

## Transmission Line Renewal and Maintenance Strategy

### Summary

This strategy guides the management of TransGrid's existing transmission line assets.

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# Contents

1.	Purpose .....	4
2.	Positioning within the Asset Management Framework.....	4
3.	Definitions .....	5
4.	Asset Management Strategy ‘Line of Sight’ .....	5
5.	Review of Previous Renewal, Disposal and Maintenance Strategies .....	7
5.1	Review of Renewal and Maintenance Initiatives.....	7
5.1.1	Historical Expenditure .....	7
5.1.2	Effectiveness of Renewal, Maintenance and Disposal Initiatives.....	7
5.2	Review of Maintenance Program .....	17
5.3	Past Performance – Asset Management Performance Indicators .....	18
6.	Transmission Line Asset Overview .....	22
6.1	Scope of Assets .....	22
6.2	Asset Base .....	22
7.	Transmission Line Asset Review .....	26
7.1	Implementation of the Renewal and Maintenance Decision Process.....	26
7.2	500 kV Transmission Lines Asset Review .....	28
7.2.1	Population Review .....	28
7.2.2	Emerging Issues, and Renewal and Maintenance Initiatives .....	28
7.2.3	500 kV Maintenance Program .....	32
7.3	330 kV Transmission Lines Asset Review .....	32
7.3.1	Population Review .....	32
7.3.2	Emerging Issues, and Renewal and Maintenance Initiatives .....	33
7.3.3	330 kV Maintenance Program .....	56
7.4	220 kV Transmission Lines Asset Review .....	56
7.4.1	Population Review .....	56
7.4.2	220 kV Transmission Line Emerging Issues, and Renewal and Maintenance Initiatives .....	57
7.4.3	220 kV Transmission Line Maintenance Program .....	61
7.5	132 kV Transmission Lines Asset Review .....	61
7.5.1	Population Review .....	61
7.5.2	132 kV Transmission Line Emerging Issues, and Renewal and Maintenance Initiatives .....	63
7.5.3	132 kV Transmission Line Maintenance Program .....	73
7.6	66 kV Transmission Lines Asset Review .....	73
7.6.1	Population Review .....	73
7.6.2	66 kV Transmission Line Emerging Issues, and Renewal and Maintenance Initiatives .....	73
7.6.3	66 kV Transmission Line Maintenance Program .....	73
8.	Future Outlook.....	73

Warning: A printed copy of this document may not be the current version

8.1	Forecast Expenditure .....	73
8.2	Anticipated Changes to the Asset Base .....	75
9.	<b>Spares.....</b>	<b>77</b>
10.	<b>Asset management capability and continual improvement.....</b>	<b>77</b>
11.	<b>Implementing the Strategies .....</b>	<b>78</b>
12.	<b>Monitoring and review .....</b>	<b>78</b>
13.	<b>Roles and Responsibilities to Develop this Asset Strategy .....</b>	<b>79</b>
14.	<b>Change history .....</b>	<b>79</b>
15.	<b>References .....</b>	<b>79</b>
16.	<b>Attachments .....</b>	<b>79</b>

## 1. Purpose

This document defines the renewal and maintenance strategies for TransGrid's Transmission Line fleet. In doing this it applies the overarching asset management strategy and objectives, and relevant Lifecycle Strategies.

The document identifies the emerging issues with TransGrid's Transmission Line assets, and details the renewal and maintenance initiatives to be implemented in response to these issues. The output of the strategy is the asset management program of works, which is derived via distinct paths as follows:

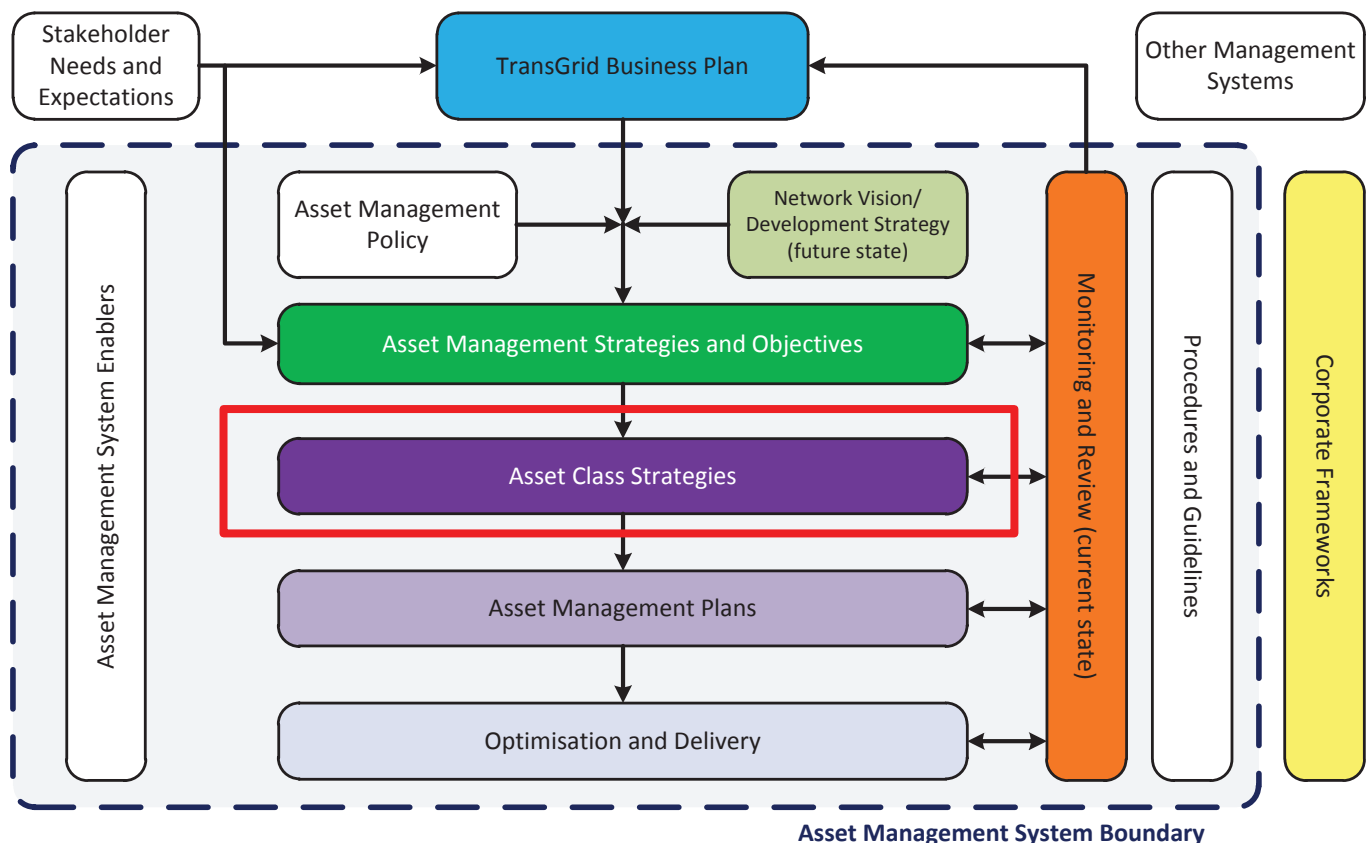
- The renewal and disposal initiatives are considered through the prescribed capital investment process and managed through the Portfolio Management group, which then leads to the resource-optimised capital works program.
- The maintenance initiatives directly drive the maintenance regimes which are detailed within the Maintenance Plan – Transmission Line Assets. The maintenance plans are then resource-optimised through TransGrid's Enterprise Resource Planning (ERP) system, *Ellipse*.

The strategies contained in this document cover the period to June 2023.

## 2. Positioning within the Asset Management Framework

The *Transmission Line Renewal and Maintenance Strategy* document is one of several that comprise the Asset Management Strategies within TransGrid's Asset Management System. This document sits below the Asset Management Strategy and Objectives document as shown in Figure 1.

**Figure 1: Asset Management System Document Hierarchy**



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### 3. Definitions

**Table 1: Definitions**

Term	Definition
<b>Asset Management Objectives</b>	<ul style="list-style-type: none"><li>• Specific and measurable outcomes required of the assets in order to achieve the Corporate Plan and objectives; and/or</li><li>• Specific and measurable level of performance required of the assets; and/or</li><li>• Specific and measurable level of the health or condition required of the assets; and/or</li><li>• Specific and measurable outcomes or achievement required of the asset management system.</li></ul>
<b>Key Hazardous Events</b>	They events of most concern associated with the assets that prevent the achievement of the corporate and asset management objectives.
<b>Emerging Issues</b>	Newly identified issues with an asset that pose a risk to the achievement of the corporate and asset management objectives.
<b>Asset Management Plans</b>	Documents specifying activities, resources, responsibilities and timescales for implementing the asset management strategy and delivering the asset management objectives.

### 4. Asset Management Strategy ‘Line of Sight’

The renewal and maintenance strategic initiatives set out in this document support the achievement of the strategies set out in the Asset Management Strategy and Objectives document. The strategic alignment of the initiatives in this document to the Asset Management Strategy and Objectives document is shown in Table 2 and Table 3.

**Table 2: Transmission Line and Cable Asset Outcomes**

Asset Management Objectives	Asset Management Performance Indicators
<ul style="list-style-type: none"> <li>Manage Transmission Line related public and staff safety risks to As Low As Reasonably Practicable (ALARP)/So Far As Is Reasonably Practicable (SFAIRP)</li> <li>Manage Transmission Line related bushfire risks (people safety) to ALARP/SFAIRP</li> </ul>	<ol style="list-style-type: none"> <li>Zero asset related LTI's</li> <li>Zero asset related fire starts</li> <li>Maintain Key Hazardous Events at 5 year average level (by calendar year):               <ol style="list-style-type: none"> <li>Conductor drop</li> <li>Structure failure</li> <li>Uncontrolled discharge/contact with electricity</li> </ol> </li> <li>Maintain average age of asset class population to a sustainable level</li> </ol>
Minimise environmental harm and property damage	<ol style="list-style-type: none"> <li>Maintain 5 year level average of fire starts (by calendar year)</li> <li>Maintain average age of asset class population to a sustainable level</li> </ol>
Maintain network reliability	<ol style="list-style-type: none"> <li>Maintain 5 year average level of loss of supply events due to Transmission Line asset faults (by calendar year)</li> <li>Maintain average age of asset class population to a sustainable level</li> </ol>

**Table 3: Transmission Line and Cable Asset Contribution to Financial Outcomes**

Asset Management Objectives	Asset Management Performance Indicators
Improve CAPEX Performance	<ol style="list-style-type: none"> <li>Improve Capital project performance</li> </ol>
Improve OPEX Performance	<ol style="list-style-type: none"> <li>Perform within 1% of Asset Management Program of Works relevant to transmission line assets</li> </ol>
Pursue STPIS revenue where cost effective	<ol style="list-style-type: none"> <li>Better than average performance of the STPIS measures (by Calendar Year):               <ol style="list-style-type: none"> <li>Transmission line fault and forced outage rates</li> </ol> </li> </ol>

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## 5. Review of Previous Renewal, Disposal and Maintenance Strategies

This section discusses the progress of the previous renewal and maintenance initiatives, and their effectiveness at meeting the asset management objectives.

