OVERHEAD LINES PORTFOLIO OVERVIEW	
Name of Scheme/Programme	Overhead Lines Portfolio Overview
Primary Investment Driver	Asset Health
Scheme reference/ mechanism or category	N/A
Output references/type	N/A
Cost	N/A
Delivery Year	N/A
Reporting Table	N/A
Outputs included in RIIO T1 Business Plan	N/A

Issue Date	Issue No	Amendment Details
October 2019	Issue 1	First issue of document
December 2019	Issue 2	Updated to reflect final business plan

Table of contents

1. INTRODUCTION

This paper provides an overview of the overhead line (OHL) assets and health issues while defining the strategy on how they are prioritised for intervention.

OHL routes shall be maintained, refurbished or have critical components replaced to maintain reliability, operational risk and safety performance at a level which meets defined criteria.

A method has been defined for detailed condition assessment, based upon present condition, known failure mechanisms, technical asset lives for the various OHL components and their key deterioration patterns, criticality of routes in terms of failure consequences, strategic importance, environmental aspects and innovation.

The OHL refurbishment and replacement strategy is also based upon the NOMS asset risk methodology as implemented with the SPEN CBRM tool. SPEN OHL CBRM model has been built and developed from the NOMS methodology based on components' condition assessment and ageing which determine a Probability of Failure (PoF) for each route. The Steel Tower OHL model comprises a number of composite models which define the PoF and Consequences of Failure (CoF), the combination of which determines the risk, for the following components:

- Steel towers, per tower.
- Conductor, per phase circuit and span.
- Earthwire, per span.
- Phase conductor fittings/insulators, per circuit and tower.
- Earthwire fittings, per tower.

2. OVERVIEW OF ASSETS AND HEALTH ISSUES

The 132kV network was built largely before mid-1960s utilising ACSR core only greased conductors.

The 275kV network was built in the 1960s and 400kV Network established in early 1970s utilising core only greased ACSR conductors up to the mid-1960s and all inner layers greased after this. It should be noted that the 400kV network has grown since the 1990s mainly by uprating existing 275kV routes.

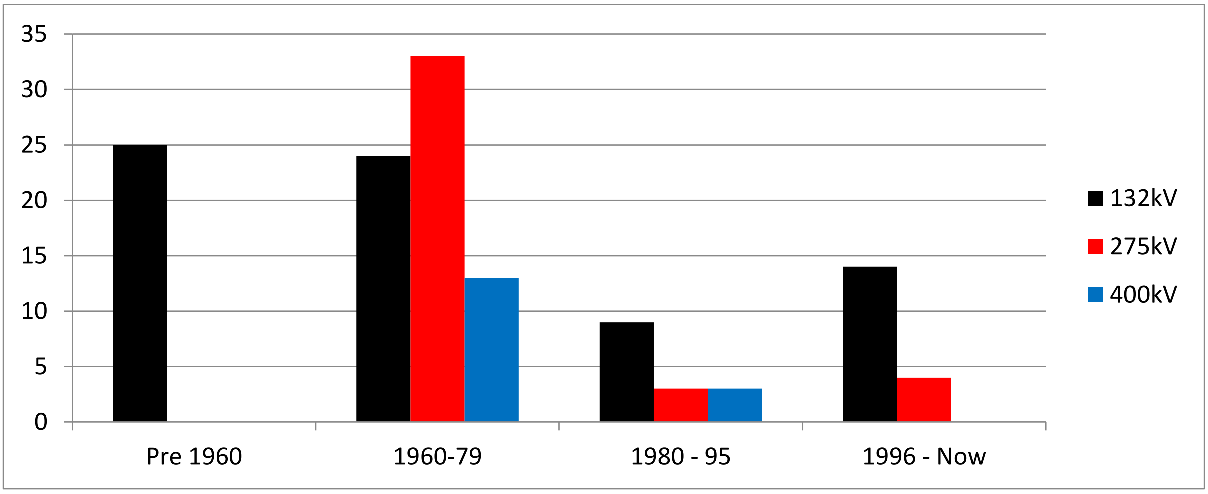

Figure 1: OHL Route construction period.

The current asset management strategy for overhead lines focuses on optimising the replacement programme of ACSR core-only greased conductors. This is based on evidence collected across the network for this type of OHL conductor and its corrosion rates. The strategy for ACSR all inner layer greased conductor is to replace spacer and damper systems to reduce fatigue and reduce the risk of wind induced damage.

Every overhead line route is assessed in detail, prioritising those in poorest condition due to environmental pollution and by risk. When viewed over the long term, the optimised profile for replacement results in a rate of 70-90 circuit km. per year. The programme commenced in RIIO-T1 and the forecast is, based on condition and risk, co-ordinating with load-related works, that the programme will complete by RIIO-T3.

By following this strategy, the replacement of the large volume of ACSR core only greased conductor installed in the 1960s can be well planned by optimising outages availability and by managing the right level of contractors required to carry out the works.

3. RIIO-T2 INVESTMENT PLAN OVERVIEW

3.1 OHL Conductors

ACSR (Aluminium Conductor Steel Reinforcement) conductors have been used at 132kV and above since the 1930s. Two phase conductor types are used:

- **ACSR 175mm^2 "Lynx":** 7 steel wires and 2 aluminium layers. Used as phase conductor on 132kV and as earthwire on 275/400kV twin conductor overhead line routes.
- **ACSR 400mm^2 "Zebra":** 7 steel wires and 3 aluminium layers. Used as phase conductor on 132/275/400kV and as earthwire on 275/400kV quad conductor overhead line routes.

