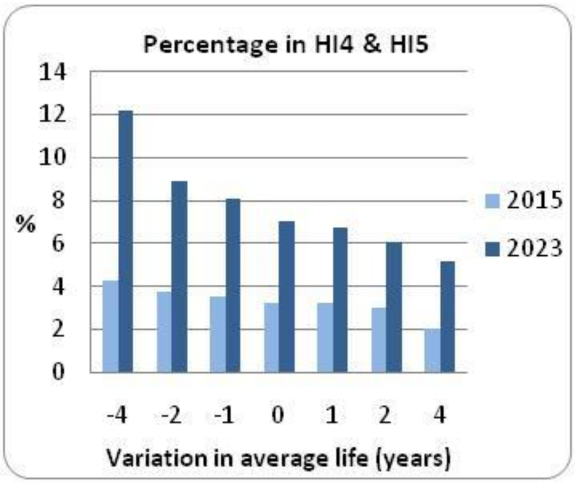
As the percentages above are rounded, the sum of a row may be 0.2% above or below 100%.

The upper and lower and current average 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 and possibly also in 2015.
- In 2015, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 3.2% to 2.0%; if four years shorter, it will remain at 4.3%.
- In 2023, if average life is four years longer, the proportion of HI4 and HI5 assets will reduce from 7.0% to 5.2%; if four years shorter, it will increase to 12.2%.

Conclusion

The ED1 replacement plan for SPN LV OHL support (poles) is moderately 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
Chelsfield Grid/Four Elms (Sundridge Zone)	33kV OHL Conductor	Asset Health	No
Canterbury South/Wingham	33kV OHL Conductor	Asset Health	No
Hartley Grid/Goudhurst	33kV OHL Conductor	Asset Health	No
Sellindge Grid local/Stanford & Tees	33kV OHL Conductor	Asset Health	No
Folkestone/ShorncliffeHythe No1	33kV OHL Conductor	Asset Health	No
Lewes Grid/Lewes Town No2	33kV OHL Conductor	Asset Health	No
Medway Grid/Wrotham Heath No2	33kV OHL Conductor	Asset Health	Yes
Lewes Grid/Lewes Town No1	33kV OHL Conductor	Asset Health	No
Ashford Grid/Smeeth	33kV OHL Conductor	Asset Health	No
Northfleet East Grid/Shornewood No1	33kV OHL Conductor	Asset Health	No
Northfleet East Grid/Shornewood No2	33kV OHL Conductor	Asset Health	No

Table 38 – 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									
	NAMP Line	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	1,111	1,111	1,111	1,111	1,111	1,111	1,111	1,111	**8,888**
HV Wood Pole	1.19.12	545	545	545	545	545	545	545	545	**4,360**
33kV Wood Pole	1.09.04	109	109	109	109	109	109	109	109	**872**
Conductor Replacement										
LV Overhead Line Renewal	1.41.03	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	**800.0**
HV Conductor Renewal	1.32.13	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	**557.8**
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**
33kV Overhead Renewals	1.09.01	0.0	72.0	0.0	13.0	6.0	10.0	29.0	9.0	**139.0**
Wood Pole Refurbishment										
33kV Refurbishment	1.09.05	340.0	340.0	340.0	340.0	340.0	340.0	340.0	340.0	**2,720**
Total		**2,343.44**	**2,415.45**	**2,343.45**	**2,356.45**	**2,349.45**	**2,353.45**	**2,372.45**	**2,352.45**	**18,886.59**

	VOLUMES										
Outputs	RIG Table										
	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	CV3	8	1,111	1,111	1,111	1,111	1,111	1,111	1,111	1,111	**8,888**
HV Wood Pole	CV3	27	545	545	545	545	545	545	545	545	**4,360**
33kV Wood Pole	CV3	53	109	109	109	109	109	109	109	109	**872**
Conductor Replacement											
LV Overhead Line Renewal	CV3	6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	**800.0**
HV Conductor Renewal	CV3	23	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	**557.8**
HV Conductor (0.025)	CV3	24	68.7	68.7	68.7	68.7	68.7	68.7	68.7	68.7	**549.8**
33kV Overhead Renewals	CV3	52	0.0	72.0	0.0	13.0	6.0	10.0	29.0	9.0	**139.0**
Wood Pole Refurbishment											
33kV Refurbishment	CV5	28	340.0	340.0	340.0	340.0	340.0	340.0	340.0	340.0	**2,720**
Total			**2,343.44**	**2,415.45**	**2,343.45**	**2,356.45**	**2,349.45**	**2,353.45**	**2,372.45**	**2,352.45**	**18,886.59**