### 5.1 Review of Renewal and Maintenance Initiatives

#### 5.1.1 Historical Expenditure

##### 5.1.1.1 Renewal Initiatives

Table 4: Historical Renewal Expenditure

Renewal Item	Estimate	Actual
Line 94B Wellington to Beryl Pole Replacements – completed June 2015	\$3.7 million	<b>\$3.8 million</b>
Line 967 Lismore to Koolkhan Pole Replacements – completed June 2015	\$7.4 million*	<b>\$10.8 million</b>
Line 94T Orange to Molong Pole Replacements – completed in 2011	\$2.32 million	<b>\$2.15 million</b>
Line 23 Tower Life Extension (tension tower painting) – completed in 2016	\$4.150 million	<b>\$3.095 million</b>

\* Note: These replacements were completed over a 10 year period; the \$7.4 million estimate was in 2006 dollars.

##### 5.1.1.2 Maintenance Initiatives

The cost for the staking trial indicated that pole staking would cost approximately \$3,000 per pole. The effectiveness of pole staking is discussed in Section 5.1.2.2.

The project to replace the emergency structures on Line X2 is combined with X5/1 structures which are yet to be replaced. As such, the final actual cost of the project is not yet known.

##### 5.1.1.3 Disposal Initiatives

Since the last issue of the Renewal and Maintenance Plan there have been no completed disposal initiatives.

### 5.1.2 Effectiveness of Renewal, Maintenance and Disposal Initiatives

#### 5.1.2.1 Renewal Initiatives

Following the pole replacements undertaken on the transmission lines listed in 5.1.1.1 the defect rate on the transmission lines has been very low.

The tower painting project on Line 23 was completed successfully thus extending the life of the structure steelwork by preventing further corrosion. Painting is performed at an optimal time on towers prior to any significant steel loss or increase in the probability of failure of the structure. Should painting not be performed prior to significant steel loss, structure replacement may be the only renewal option which may not prove as cost effective over the asset life.

#### 5.1.2.2 Maintenance Initiatives

A pole staking trial was undertaken on suspect 132kV wood poles. The trial found that pole staking was only suitable as reinforcement on a minority of defect wood poles. Staking requires the wood pole defect location to be at or close to the ground line, which is not the case on the majority of poles. It was also found that two stakes per pole would be required, which restricts future maintenance to monitor the condition of the pole where the stakes are mechanically connected to the pole. With two pole stakes, it was generally found that the pole could be reinforced to a maximum safety factor of 2. New poles have a safety factor of 4. Thus the reinforcement of the poles reduces the security of the transmission line and increases the risk of pole failure. The reinforcement of wood

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poles is also not consistent with the asset management performance indicator to maintain the average age of asset class population to a sustainable level, refer Section 8. As such, further pole staking will not be pursued as a wide spread medium to long term solution on the network.

The emergency structures on Line X2 were replaced with permanent single concrete pole type structures. This eliminates the need to conduct underground inspections. These emergency structures on X2 were installed off-easement, placing an angle load on the adjacent towers that was beyond the design capacity. The new structures in the original alignment restore the transmission line section to at least its original design parameters thus reducing the probability of failure. As Line X2 is radial, failure of these structures has a large consequence on customer reliability. Ongoing and in progress initiatives are detailed in their respective asset class in section 7.

#### **5.1.2.3 Disposal Initiatives**

Since the last issue of the Renewal and Maintenance Plan there have been no completed disposal initiatives.



**Table 5: Previous Renewal and Maintenance Initiatives**

Assets	Asset Management Objective	Current Issues	Strategic Initiative	Progress (completion and expenditure)	Reference Documents
<p>The following transmission lines:</p> <ul style="list-style-type: none"> <li>• X2</li> <li>• X5/1</li> <li>• X5/3</li> <li>• 63</li> <li>• 51</li> <li>• 01</li> <li>• 2</li> <li>• 3</li> <li>• 07</li> <li>• 64</li> <li>• 65</li> <li>• 66</li> <li>• 97G</li> <li>• 83</li> <li>• 84</li> <li>• 88</li> <li>• 85</li> <li>• 86</li> <li>• 8C/8E</li> <li>• 87</li> <li>• 89</li> <li>• 96C</li> <li>• 969</li> <li>• 9U3</li> <li>• 96M</li> </ul>	<ul style="list-style-type: none"> <li>• Maintain network reliability.</li> <li>• Manage Transmission Line related public and staff safety risks to As Low As Reasonably Practicable (ALARP)/So Far As Is Reasonably Practicable (SFAIRP).</li> <li>• Improve OPEX Performance.</li> <li>• Pursue STPIS revenue where cost effective.</li> </ul>	<p>Long remote lines.</p> <p>Market constraints</p> <p>Increased maintenance requirements in very remote locations.</p> <p>Lines with high fault rate.</p>	<p>Expand the travelling wave fault locator system in locations that will achieve efficiencies and market benefits.</p>	<p>Installation of Travelling wave fault locators at the identified sites by December 2017</p>	<p>Need No: 426</p> <p>Need Statement: NS 9522</p> <p>Option Evaluation Report: OER-7030</p> <p>NCIPAP 2014/15 – 2017/18 Section 3.6</p>

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Assets	Asset Management Objective	Current Issues	Strategic Initiative	Progress (completion and expenditure)	Reference Documents
330 kV Lines: <ul style="list-style-type: none"> <li>01</li> <li>3C</li> <li>6</li> <li>07</li> <li>9</li> </ul> 132 kV Lines: <ul style="list-style-type: none"> <li>976/1</li> <li>977/1</li> <li>978</li> <li>97D</li> </ul>	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Lines within the ACT do not have easements	Acquire 60 metre easements encompassing TransGrid's existing 330 kV lines in the ACT (total of 80 km)  Acquire 45 metre easements encompassing TransGrid's existing 132 kV lines in the ACT (total of 34 km)	Acquisition of easements on existing lines within the ACT by December 2017.	Need No: 663 Need Statement Continuing: NS-0663 Option Evaluation Report: OER-0663
Snowy Lines: <ul style="list-style-type: none"> <li>01, 2, 64, 65, U1, U3, U5, U7</li> </ul>	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Improve CAPEX Performance.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Mid span joint failures on Silmalec conductor	Develop systems to allow reinforcement of mid span joints from helicopter using longline method.  Reinforce mid span joints.	All mid span joints that can be accessed from ground have been replaced.  Scoping of reinforcement options and methodology has commenced.  Completion by December 2017.	Need No: 1290 (2016 – 2018) and 1590 (2019 – 2023) Need Statement: NS-1290 and NS-1590 Option Evaluation Report: OER-1590
Snowy Lines: <ul style="list-style-type: none"> <li>01, 2, 64, 65, 66, L1, L3, L5, M1, M3, M5, M7, M9, M11, M13, U1, U3, U5, U7</li> </ul>	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Improve CAPEX Performance.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Deadend failure on Silmalec conductor	Develop systems to allow replacement or reinforcement of deadend on Silmalec conductor.	Easily accessible dead ends have been replaced.  Scoping of replacement/reinforcement options and methodology has commenced.  Completion by December 2017.	Need No: 1290 (2016 – 2018) and 1590 (2019 – 2023) Need Statement: NS-1290 and NS-1590 Option Evaluation Report: OER-1590

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Assets	Asset Management Objective	Current Issues	Strategic Initiative	Progress (completion and expenditure)	Reference Documents
Snowy Lines: 01, 2, 64, 65, 66, L1, L3, L5, M1, M3, M5, M7, M9, M11, M13, U1, U3, U5, U7	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Maintain network reliability.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	"ELGRA" Vibration dampers on Silmalec conductor are ineffective.	Replace vibration dampers on Silmalec conductor.	No progress	Need No: 1290 (2016 – 2018) and 1590 (2019 – 2023) Need Statement: NS-1290 and NS-1590 Option Evaluation Report: OER-1590
Snowy Lines: 64, 65, 66	Manage Transmission Line related staff safety risks to As Low As Reasonably Practicable (ALARP)/So Far As Is Reasonably Practicable (SFAIRP).	Collapsible crossarms may not be adequate to support maintenance loads	Determine maximum loadings. Design reinforcements. Order an appropriate number of reinforcement sets that will be kept in the store. The reinforcements will then be installed as and when required.	No progress	Working group minutes
Lines with grillage structures: 1 36 990 10 4 995 11 5 99X 16 65 9R5 17 66 9R6 18 8 U1 2 88 U3 21 9 U5 24 90 U7 2M 970 35 97K	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Ground line and buried steel tower corrosion	Continue with grillage half-cell checks, replacing and/or adding sacrificial anodes as required. Investigation of grillage condition	Ongoing	Transmission Line Maintenance Plan Transmission Line and Easement Condition Data Collection Internal Work Request IWR0061 and IWR0110

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Assets	Asset Management Objective	Current Issues	Strategic Initiative	Progress (completion and expenditure)	Reference Documents
Steel lattice towers	Improve CAPEX Performance	Corrosion of steel towers to the extent that refurbishing is no longer possible.	Monitor corrosion of steel towers to ensure assets not suitable for replacement shall not get to condition where refurbishment is not possible	Ongoing during routine maintenance.	Transmission Line Maintenance Plan Transmission Line and Easement Condition Data Collection
330 kV lines with SC/GZ earthwire	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP.</li> <li>Maintain network reliability.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Corrosion of steel earthwire	Continue to inspect and monitor the identified issues with steel earthwire corrosion.	Ongoing during routine maintenance.	Transmission Line Maintenance Plan Transmission Line and Easement Condition Data Collection
All assets – Conductors and fittings	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of fittings and conductors.</p> <p>Non-standard or banned fittings</p>	Continue to inspect and monitor the identified issues during routine maintenance	Ongoing during routine maintenance.	Transmission Line Maintenance Plan Transmission Line and Easement Condition Data Collection
330 kV lines strung with OPGW:	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Excessive fitting wear on OPGW on spans with high wind/weight span ratios.	Routine climbing inspections of identified high wind/weight span towers to monitor effectiveness of remedial action (fitting modifications).	No OPGW fitting wear defects have been reported to the asset manager.	Transmission Line Maintenance Plan Transmission Line and Easement Condition Data Collection

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Assets	Asset Management Objective	Current Issues	Strategic Initiative	Progress (completion and expenditure)	Reference Documents
132 kV wood pole lines	Improve OPEX Performance	Termites and rot in timber structures	Carry out pole staking trial on Lines 94K and 944. The trial will use a selection of the four leading designs. The aim of pole staking is to delay a wood pole replacement.	Completion of pole staking trial completed and report provided June 2016. Refer Section 5.1.2.2	Asset Manager direction to Field Services
132 kV wood pole lines <ul style="list-style-type: none"> <li>94K</li> <li>96L</li> <li>96F</li> <li>99A</li> <li>99D</li> <li>99J</li> </ul>	Improve OPEX Performance	Wood pole lines with high defect rates	Provide line schedules to enable defect replacement of wood pole structures with concrete pole structures by 29/04/16	The following Line schedules have been provided: <ul style="list-style-type: none"> <li>94K</li> </ul> The following are ongoing: <ul style="list-style-type: none"> <li>96L</li> <li>96F</li> <li>99A</li> <li>99D</li> <li>99J</li> </ul>	Internal Work Request: Ad hoc Line Schedules
Line 99F – Uranquinty to Yanco	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Maintain network reliability</li> <li>Minimise environmental harm and property damage.</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> <li>Improve CAPEX Performance</li> </ul>	Wood pole line with high defect rate	Replace wood poles on Line 99F with concrete structures. Upgrade to 100°C design temperature to account for future growth.	PAD issued August 2016. To be completed by June 2018.	Need ID: DCN-143