These greased ACSR type conductors predominated from the 1940s up to 1980s, however, in the 1990s the industry began moving instead towards the use of All Aluminium Alloy Conductors (AAAC) as a natural replacement of original ACSR conductor which gave a similar performance whilst reducing the risk of corrosion. The types of AAAC conductors used are: AAAC 200mm^2 "Poplar", AAAC 250mm^2 "Sycamore", AAAC 300mm^2 "Upas", AAAC 425mm^2 "Totara", AAAC 500mm^2 "Rubus", AAAC 700mm^2 "Araucaria".

ACSR conductor life is based on the measurement of loss of strength caused by corrosion and/or wind induced damage (fatigue):

- **Internal corrosion** is caused principally by industrial and sea salt pollution in the presence of moisture. Inspection techniques like Cormon and conductor samples are used to understand the level of deterioration of the sample.

  All SPT's ACSR conductors had grease applied during manufacture to prevent corrosion of the steel core. In the 1940-65/70 period, grease was applied to the steel core only, whereas at later dates all of the inner layers were greased. Considerable overlap of the 1965/70 transition date occurred with different manufacturers. ACSR conductors with grease applied only on the steel core are considerably more susceptible to severe internal corrosion.
- **Wind induced damage** induced by oscillation of the main OHL components will generally cause damage by fatigue. Quad and twin bundles are prone to wear due to wind induced oscillation. This causes damage to the conductor at spacer clamping positions with the damage determining end of life. Inspection techniques such as visual inspections, experience with certain types of equipment in the past (spacers) and infra-red thermography are used to assess the risk.

A summary of the current description of asset based is shown in graphic below:

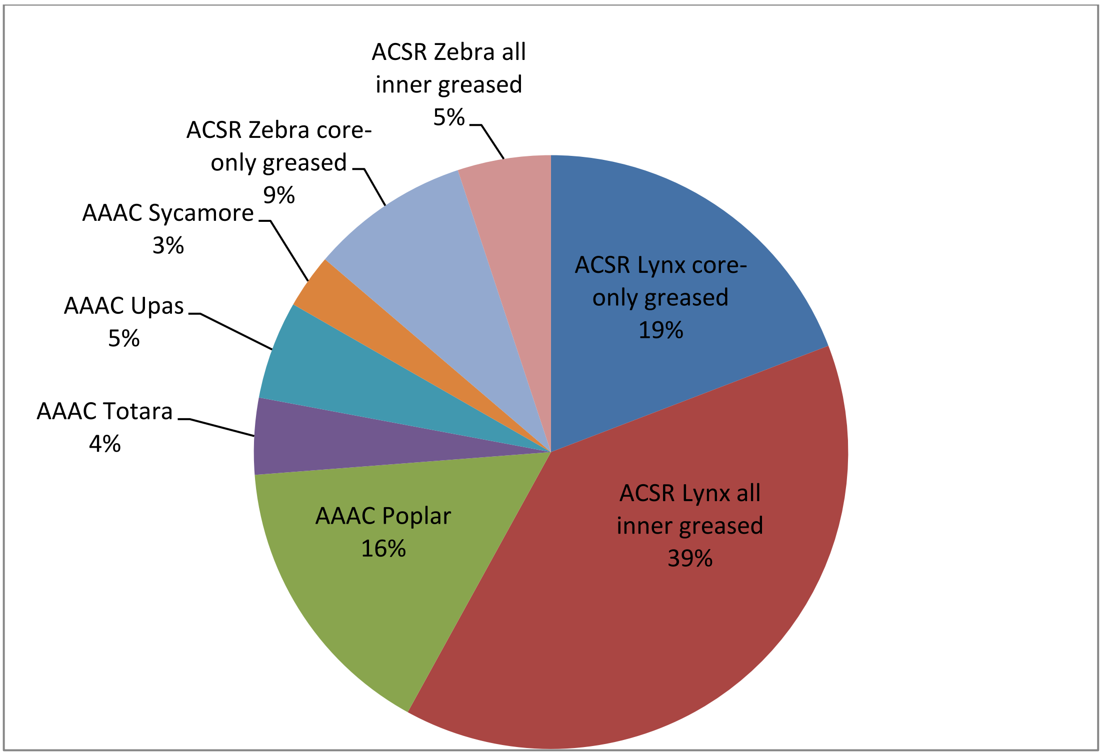

Figure 2: 132kV phase conductor population by 2021 in SPEN Transmission Network.