[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

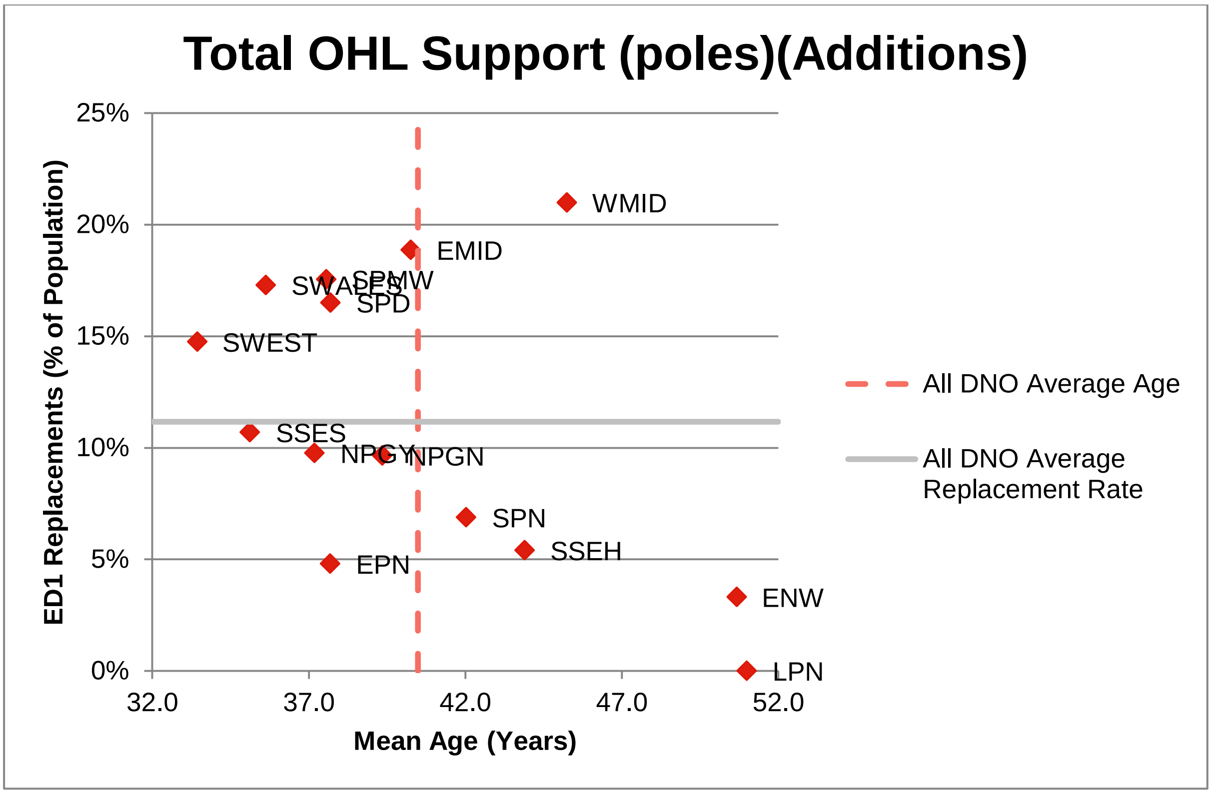


Figure 62 - Levels of proposed asset replacement in ED1 as a percentage of installed network

The graph shows that SPN'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	550	558	+8	CV5 to CV3 change equates to adding 640km conductor to CV3. 549.76km in 2013 moved to CV3 24
		UCI (£k)	49.8	23.8	-26	UCI reduced as poles replaced will be on the D pole line CV3 27
		Investment (£m) Row 23	27.4	13.3	-14.1	
	Replace	Volume km (BLX Conductor) Row 24	0	550	+550	Movement of +549.76km from CV3 23 to CV3 24
		UCI (£k)	0	35.7	+35.7	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	19.6	+19.6	
	TOTAL	**Investment Row 23 and 24 (£m)**	**27.4**	**32.9**	**+5.5**	

Table 39 – 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 (SPN) V4a	Replace	Volume (Poles)	280	5936	+5,656	+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 40 – 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 (conductor replacement) and CV3 27 (pole replacement). In monetary terms this means there was a movement of £18.34m 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 £5.5m and net increase of HV OHL conductor of 558km.