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Assets	Asset Management Objective	Current Issues	Strategic Initiative	Progress (completion and expenditure)	Reference Documents
Line 970 – Yass to Burrinjuck	<ul style="list-style-type: none"> <li>Manage Transmission Line</li> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Maintain network reliability</li> <li>Minimise environmental harm and property damage.</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> </ul>	Wood pole line with high defect rate. Line well beyond end of life.	Replace all wood pole structures with concrete pole design.	78 of 92 structures replaced (as of Sep 16) Practical Completion scheduled March 2017.	Need ID: DCN-130
Line 96H – Lismore to Koolkhan	<ul style="list-style-type: none"> <li>Manage Transmission Line</li> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> <li>Improve OPEX Performance</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Line 96H issues:</p> <ul style="list-style-type: none"> <li>King bolts are used rather than pole bands on “flying angle” constructions.</li> <li>Under-designed line – 66kV uprated to 132 kV simply by adding extra disc insulators.</li> <li>Corrosion of guy anchors underground.</li> </ul> <p>Poor wood pole condition</p>	Replace all structures to current 132 kV concrete pole design.	<p>Possession of site granted Sep 2016.</p> <p>Required Completion December 2017.</p>	Need ID: DCN-417

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Assets	Asset Management Objective	Current Issues	Strategic Initiative	Progress (completion and expenditure)	Reference Documents
330 kV and 132 kV assets	Manage Transmission Line related people safety risks to ALARP/SFAIRP	Low spans with clearances that breach design standards at credible line loads.	Remediate low spans as per guideline "Low Span Assessment – Risk Management Approach". Transmission line modifications are to be to design temperature with AS7000 clearances.	Complete by June 2018.	Need No's: DCN129 DCN131 DCN243 DCN532 DCN533 593 594 595 596 597 598
All 500 kV lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Damage to aluminium conductor strands around Quad Spacer Dampers	Continue to inspect and monitor the identified issues through defect management and defect maintenance	Ongoing	Transmission Line Maintenance Plan Transmission Line and Easement Condition Data Collection
All 500 kV lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Corrosion and residue build up on V-String Suspension Insulators.	Continue to inspect and monitor the identified issues through defect management and defect maintenance	Ongoing	Transmission Line Maintenance Plan Transmission Line and Easement Condition Data Collection
Emergency structures on X2 and X5/1	<ul style="list-style-type: none"> <li>Maintain network reliability</li> <li>Improve OPEX Performance</li> </ul>	Increased failure probability of emergency wood pole structures. These structures are very remote	Replace emergency wood pole structures (21) with lattice or single concrete/steel pole structures.	Emergency structures on X2 have been replaced. The remaining structures on X5/1 are planned to be replaced by December 2016.	Need ID: DCN 176

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Assets	Asset Management Objective	Current Issues	Strategic Initiative	Progress (completion and expenditure)	Reference Documents
All Transmission Line Assets	<ul style="list-style-type: none"> <li>• Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>• Minimise environmental harm and property damage.</li> <li>• Maintain network reliability</li> <li>• Improve CAPEX Performance</li> <li>• Improve OPEX Performance</li> </ul>	Asset condition data of insufficient quality to support decision making.	Improve asset data quality through SLAs and the implementation of AIM (Asset Inspection Manager)	AIM has been rolled out to Transmission Lines. Data will become available progressively.	N/A

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## 5.2 Review of Maintenance Program

These maintenance and inspection interventions and frequencies have been refined over a number of years and are based on consideration of the specific asset failure modes, and seek to strike an optimised balance between preventative and reactive maintenance.

The Service Providers report, on a monthly basis, their actual performance in achieving the planned work to the TransGrid Executive. The results of the service provider's actual performance are published via Executive Dashboard reporting on TransGrid's intranet, called *The Wire*.

Asset Managers review the actual performance of the service providers to deliver the Renewal Plan and the Maintenance Plan. Significant variances between planned performance and actual performance are analysed by the Asset Manager and discussed with the service provider. The outcomes of these discussions may result in the:

- > Service provider undertaking additional work to address any backlogs in order to get back on track with the plan.
- > Asset Manager modifying the plans.

The actual performance for the 24 month period to June 2016 was:

**Table 6 – Transmission Line Asset Maintenance Expenditure**

Financial Year	Inspection and Routine Maintenance*		Corrective Maintenance (defect)	
	Budget	Actual	Budget	Actual
FY2014/15	\$5.2M	\$5.4M	\$3.2M	\$4.2M
FY2015/16	\$2.00M	\$1.59M	\$3.42M	\$2.89M

**Table 7 – Easements Maintenance Expenditure**

Financial Year	Inspection, Routine and Condition Based Maintenance*		Corrective Maintenance (defect)	
	Budget	Actual	Budget	Actual
FY2014/15	\$12.9M	\$11.4M	\$0.7M	\$1.2M
FY2015/16	\$15.52M	\$10.50M	\$0.83M	\$2.08M

\*Note: There are significant changes in these budgets between financial years due to restructure of Mains/easements teams and changes to reporting.

The budget was significantly underspent so the plan did not meet the KPI of being within 1% of Asset Management Program of Works. Routine inspection and maintenance task completion is not a KPI under "Asset Management Strategy and Objectives". However, it is worth noting that reporting states 98.66% of the planned 2015/16 maintenance schedule was completed. The shortfall in actual spend and reported achievements do not align and is currently being investigated.

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As many of the KPI's are on a calendar year, it is difficult to draw direct conclusions on maintenance spend performance, especially with the change in reporting. As noted in Section 5.3, many of the 2015 calendar year KPI's were not met.

The past Maintenance Plan set the routine inspection and maintenance tasks and frequencies for the Transmission Lines and their easements and these have been determined based on analysis of the following criteria:

- > Results of undertaking prior years' inspection and maintenance tasks.
- > Criticality of the asset in TransGrid's network.
- > Experience from the operation of the asset, including defect history and failure history, location of the asset and analysis of the age of the asset.
- > Specific issues or areas such as public safety areas or areas with higher easement vegetation growth rates.
- > Results of condition assessments.
- > Assessment of the risk of failure and unplanned outages.

Inspections included the following:

- > Aerial inspections
- > Ground inspections
- > Compliance inspections
- > LIDAR inspections
- > Underground inspections (wood poles)
- > Climbing Inspections (wood poles and selected towers with OPGW)
- > Thermographic inspection
- > Detailed Aerial photography

The revised Maintenance Plan – Transmission Line Assets for 2016/17 financial years onwards essentially eliminated ground inspections and detailed aerial photography, replacing it with a more detailed climbing inspection every 5 years (less frequent). The changes are outlined in Table 11.

### **5.3 Past Performance – Asset Management Performance Indicators**

The KPI's that demonstrate the effectiveness of this Renewal and Maintenance Strategy to mitigate the network related safety, reliability, environment, financial, compliance and reputational risks in support of the achievement of the asset management targets and objectives are the number of failures shown in Figure 2

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The Transmission Line failure KPI has not been met since 2011, as shown in Figure 2.

Figure 2, the number of fire starts shown in Figure 3

As shown in Figure 3, the fire starts KPI was not met in the 2015 calendar year, but was met the two years prior. The KPI will be met for 2016 if there are no further incidents.

Figure 3, the number of energy not supplied event in Figure 4 and the AER STPIS metrics shown in Figure 5.

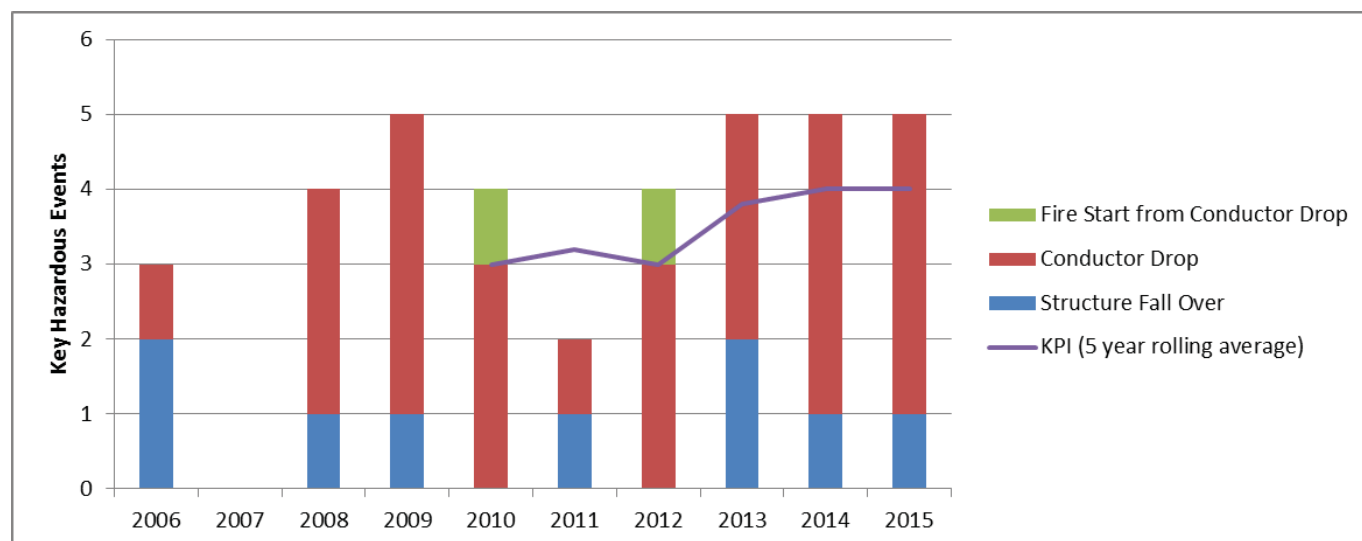
**Table 8 – Performance against Asset Management Performance Indicators**

Asset Management Objectives	Asset Management Performance Indicator	Past Performance
<ul style="list-style-type: none"> <li>Manage network related public and staff safety risks to As Low As Reasonably Practicable (ALARP)/So Far As Is Reasonably Practicable (SFAIRP)</li> <li>Manage network related bushfire risks (people safety) to ALARP/SFAIRP</li> </ul>	<ol style="list-style-type: none"> <li>Zero asset related LTI's</li> <li>Zero asset related fire starts</li> <li>Maintain Key Hazardous Events at 5 year average level:               <ol style="list-style-type: none"> <li>Conductor drop</li> <li>Structure failure</li> <li>Uncontrolled discharge/contact with electricity</li> </ol> </li> </ol>	<ul style="list-style-type: none"> <li>Zero LTI due to asset failure KPI was met.</li> <li>As shown in Figure 3, the fire starts KPI was not met in the 2015 calendar year, but was met the two years prior. The KPI will be met for 2016 if there are no further incidents.</li> <li>Key hazardous event trending is shown below in Figure 2 . This KPI has not been met since 2011.</li> </ul>
Minimise environmental harm and property damage	Maintain 5 year level average of fire starts	Transmission line fire starts are as per Figure 3. There has not been a fire start due to transmission line asset failure since 2012. In terms of transmission line assets alone this KPI can be considered met, however when easements are considered the target was not met in 2015 calendar year due to vegetation grow-ins and fall-ins.
Maintain network reliability	Maintain 5 year average level of loss of supply events due to Transmission Line asset faults (by calendar year)	The five year loss of supply events are shown in Figure 4. The KPI was achieved in the 2014 and 2015 calendar years but will not be met in 2016 calendar year as the target has been exceeded.
Pursue STPIS revenue where cost effective	Better than average performance of the STPIS measures: Transmission line fault and forced outage rates	<p>The transmission line fault outage rate has been reducing on an average basis since 2009.</p> <p>The 2015 calendar year for forced outage rate was the worst on record, this measure trending to be below average for 2016 (data until October).</p> <p>The STPIS performance is shown in Figure 5</p>

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The Transmission Line failure KPI has not been met since 2011, as shown in Figure 2.