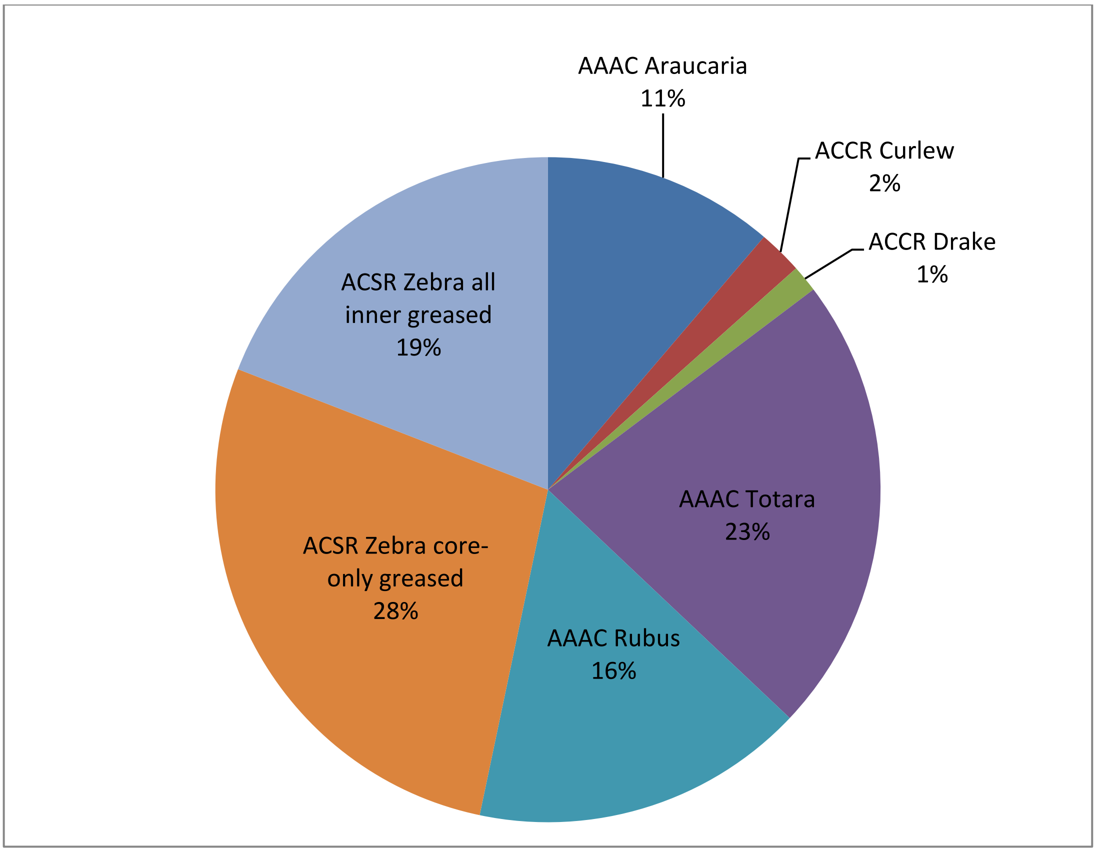

Figure 3: 275/400kV phase conductor population by 2021 in SPEN Transmission Network.

The RIIO-T2 plan for OHL conductor replacement is summarised below and compared against RIIO-T1 plan:

RIIO-T1 Major Interventions *(8 years)* *Conductor Replacement*		
Asset	**Volume (cct. Km)**	**Cost (£M)**
132kV ACSR “Lynx” core-only greased	297	**204**
132kV ACSR “Zebra” core-only greased	-	
275/400kV ACSR “Zebra” core-only greased	425	
275/400kV ACSR “Zebra” all inner greased	-	
TOTALS/YEAR	**90**	**26**

Table 1: RIIO-T1 plan as per RRP July 2019.

RIIO-T2 Major Interventions *(5 years)* *Conductor Replacement*		
Asset	**Volume (cct. Km)**	**Cost (£M)**
132kV ACSR “Lynx” core-only greased	103	**103.2**
132kV ACSR “Zebra” core-only greased	45	
275/400kV ACSR “Zebra” core-only greased	150	
275/400kV ACSR “Zebra” all inner greased	36	
TOTALS/YEAR	**67**	**21**

Table 2: RIIO-T2 plan.

Note that there is an additional 400kV route (136 cct. Km) that is proposed as a ring-fenced PCD.

An overview of the overhead line conductor asset condition by 2021 is summarised in graphic below. It highlights routes for intervention in RIIO-T2 (in red) and those planned for RIIO-T3 (amber):

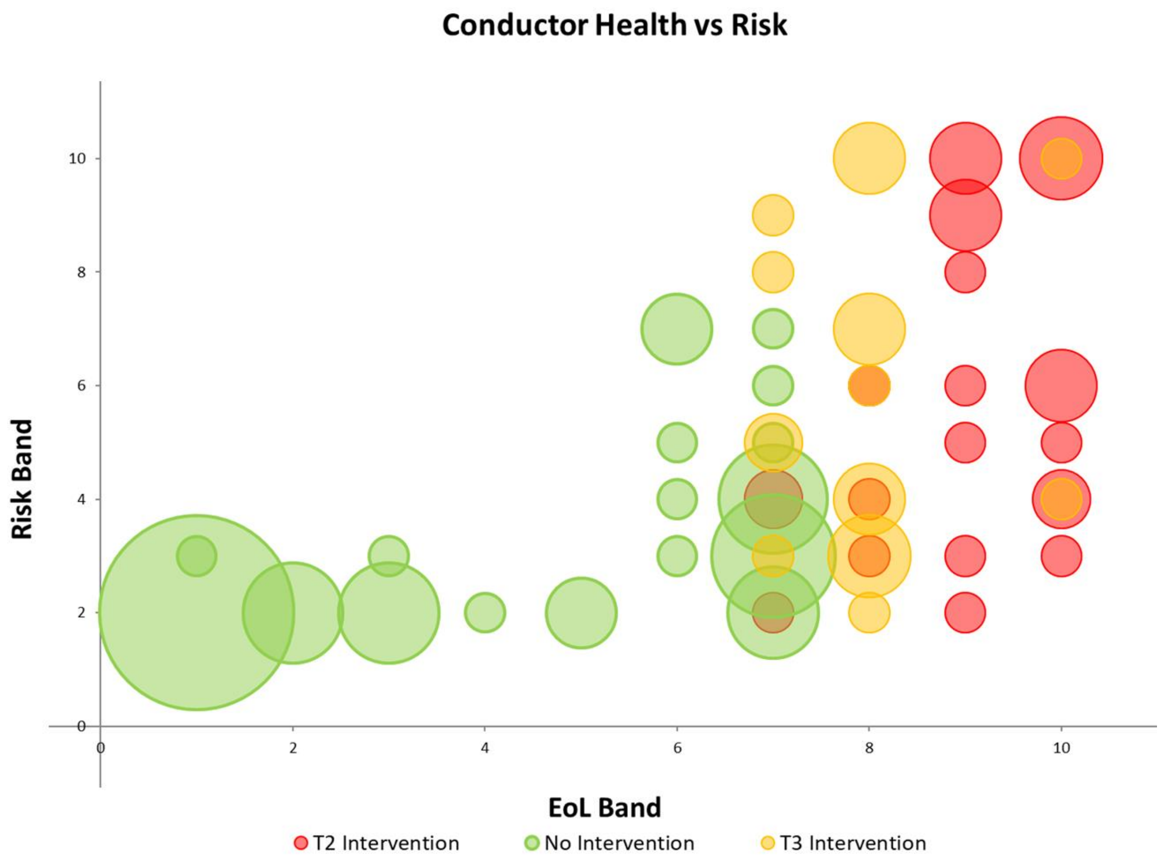

Figure 4: OHL conductor asset condition overview by 2021 in SPEN Transmission Network.

It should be noted that there are some assets in higher bands that have not been planned for intervention until RIIO-T3. These interventions have been profiled in this way for the following reasons:

- There is an interactive load-related project planned in RIIO-T3. The load-related works in some cases require the same solution but the non-load works have not been included in the RIIO-T2 plan to avoid unnecessary outages affecting major system boundaries. In other cases, the load-related solution may be different, and the approach taken avoids stranded investment. In all cases, a detailed assessment of the assets has verified that the risk is manageable until the load-related project is delivered.
- We have prioritised some interventions over others with the same lead asset issues. The projects that we plan to complete in RIIO-T3 do not have as severe issues with non-lead assets. The holistic view of the whole asset base – not placing undue focus on the single risk value of the lead assets – has informed these decisions.

Where the decision has been taken to defer an intervention as outlined in the two points above, we ensure that we have plans in place to increase surveillance (where applicable), and to recover from failures should they occur.

Graphics below provides an overview of current asset base and compared against end of RIIO-T2 period after interventions by 2026. It also shows projection to 2031 after completion of interventions (excluding load related works).

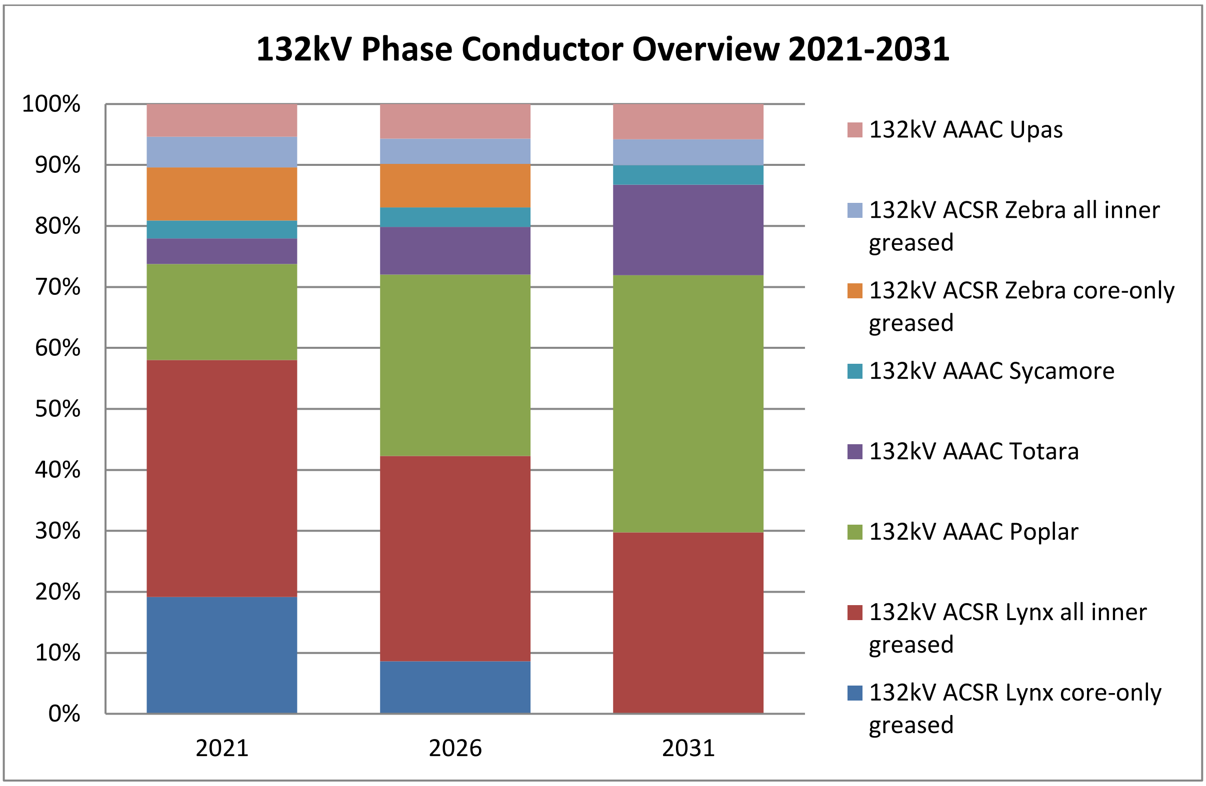

Figure 5: 132kV phase conductor overview 2021-2031.