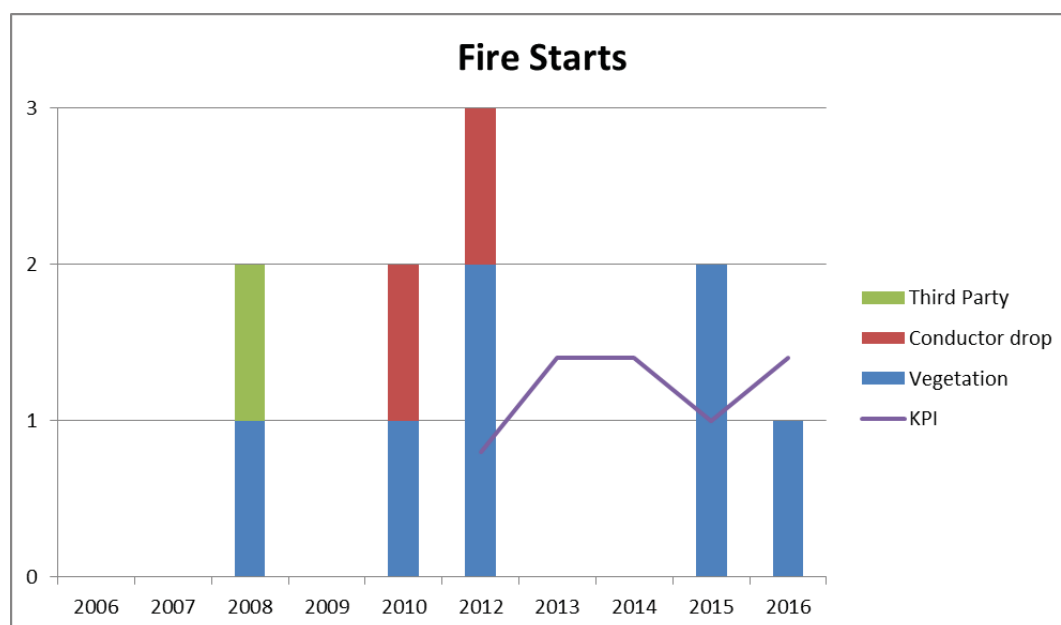
**Figure 2: Transmission Line Failures by Hazard Type**



Note: Counts are by calendar years.

As shown in Figure 3, the fire starts KPI was not met in the 2015 calendar year, but was met the two years prior. The KPI will be met for 2016 if there are no further incidents.

**Figure 3: Fire Starts**

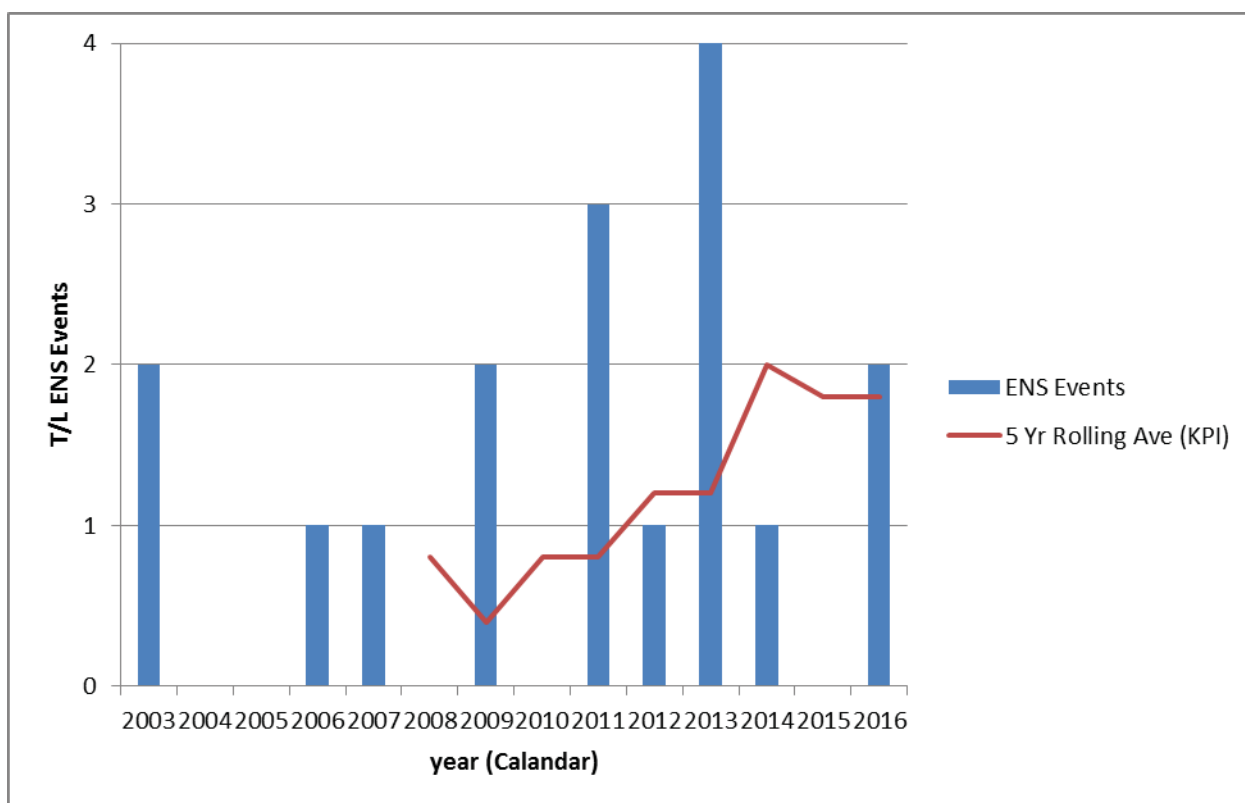


Notes:

- Counts are by calendar years.
- Third party fire start was due to aircraft strike causing conductor to drop

The KPI (ENS events less than 5 year rolling average) was met in the 2014 and 2015 calendar years. The current 2016 year events have exceeded the KPI target.

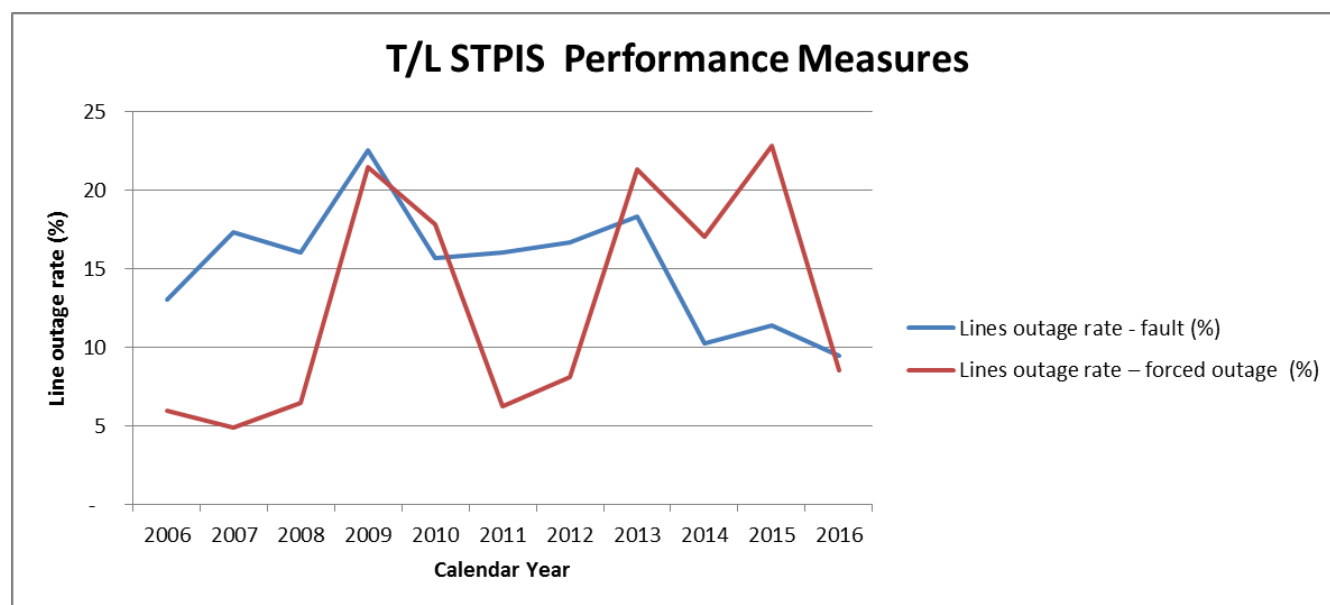
**Figure 4: Transmission Line Energy Not Supplied Events**



Note: Counts are by calendar years.

In regards to STPIS performance, the transmission line fault outage rate has been reducing on an average basis since 2009. The 2015 calendar year for forced outage rate was the worst on record. The 2016 figure (to October) is tracking to meet the KPI.

**Figure 5: Transmission Line STPIS Performance Measures**



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## 6. Transmission Line Asset Overview

### 6.1 Scope of Assets

The following assets are considered within the scope of this strategy:

- > 500 kV Transmission Line Assets
- > 330 kV Transmission Line Assets
- > 220 kV Transmission Line Assets
- > 132 kV Transmission Line Assets
- > 66 kV Transmission Line Assets
- > Associated Easements

The following transmission line assets are outside the scope of this strategy:

- > Strung bus within substations.
- > Distribution Network Service Providers (DNSP) have 132 kV Transmission Lines which are sometimes tee connected to TransGrid's transmission lines. The transmission line sections owned by DNSP's are not covered within the scope of this document.

### 6.2 Asset Base

As detailed in the 2016 FY RIN, TransGrid has over 12,900 km of transmission line circuit within its network which are supported by around 37,414 structures. The total route length is greater than 11,200km. A snapshot of the transmission line asset base is provided in Table 9.