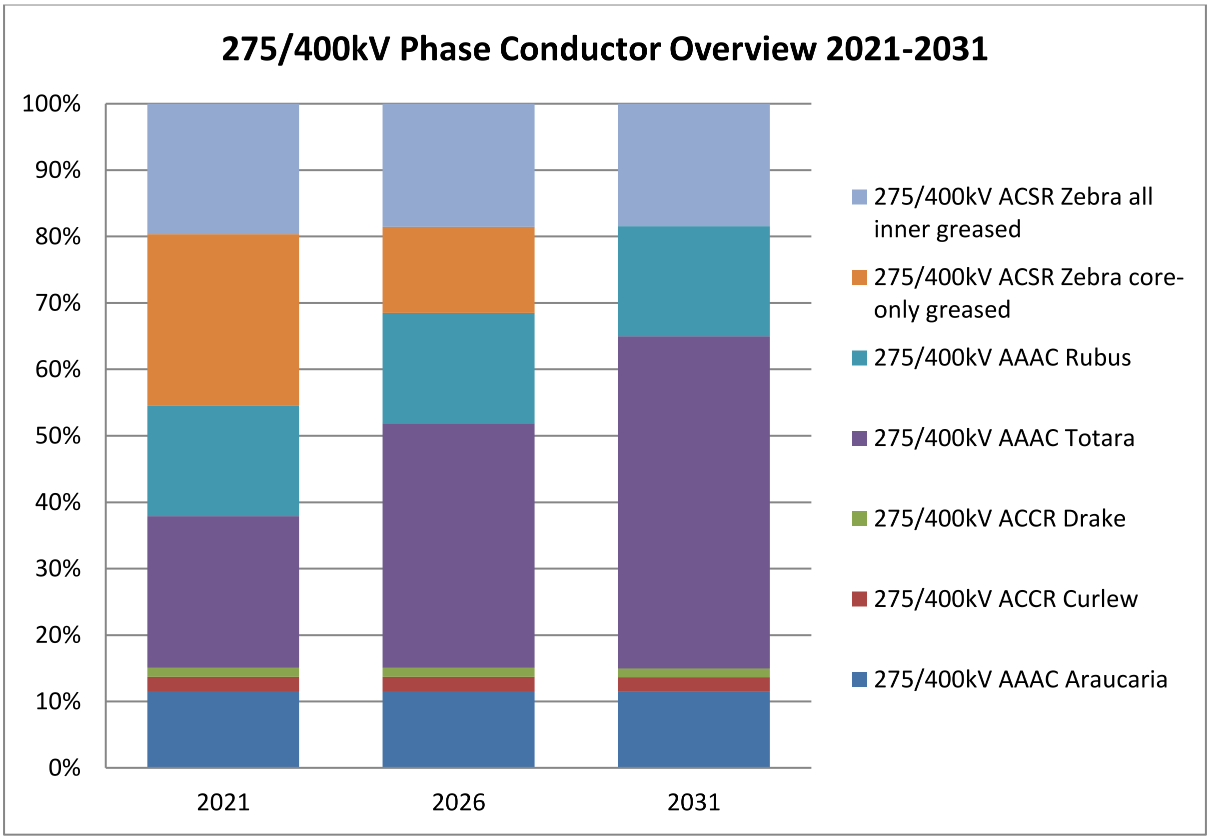

Figure 6: 275/400kV phase conductor overview 2021-2031

3.2 OHL Fittings

The key life limiting factors affecting the health of conductor fittings and insulators are:

- Corrosion of components.
- Failures of brown porcelain insulators caused by corrosion of the steel pin of the cap and pin assembly.
- Loss of the split pin and washer from the swivel pin at the earth end of suspension insulators on 400kV L6 lines has resulted in failure of insulator strings.
- Problems reported on Andre spacer installed on L6 routes causing damage to the external layers of the conductors.
- Vibration effect, mostly on bundled conductors and more severe on quad bundles. Damage mostly occurs around fittings affecting the aluminium strands.
- Tate and Noral compression joints on ACSR.

An overview of the overhead line fittings asset base by 2021 is summarised in graphic below:

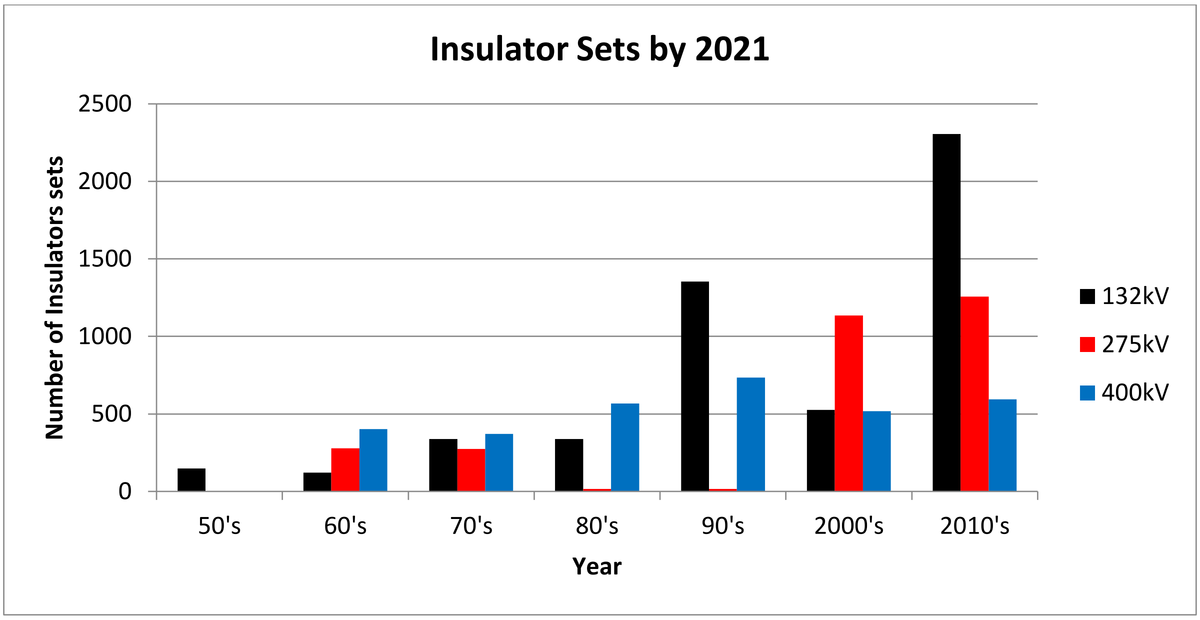

Figure 7: insulator set profile by 2021 in SPEN Transmission Network.

RIIO-T2 plan for OHL Fittings replacement is summarised below and compared against RIIO-T1 plan:

RIIO-T1 Minor Interventions *(8 years)* *Involve Insulator and Spacer Replacement*		
Asset	**Volume (sets)**	**Cost (£M)**
132kV Routes	997	44.5
275kV Routes	908	
400kV Routes	12	
TOTALS/YEAR	**383**	**5.56**

Table 3: RIIO-T1 plan as per RRP July 2019.

RIIO-T2 Minor Interventions *(5 years)* *Involve Insulator and Spacer Replacement*		
Asset	**Volume (sets)**	**Cost (£M)**
132kV Routes	-	39.54
275kV Routes	485	
400kV Routes	751	
TOTALS/YEAR	**247**	**7.91**

Table 4: RIIO-T2 plan.

An overview of the overhead line fittings asset condition by 2021 is summarised in graphic below. It highlights routes for intervention in RIIO-T2 (in red):

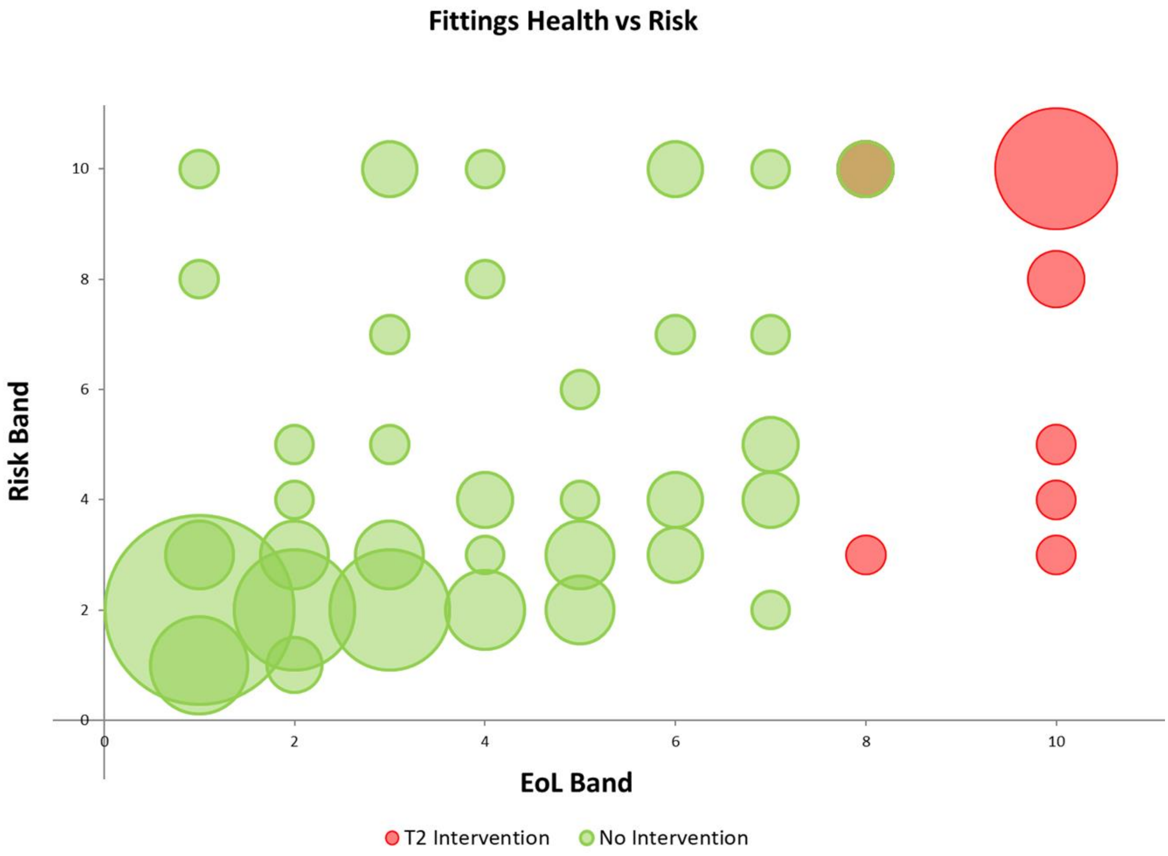

Figure 8: OHL fittings asset condition overview by 2021

The chart below provides an overview of overhead line fitting asset base by end of RIIO-T2 period after interventions.