**Table 9: Transmission Lines Asset Base.**

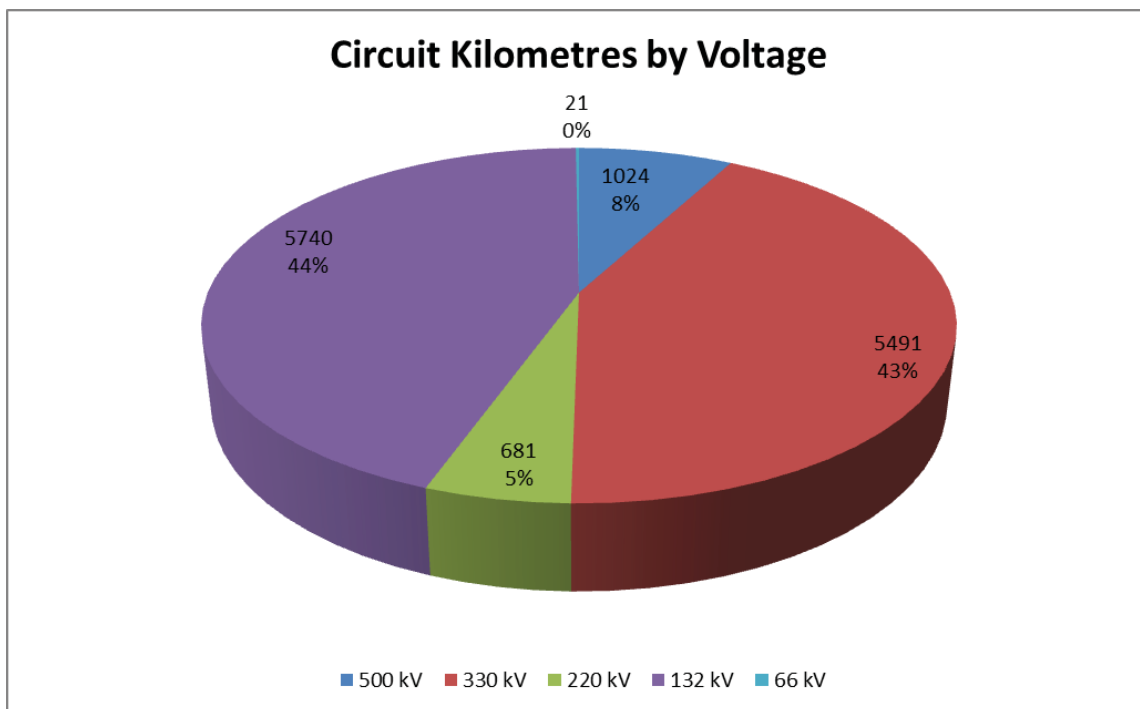
Asset	Total Circuit Length	Total Structures	Description
500 kV Transmission Lines and associated easements.	1023 km	<ul style="list-style-type: none"><li>Steel structures: 1,177<ul style="list-style-type: none"><li>Costal: 26</li><li>Inland: 1,151</li></ul></li></ul>	<ul style="list-style-type: none"><li>500 kV transmission lines are located within the Northern, Southern and Central Regions.</li><li>There is a total of <u>1023 km</u> of circuit length which are all supported by steel lattice structures.</li></ul>
330 kV Transmission Lines and associated easements.	5,490 km	<ul style="list-style-type: none"><li>Steel structures: 11,379<ul style="list-style-type: none"><li>Costal: 1,218</li><li>Inland: 10,161</li></ul></li><li>Concrete poles structures: 59</li><li>Wood poles structures: 438</li></ul>	<ul style="list-style-type: none"><li>330 kV transmission lines are located within the Northern, Southern and Central Regions.</li><li>There are a total of 5,490 km of circuit length supported by:<ul style="list-style-type: none"><li>Steel structures (includes lattice and pole) – 96%</li><li>Wood pole – 4%</li><li>Concrete pole - &lt;1%</li></ul></li></ul>
220 kV Transmission Lines and associated easements.	681 km	<ul style="list-style-type: none"><li>Steel structures: 1,704</li><li>Concrete pole structures: 4</li><li>Wood Pole structures: 17</li></ul>	<ul style="list-style-type: none"><li>220 kV transmission lines are located in the Southern Region.</li><li>There are a total of 681 km of single circuit which are all supported by steel lattice structures, with the exception of 17 emergency wood pole structures</li><li>4 concrete pole structures were installed to remove emergency wood pole structures.</li></ul>

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Asset	Total Circuit Length	Total Structures	Description
132 kV Transmission Lines and associated easement.	5,739 km	<ul style="list-style-type: none"> <li>Steel structures: 599 <ul style="list-style-type: none"> <li>Costal: 51</li> <li>Inland: 548</li> </ul> </li> <li>Concrete pole structures: 7,576</li> <li>Wood pole structures: 14,467</li> </ul>	<ul style="list-style-type: none"> <li>132 kV transmission lines are located within the Northern, Southern and Central Regions.</li> <li>There are a total of 5,739 km of dual and single circuit length supported by: <ul style="list-style-type: none"> <li>Wood pole – 64%</li> <li>Concrete pole – 33%</li> <li>Steel pole and Steel lattice structures – 3%</li> </ul> </li> </ul>
66 kV Transmission Lines. No 66kV easements (on TransGrid property)	21 km	<ul style="list-style-type: none"> <li>Concrete pole structures: 5</li> </ul>	<ul style="list-style-type: none"> <li>These are located at Molong and Glenn Innes. The majority of the circuits share dual circuit structures with another TransGrid 132 kV circuit. There are a small number of single circuit 66 kV structures (on TransGrid property) connecting the 66 kV lines bays in the respective substations to the dual circuit structures.</li> </ul>

The breakdown of total circuit length is shown by voltage in Figure 6.

**Figure 6: Transmission Line Assets by Voltage.**



The nominal lifespan of a transmission line varies depending upon its individual components and the external environment to which it is exposed. The individual components can be broadly categorised as electrical conductors, supporting structures and fittings. The nominal lifespan for transmission line components are provided in Table 10.

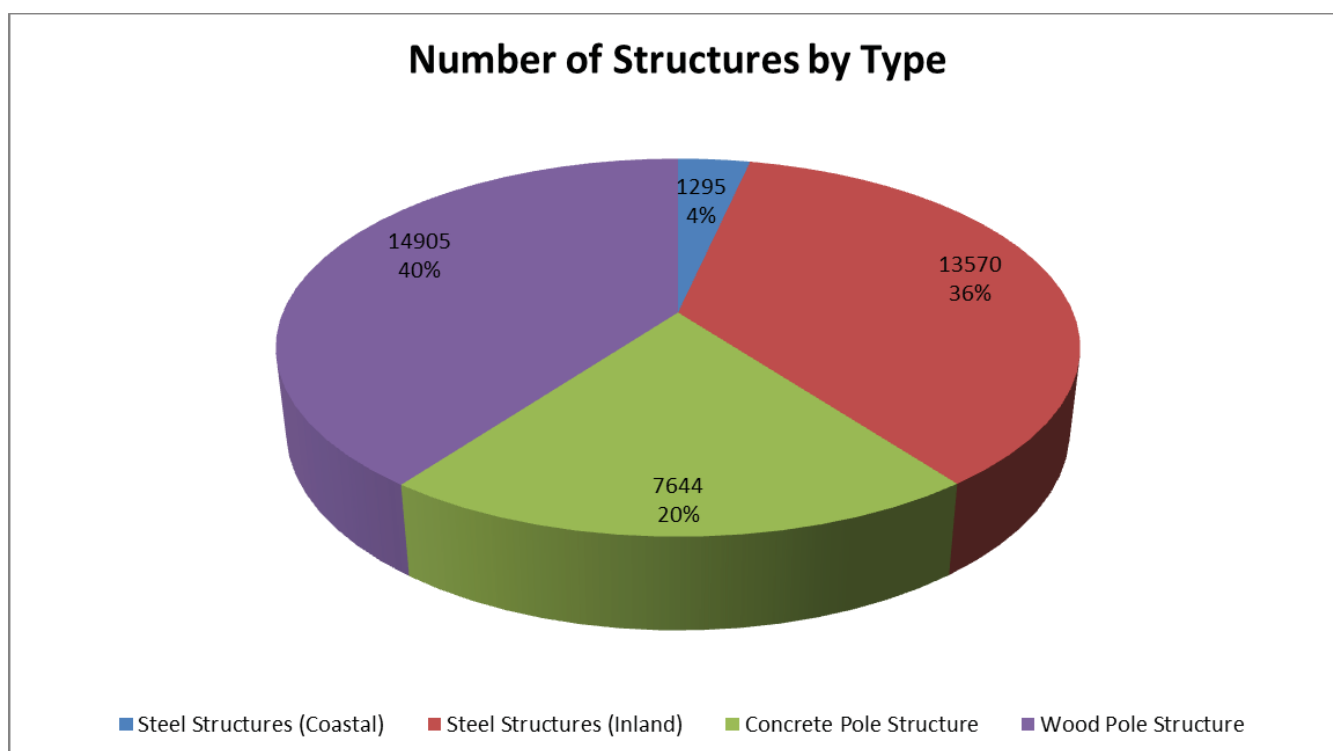


**Table 10: Nominal Lifespan of Transmission Line Components.**

Component	Nominal Lifespan (years)
Steel Structure	40 (Coastal) 75 (Inland)
Wood Pole	65
Concrete Pole	70
Aluminium Conductor	60 (Coastal) 80 (Inland)
Porcelain and Glass Disc Insulators	40 (Coastal) 65 (Inland)
Composite Longrod Insulators	40

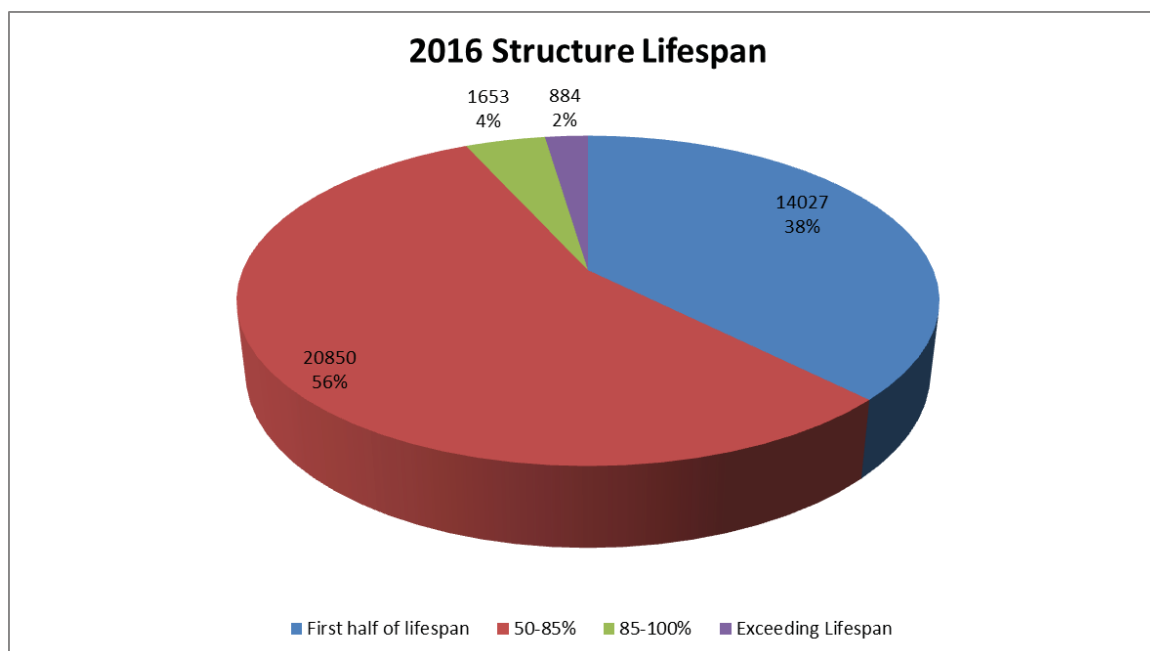
TransGrid's transmission line assets are broken down by structure type in Figure 7.

**Figure 7: Transmission Line Assets by Structure Type.**



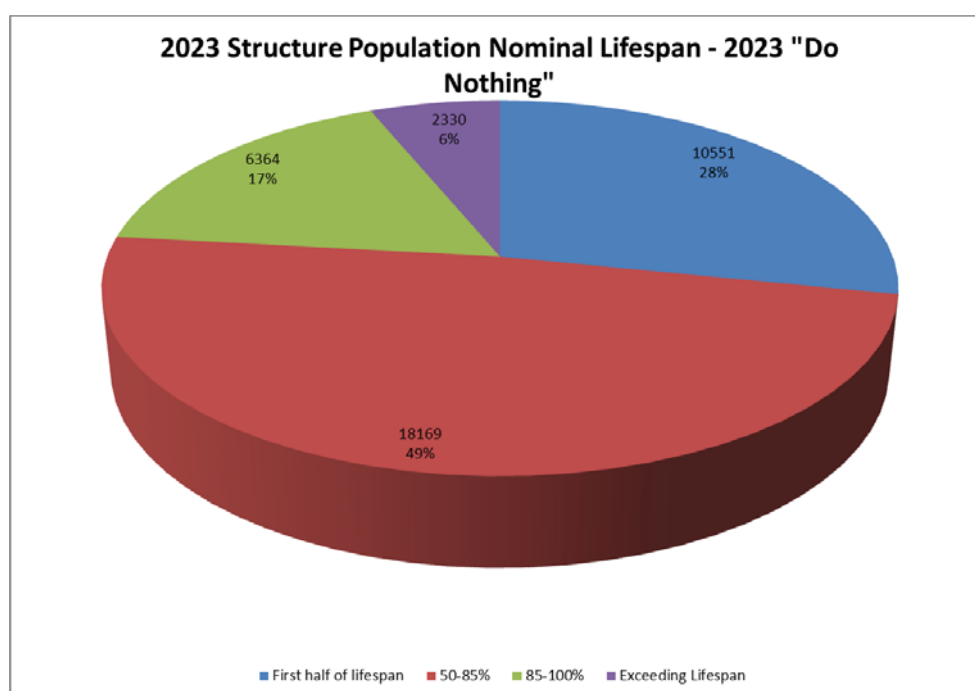
Analysed on a remaining life basis, at June 2016 the asset age profile is as shown in Figure 8.

**Figure 8 2016 Structure Remaining Life**



Analysed on a remaining life basis, if no intervening measures are taken, the 2023 forecast profile will be as per Figure 9.

**Figure 9: 2023 structure lifespan “do nothing” forecast.**



This age profile shows that around 23% of TransGrid’s transmission line assets are approaching or exceeding their nominal lifespan at the end of the 2023 period (an increase from 6%); which indicates that these assets are likely to be subject to deteriorating health and obsolescence issues. The assets that are approaching or exceeding their nominal lifespan within the period are as follows:

- > 132 kV wood poles: 4,969 pole structures approaching and 1,163 exceeding their nominal lifespan.

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- > 132 kV steel structures: 97 structures approaching and 72 structures exceeding their nominal lifespan.
- > 330 kV steel structures: 1,297 structures approaching and 1,069 exceeding their nominal lifespan.

## 7. Transmission Line Asset Review

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This section discusses the emerging issues and the associated strategies to address these with respect to the Transmission Line asset population. The discussion results from the renewal, maintenance and disposal decision process outlined in the *Asset Management Strategy and Objectives* document.

All strategic initiatives with respect to TransGrid's Transmission Line assets are outlined in this section, including the renewal, disposal and maintenance initiatives that feed into the capital works program and the maintenance plans. Further details can be found in the relevant Maintenance Plan, and the referenced governance documents.

### 7.1 Implementation of the Renewal and Maintenance Decision Process

TransGrid undertakes a variety of performance, cost, risk and compliance analyses to capture the range of current and emerging issues that are apparent with respect to individual assets and asset groups. The analysis takes into consideration:

- > Population age profiling against nominal asset lifespan.
- > Asset inspection and condition assessments.
- > Failure mode.
- > Failure and defect rates.
- > Failure investigations.
- > Maintenance program outcomes.
- > Communication from maintenance staff through the working groups.

Once the entire scope of issues are identified and the appropriate analysis undertaken, the asset manager will consider a number of options and determine the most appropriate course of action to address the issue and associated risks. The course of action is generally to either monitor the asset, undertake maintenance, renew, or dispose of the asset. The decision making process is described further in the *Asset Management Strategy and Objectives* document.

Renewal initiatives are developed through TransGrid's Network Investment Process<sup>1</sup>. Within the Network Investment Process a Needs and Opportunities Statement (NOS) is first developed, which captures the current and emerging issues and assesses the risks associated with an asset or group of assets. The NOS is followed by an Options Evaluation Report (OER) which evaluates the options and identifies the preferred option. The preferred options are combined to produce a resource-optimised capital works program.

TransGrid has developed a risk tool for the 2018-23 capital program. This tool provides a more granular view of the pre and post-investment risks associated with building new or replacing existing network and supporting business assets (including IT, fleet and facilities). This will help to ensure that:

- > TransGrid only invests where there is a clear business case for doing so
- > the solution chosen to address the identified need is the most efficient and
- > different investments can be compared on a like for like basis so that TransGrid can select the portfolio of projects and programs that maximises business value from the available capital.

Disposal initiatives are also developed through TransGrid's Network Investment Process. Disposal of goods and materials are managed in accordance with TransGrid's procedures:

- > Disposal of Goods and Materials.

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<sup>1</sup> Details of the relevant project planning documents for these renewal initiatives can be obtained at <http://thewire/dc/planning/ProjectPlanningDocuments/Pages/default.aspx>

> Disposal Strategy as defined in the parent Asset Management Strategies and Objectives document.

Significant changes to the Maintenance Plan - Transmission Line Assets was made in the 2016 revision, focused at rationalising and optimising maintenance activities as well as collecting asset nameplate and detailed condition data. Re-evaluation of opportunities to refine the processes were considered and assessments made on consideration of the specific asset failure modes, condition, criticality, performance, risk and consequences of failure in an attempt strike an optimised balance between preventative and reactive maintenance. The maintenance initiatives directly drive the routine maintenance regimes which are detailed within the Maintenance Plan - Transmission Line Assets. The main changes to the maintenance program are summarised in Table 11.

**Table 11: Transmission Line Assets Routine Maintenance Changes for 2016**

Line Type	Type of Inspection	Available Frequencies (time between inspections)	Comment/Change
<b>All lines</b>	<i>Aerial Inspection</i>	1 year	Where flight restrictions do not allow aerial inspections to be undertaken on a section of a line, a follow up <i>compliance inspection</i> of the missed section(s) shall be performed within 3 months.
<b>Selected Lines</b>	<i>Compliance Inspection</i>	2 years	To be performed on the sections of transmission lines identified as close to publicly frequented areas in the <a href="#">Public Electricity Safety Awareness (PESA) Plan</a> .
	<i>Structure Earthing Test</i>	10 years	To be performed on the sections of transmission lines identified as close to publicly frequented areas in the <a href="#">Public Electricity Safety Awareness (PESA) Plan</a> .
	<i>Aircraft Warning Light Inspection</i>	6 months	Previously undertaken outside of maintenance plan
	<i>Detailed Aerial Photographic Inspection</i>	Removed	Will be completed as and when required as directed by the Transmission Line and Cables Asset Manager as a maintenance initiative.
<b>Steel Tower, Steel Pole, Concrete Pole</b>	<i>Ground Inspection</i>	Removed	Replaced with <i>Climbing inspection</i>
	<i>Ground and Climbing inspection</i>	5 years	The first <i>climbing inspection</i> shall be performed at the next scheduled <i>ground inspection</i> date.
<b>Wood Pole</b>	<i>Ground Inspection</i>	Removed	Functional requirements covered by LiDAR, Aerial Inspections and offset climbing and underground inspections.
	<i>Ground and Climbing Inspection</i>	3 to 6 years	On tension and flying angle structures where proximity of energised conductors to structure components prevents complete access to the pole, if the insulators are attached via a kingbolt/eyebolt (as opposed to a pole band) an outage is to be taken to assess the structure and attachments for its entire length.  Wood pole <i>climbing inspections</i> shall be scheduled in between the UGI such that the transmission line inspections occur no more than 3 years apart.  Frequencies are set on a line by line basis by the Asset Manager based on assessment of defect and failure rates.
	<i>Underground Inspection (wood poles only)</i>	3 to 6 years	No change. Offset with climbing inspection.  Frequencies are set on a line by line basis by the Asset Manager based on assessment of defect and failure rates.

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Thermographic Inspections, Foundation Inspections and New Line Climbing Inspections remain unchanged. The 2016 maintenance plan updates have resulted in an estimated reduction of the routine transmission line maintenance cost from \$5.4M to \$4.6M (from 2015/16 to 2016/17).

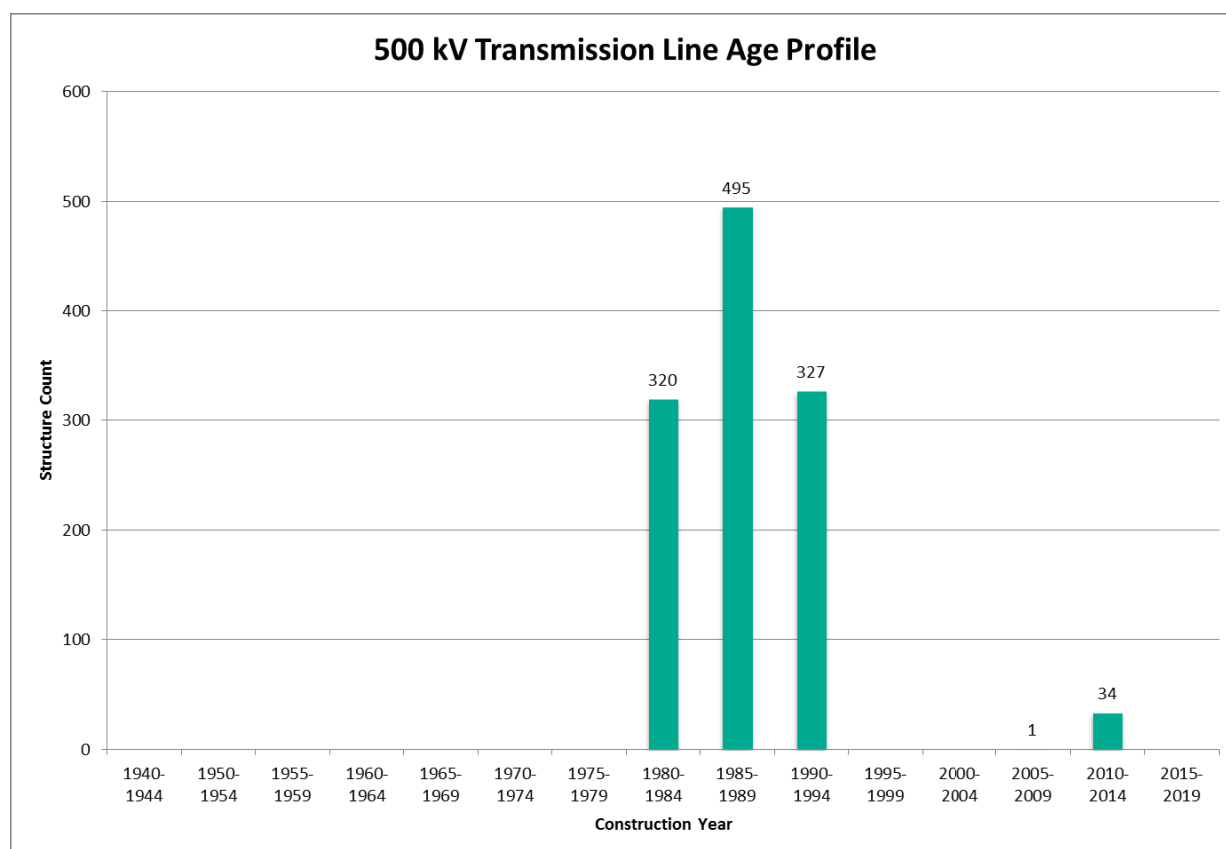
## 7.2 500 kV Transmission Lines Asset Review