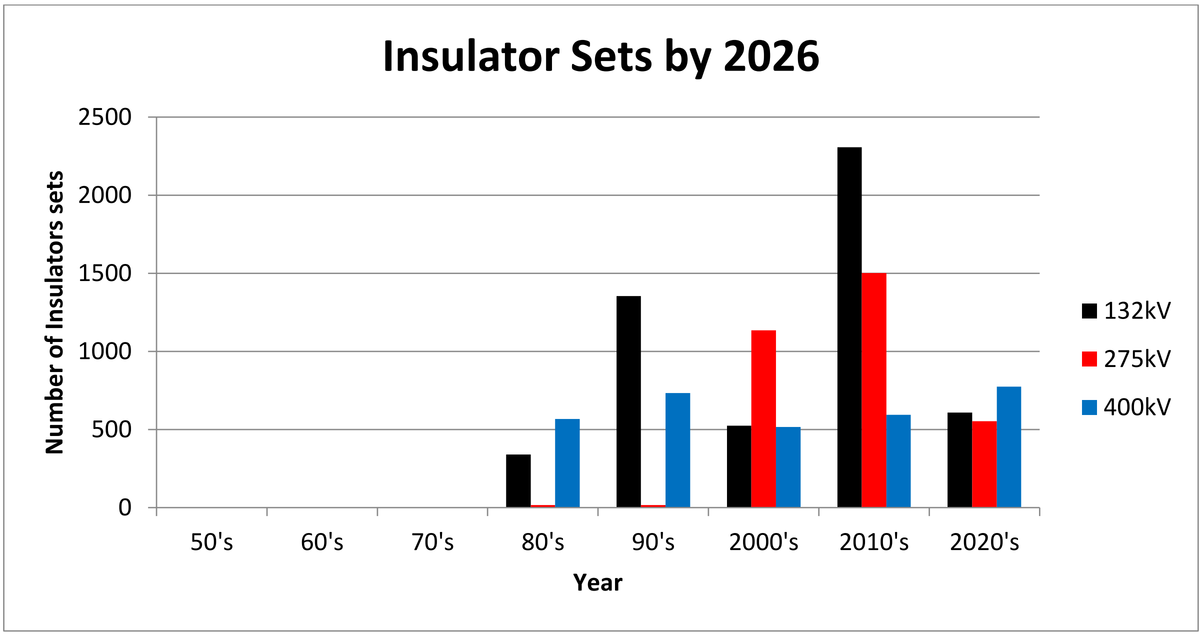

Figure 8: insulator set profile by 2021.

3.3 OHL Towers and Poles

The key life limiting processes affecting structures are:

- Corrosion of towers occurs when the paint system deteriorates and the galvanising corrodes.
- Current design codes which bring limitations to historical tower designs.
- TGN 161: L8 and L2 (D, D10 and D30) inability to withstand broken wire design loading conditions.
- TGN 163: Suspension insulator crossarm attachment channel weakness on L2 and L3 towers.
- EMI 925: L6 J.L. Eve notched type bracing failure as a result of prolonged wind loading.

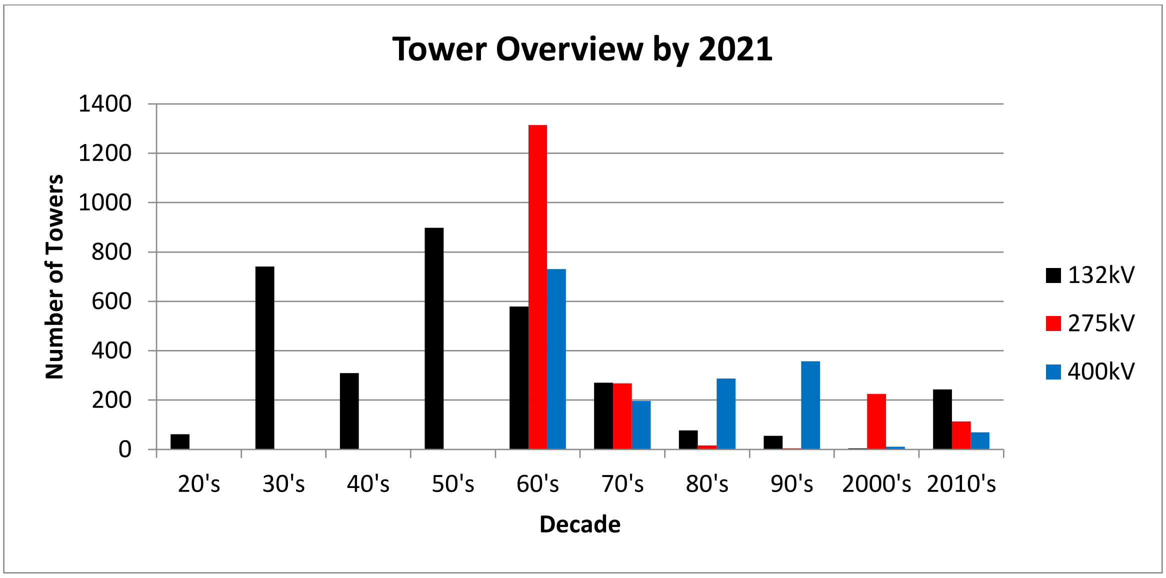

Figure 6: OHL tower profile by 2021.

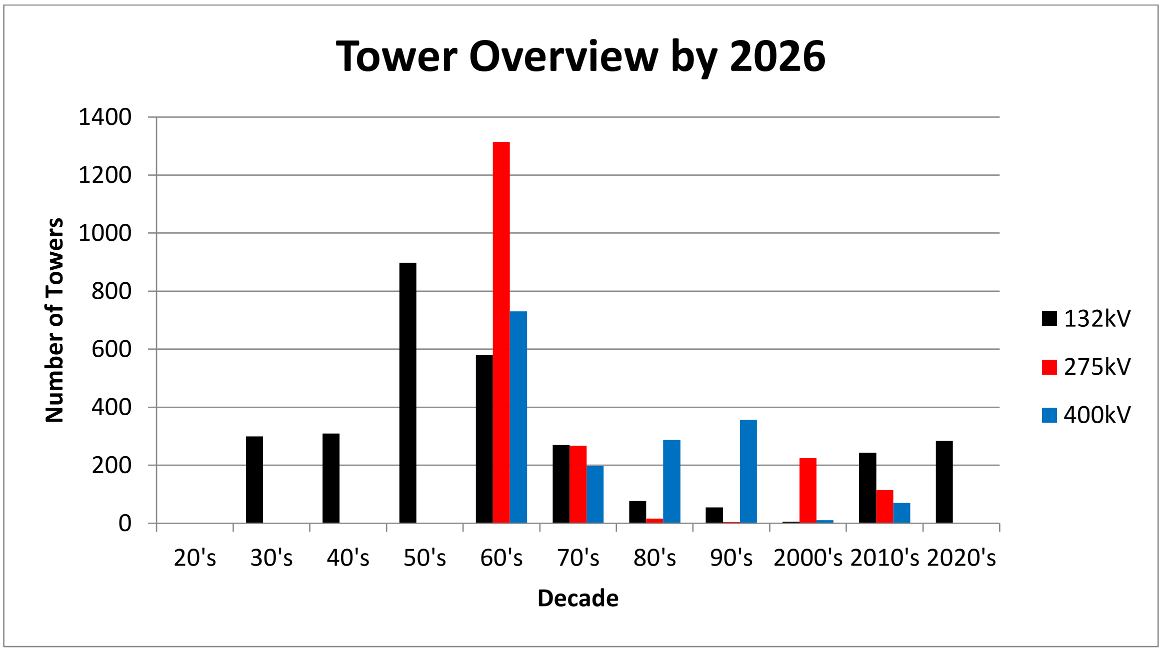

Figure 7: OHL tower profile by 2026.