### 7.2.1 Population Review

The 500 kV network makes up approximately 9% of TransGrid's transmission line asset base by circuit kilometres. It has approximately 510 km of transmission line route which are supported by over 1,100 structures. The 500 kV network is mostly located inland and is entirely supported by steel structure structures, which have a nominal lifespan of 75 years. Twenty six structures are classified as costal. The first elements were commissioned in 1982 and all assets remain within the first half of their nominal lifespan. The 500 kV network is relatively young compared to TransGrid's other steel structure transmission lines and is showing minor signs of deterioration on a small number of structures and spans.

The age profile of TransGrid's 500 kV transmission line assets is shown in Figure 10.

Figure 10: 500 kV Transmission Line Age Profile



### 7.2.2 Emerging Issues, and Renewal and Maintenance Initiatives

The specific issues relating to the 500 kV transmission lines is discussed below with respect to the three main transmission line elements listed in Table 12.

### 7.2.2.1 500 kV Transmission Line Emerging Issues

#### Fittings

The current and emerging issues relating to 500 kV fittings are as follows:

- > Insulator corrosion and staining: Corrosion of the base caps has led to rust staining of some V-String Suspension Insulators on the 500 kV 5A1/5A2 Eraring - Kemps Creek transmission line. Analysis indicates that electrical discharge (known as “corona”) at the base of the cap has caused localised deterioration of the zinc coating leaving these areas exposed to corrosion. The corrosion could eventually lead to mechanical failure of the insulators;

The corrosion of the base cap has led to rust staining down the string insulator which appears to be increasing over time. A build-up of residue on insulators causes electrical “tracking” which can eventually lead to “flashover”. Flashovers are a common failure mode for electrical insulators. However, electrical testing has not indicated any reduction in the electrical insulating properties of the V-string insulators at present.

#### Electrical conductors

The current and emerging issues relating to 500 kV electrical conductors are as follows:

- > Conductor damage: The 5A1/5A2 Eraring - Kemps Creek transmission line suffered damage to strands of the aluminium conductors following poor installation of “Quad Spacer Dampers” during construction. Spacer dampers separate the conductors to prevent loose cable damage and also absorb physical vibrations in the lines. The installation issues were rectified; however the damaged conductors remain in service. Further analysis found that the damage only affected the outer aluminium strands and not the galvanised steel wire which provides mechanical strength; as such the mechanical integrity of the conductors is thought to remain uncompromised.

#### Structures

In general, the 500 kV structures are in a good condition overall and no current or emerging issues have been identified:

- > Soil covered concrete foundations: On some steel structures with concrete foundations, the top of the concrete pedestal is below ground line due to soil wash-ins. This can result in corrosion at groundline where moisture and oxygen in the soil aid oxidation.

### 7.2.2.2 500 kV Renewal Initiatives

A targeted renewal of the towers on Line 5A1/5A2 has been included in the 2018-23 revenue proposal submission addressing issues with corrosion to tower steelwork at groundline due to soil coverage, replacement of a small number of tower bolts, damaged earth straps and poor condition insulator strings.

### 7.2.2.3 500 kV Maintenance Initiatives

During routine inspections the following emerging issues are monitored:

- > Corrosion and residue build up on V-String Suspension Insulators.
- > Damage to aluminium conductor strands around Quad Spacer Dampers.

Issues found will be actioned under corrective maintenance.

Emerging issues on associated easements are:

- > Hazard trees on easements.
- > Unauthorised easement encroachments.

### 7.2.2.4 500 kV Disposal Initiatives

There are currently no 500 kV disposal initiatives.

**Table 12: 500 kV Transmission Line Assets Emerging Issues, and Renewal and Maintenance Initiatives**

Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
All 500 kV lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Damage to aluminium conductor strands around Quad Spacer Dampers	Continue to inspect and monitor the identified issues through defect management and defect maintenance	Ongoing	Transmission Line Maintenance Plan
All 500 kV lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Corrosion and residue build up on V-String Suspension Insulators.	Continue to inspect and monitor the identified issues through defect management and defect maintenance	Ongoing	Transmission Line Maintenance Plan
Line 5A1/5A2	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Corrosion of steelwork and components at end of life. Reduction in security of supply.	<p>Ground line corrosion – 9 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Corrosion of fasteners – Replace 2% of fasteners on 16 towers</p> <p>Buried concrete foundations– 16 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of earth strap – 3 towers – replacement</p> <p>Insulators – 36 insulator string replacements</p>	Included in 2018-23 Revenue proposal	Need ID: 1278

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
All 500kV Lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> </ul>	Hazard trees causing transmission line faults	Identification and scoping of hazard tree risk. Removal of hazard trees where required.	Ongoing	
	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Improve OPEX Performance</li> </ul>	Unauthorised encroachments on easements present a safety risk to maintenance staff and the public	Identify encroachments and order their removal where required.	Ongoing	
	<ul style="list-style-type: none"> <li>Improve CAPEX Performance</li> <li>Improve OPEX Performance</li> </ul>	Asset condition data of insufficient quality and detail to support decision making.	Improve asset data quality through SLAs and the implementation of AIM (Asset Inspection Manager)	AIM has been rolled out to Transmission Lines. Data will become available progressively.	N/A
All Transmission Line Assets					

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### 7.2.3 500 kV Maintenance Program

For the 500 kV Transmission Line assets, all structures are steel towers. The maintenance program consists of the following:

- Routine inspections and maintenance.
- Corrective (or “defect”) maintenance addressing out of specification conditions. The need to conduct corrective maintenance is usually identified during a routine inspection.
  - Where possible and practical, these defects are addressed at the same time as the inspection.
  - Otherwise, these are prioritised on a basis as per Maintenance Plan - Transmission Line Assets.
- Easement maintenance as detailed in the Maintenance Plan – Easements and Access Tracks.

Section 7.1 details the 2016 changes to maintenance plan.

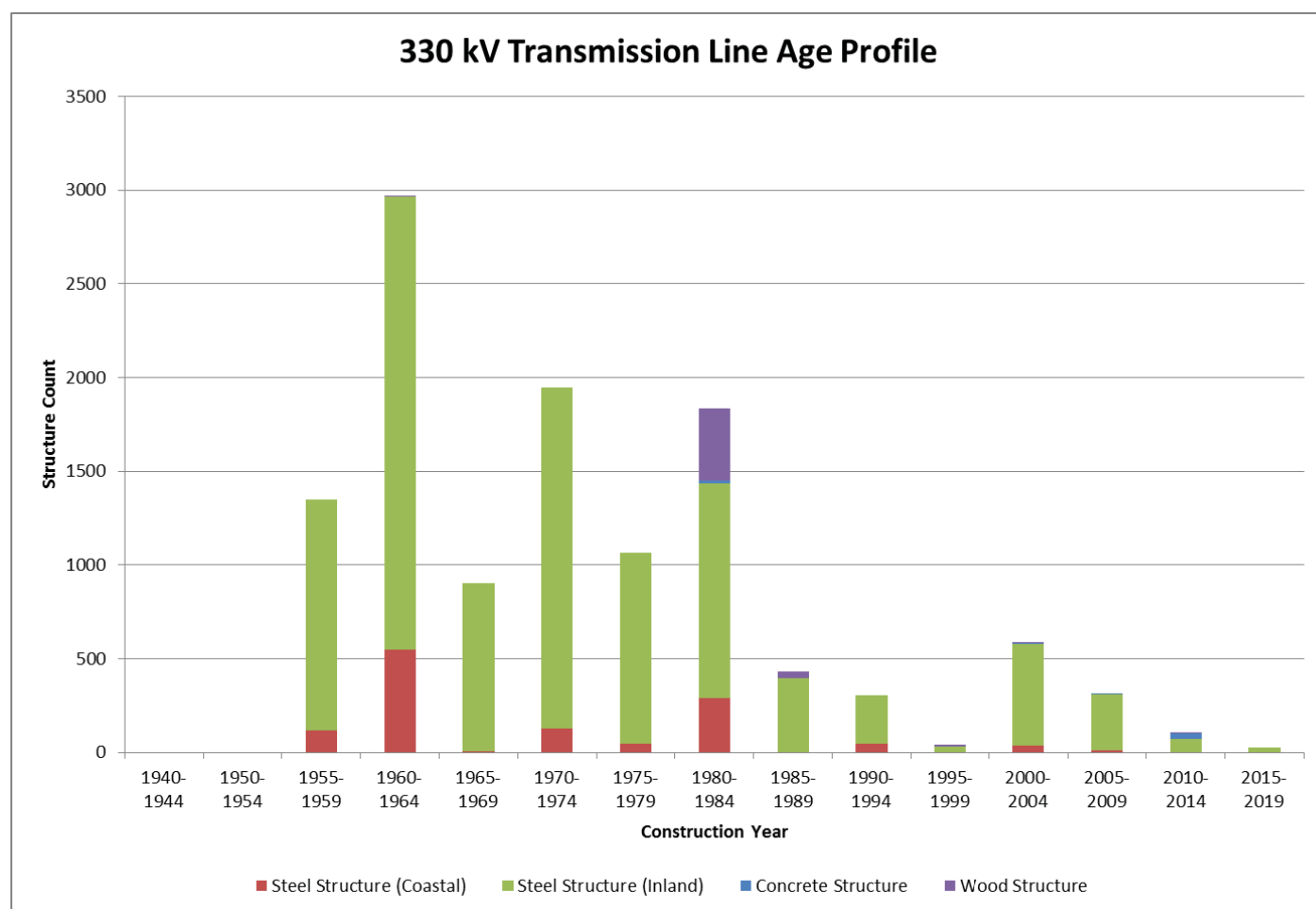
## 7.3 330 kV Transmission Lines Asset Review

### 7.3.1 Population Review

The 330 kV network makes up approximately 43% of TransGrid’s transmission line asset base by circuit kilometres. It has over 4,700 km of transmission lines route (over 5,400 circuit km) which are supported by over 11,000 structures, over 97% of which are steel structures. TransGrid’s 330 kV network is comprised of both inland and coastal infrastructure. The first elements of TransGrid’s current 330 kV network were commissioned in 1957.