Poles:

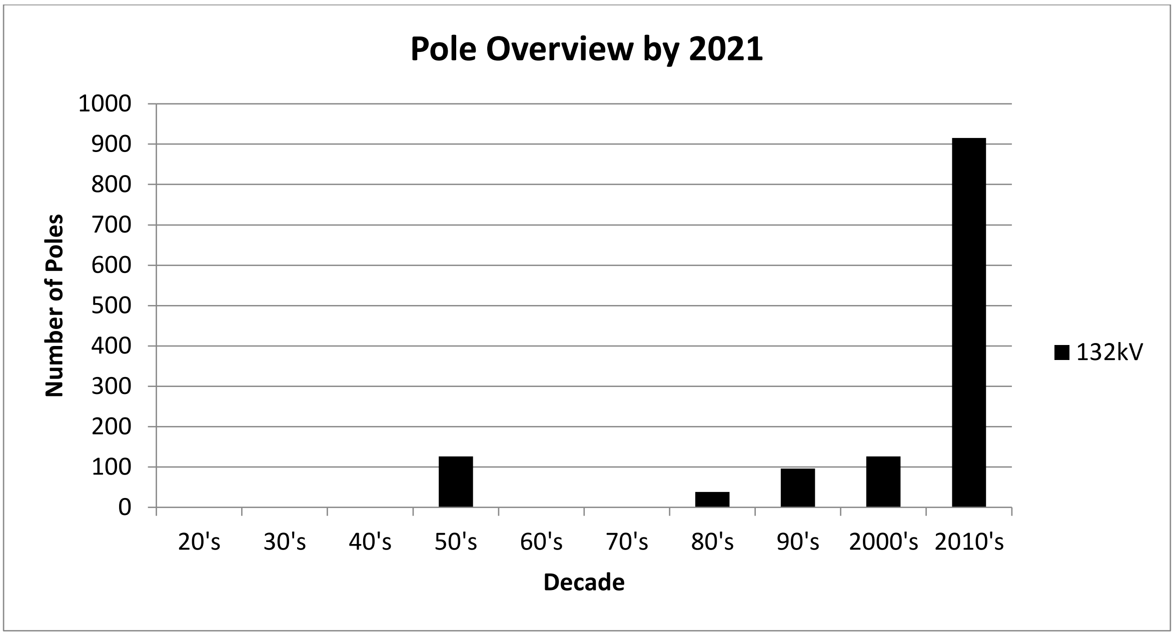

Figure 8: OHL pole profile by 2021.

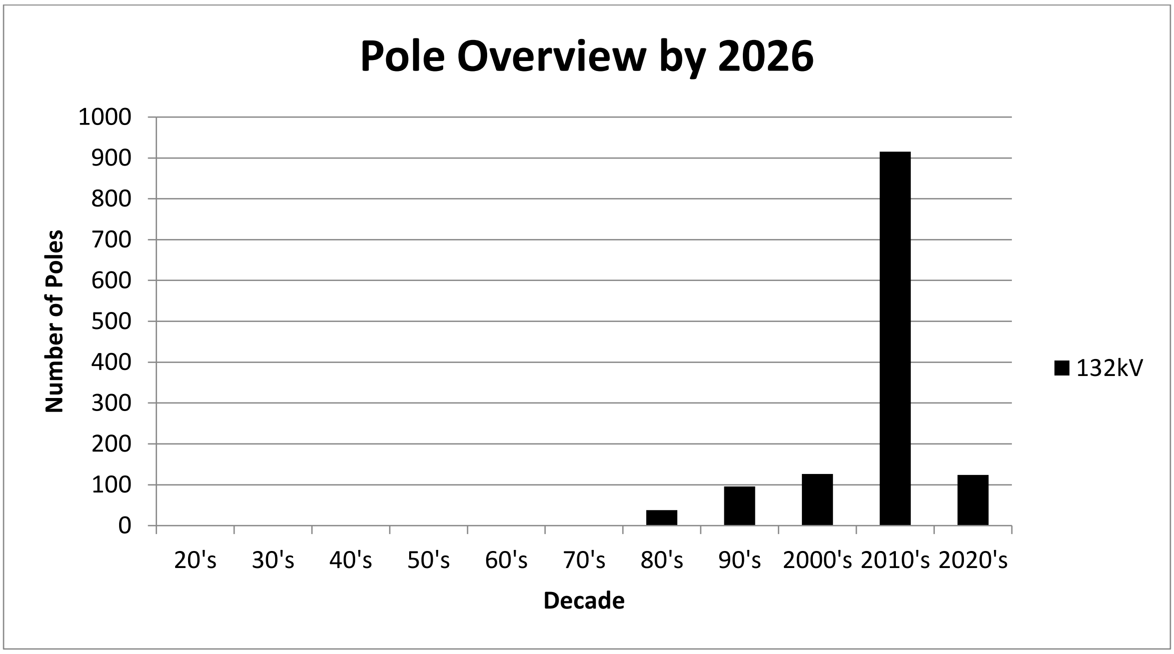

Figure 9: OHL pole profile by 2026.