The age profile of TransGrid’s 330 kV transmission line assets is shown in Figure 11.

Figure 11: 330 kV Transmission Line Age Profile.



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## 7.3.2 Emerging Issues, and Renewal and Maintenance Initiatives

### 7.3.2.1 330 kV Transmission Line Emerging Issues

The specific issues relating to the 330 kV transmission lines is discussed below with respect to the three main transmission line elements listed below.

#### Fittings

The current and emerging issues relating to 330 kV fittings are as follows:

- > Corrosion of nuts, bolts and insulator pins: This is a particular issue in coastal areas and ranges from minor to severe. Inspections of discs removed from 21, 2M and 22 transmission lines in the Somersby area in 2011 following a failure on 21 transmission lines have shown that there can be significant pin corrosion and deterioration. The corrosion has been shown to significantly reduce the diameter of the pins, which compromises their structural integrity.
- > Ineffective Stockbridge vibration dampers – Stockbridge vibration dampers are installed on most 330 kV lines across the network. Old dampers are showing signs of droop and are not providing adequate performance.
- > Failure of Silmalec Mid Span Joints (MSJ) – There have been three mid span joint failures on transmission lines with Silmalec AAAC conductor. Failures have been through the centre of the joint and may be due to compression of the joint tube in the centre with a gap between the conductors to be joined. All MSJ which are accessible from EWP have been replaced. Options for remediation, including safe methods of access for the remaining MSJ's are being developed. These methods could be used to manage the other Silmalec issues described below.
- > Failure of Silmalec deadends – In February 2015 a deadend on transmission line U7 failed. Metallurgical examination found that the failure was a progressive (fatigue) failure that initiated from the lower corner of the first crimp.
- > Ineffective vibration dampers on Silmalec conductor –ELGRA vibration dampers from Sweden were installed on the first 330 kV lines emanating from the Snowy Hydro Electric scheme from the late 1950s. These dampers have been found to be ineffective worldwide.

The current and emerging issues relating to 330 kV conductors are as follows:

- > Conductor issues are predominantly corrosion related. This is a particular issue of galvanised steel earthwire in coastal areas and ranges from minor to severe. Options where strategic replacement of earthwire with OPGW provides economic benefits are considered.
- > Low hanging conductor spans. These are spans with low electrical clearances which do not meet design standards (grandfathered to date of construction).

#### Structures

The current and emerging issues relating to 330 kV structures are as follows:

- > Corrosion of steel tower members: A number of steel towers have degraded through loss of zinc coating and subsequent corrosion of the steel. The towers located in coastal and industrial areas have suffered the greatest deterioration. This reduces the transmission line security of supply.
- > Corrosion of nuts, bolts and fasteners on steel towers: This is a particular issue in coastal areas and ranges from minor to severe. Routine inspections on lines in the Newcastle, Central Coast, Sydney and Dapto regions have indicated that there can be significant corrosion on bolt heads and blown nuts, which compromises the structural integrity of the steel tower structure and/or conductor fittings. This reduces the transmission line security of supply.
- > Corrosion of steel footings: A large number of the steel tower structures constructed prior to the late 1960s were installed with buried steel "grillage" foundations. A chemical reaction occurs due to contact with the soil which leads to corrosion of the zinc coating and the underlying steel. The majority of grillage foundation towers were fitted with sacrificial magnesium anodes. A review has found these anodes to be ineffective in a number of locations where severe soil corrosion conditions are expected. This reduces the transmission line security of supply.

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- > Soil covered concrete foundations: On some steel structures with concrete foundations, the top of the concrete pedestal is below ground-line due to soil wash-ins. This can result in corrosion due to contact with the soil which leads to corrosion of the zinc coating and the underlying steel. This can reduce the transmission line security of supply.
- > Damage to tower earthing: A number of earth straps on steel tower structures have been compromised, affecting earthing performance and presenting a people safety risk.
- > Collapsible crossarms on Snowy Lines 65, 65, 66: These crossarms have been deemed not suitable for supporting a worker to carry out maintenance tasks on the tower. Design and minor structure modifications are required. The intention is to install only when required prior to works.
- > Composite wood poles on Line 86: Tamworth to Armidale Line 86 was constructed using mostly composite wood poles. It is the only 330 kV wood pole line. Wood rot beneath the composite pole joint sleeve is prevalent throughout the line, affecting their structural integrity. Wood pole transmission lines were also designed to a lower set of design criteria than steel tower transmission lines which reduces the security of supply between the major generation at Newcastle, the Tamworth/Armidale region and Queensland.
- > Tower Asbestos Paint: Asbestos containing paint has been identified on steel towers across TransGrid's transmission network. The paint is generally limited to the lower part of the tower legs, however there are a few towers identified as having been completely painted with the asbestos paint. The extent of this issue across the network is still under investigation, but is believed to affect all tower lines constructed pre-1980. The paint has been found to be in poor condition, generally flaking and peeling from the structure.
- > Emergency Structures: Lines 3 and 6 have had emergency wood poles structures installed after storm failures of the original steel towers. The structures are designed as temporary structures to lower design criteria compared to the original permanent line effectively reducing the expected life of these emergency temporary structures. They were always expected to be a temporary solution only and do not have the full design capabilities of the steel tower structures they replaced reducing the transmission line security of supply.
- > Corrosion of steel poles: Corrosion at the joins between the sections of the steel poles on transmission lines 12, 13, 76 and 78 at the lead up to Sydney South substation may affect the structural integrity of the poles.
- > Older single circuit transmission line structures were designed to the standards at that time but were found to be a lower set of design criteria compared with newer structures. Following a number of structure failures in extreme wind events, investigations found single circuit suspension towers had design deficiencies in the governing load combinations when compared to more recent design philosophies and standards. Strengthening of structures with utilisation over 85% at road crossings and public areas has occurred. However, groups of structures on different lines in close proximity which may impact system stability if damaged (such as near major generator substations) may not have been strengthened, representing a potential weakness in the security of supply.
- > Some 330 kV lines, when taken out of service, impose constraints to generation and/or the electricity market. Therefore it is important to ensure that faults on these lines are rectified as soon as possible. Travelling wave fault location provides improved accuracy of faults on the network compared to distance to fault measurements from protection relays, which have particular measurement difficulties for certain types of faults. This enables quicker commencement of repairs for sustained faults, assessment of potential damage from transient faults and detection of external impacts such as fire starts. This improves the capability of the network by reducing the duration of unplanned outages, and allowing faster response to minimise the external impacts of a fault. The reduced time taken for an after fault patrol also assists with fatigue management.

### 7.3.2.2 330 kV Renewal Initiatives

The following renewal initiatives are planned from the date of this plan until June 2023. Details on the specific assets are noted in Table 13.

- > Targeted replacement of insulators with pin corrosion.
- > Targeted replacement of Stockbridge vibration dampers with excessive droop.
- > Targeted replacement of SC/GZ earthwire with consideration for replacement with OPGW where there is a strategic benefit.
- > Corrosion of steel tower members:
  - Targeted minor member replacement

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- Targeted corrosion remediation - abrasive blast cleaning to remove any corrosion product and application of Zinga paint.
  - Targeted whole tower corrosion remediation
  - > Targeted replacement of corroded steel tower nuts, bolts and fasteners.
  - > Grillage foundations corrosion remediation:
    - Structures which have been classified as located in areas of aggressive soils are to have the grillage foundation dug out, and the footing steel work repaired, or reinstated where required, then concrete encased.
    - Installation of new or additional sacrificial anodes elsewhere.
  - > Soil covered concrete foundations
    - Clear soil from buried tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel
    - Clear soil from buried tower legs, scabbling of concrete footing, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion
  - > Replacement of damaged earth straps to the current standard.
  - > Rebuild Line 86 Tamworth – Armidale:
    - Reusing conductor and earthwire; or
    - With new conductor to upgrade the line to also provide market benefits (RIT-T required).
  - > Line 11 – Sydney South – Dapto – Targeted suspension structure replacement.
  - > Silmalec Conductor Mid Span Joints (MSJ) replacement of reinforcement. Lines with generally higher conductor tensions (> 48kN) have been prioritised for completion by June 2018, with the remaining lines to be completed by June 2023.
  - > Silmalec Conductor dead end replacement of reinforcement. Lines with generally higher conductor tensions (> 48kN) have been prioritised for completion by June 2018, with the remaining lines to be completed by June 2023.
  - > Replace all ELGRA vibration dampers (Silmalec AAAC conductor).
  - > Removal of transmission structure asbestos paint using solvents.
  - > Low Spans - TransGrid's low span strategy is to prioritise spans for remediation using a risk based approach. Lines temperatures during credible contingency scenarios have been calculated and the low spans at this temperature are then determined. A risk assessment is then conducted on these spans taking into account traverseability, land use and extent of clearance violation (both violation height and violation area). The high and medium risk spans will then be remediated to the design temperature while the low and very low risk classifications will only be remediated if the cost of doing so would be is not disproportionate to the benefit gained. Where low spans are not remediated, engineering and administrative controls will be implemented.
- A grandfathering principle applies when determining the clearance requirements, so older lines do not have to comply with new standards.

### 7.3.2.3 330 kV Maintenance Initiatives

- > The following maintenance initiatives are planned from the date of this plan until June 2023. Details on the specific assets are noted in Table 13. Collapsible crossarm reinforcements to be designed and implemented as required.
- > Line 3 and 6 emergency structures to be replaced with concrete or pole structures.
- > Line 12, 13, 76 and 78 steel pole joint corrosion remediation.
- > Expand the travelling wave fault locator system.
- > Strengthening of single circuit steel tower lines in strategic locations to bring to current design criteria.

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Emerging issues on associated easements are:

- > Hazard trees on easements.
- > Unauthorised easement encroachments.

#### **7.3.2.4 330 kV Disposal Initiatives**

Dismantling and disposal of the short sections of 330 kV wood pole lines at Bayswater and Mount Piper. These structures were used to connect the 500 kV structures to the 330 kV switchyards. Since the 500 kV conversion, these are now defunct however still require maintenance.

**Table 13: 330 kV Transmission Line Asset Emerging Issues, and Renewal and Maintenance Initiatives**

Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
Line 81	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 15 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 32 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of tower members – 32 towers – Replacement of 1% crossarm steel members per tower</p> <p>Corrosion of fasteners – Replace 5% of fasteners on 32 towers</p> <p>Corrosion of conductor fittings – 128 fitting replacements</p> <p>Corrosion of earthwire fittings – 80 fitting replacements</p> <p>Corrosion of earthwire – replacement of 14km of earthwire</p>	Included in 2018-23 Revenue proposal	Need ID: 1268
Line 3W	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 15 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 15 towers - Dig out tower legs, scabbling of concrete footing, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 30 towers -</p>	Included in 2018-23 Revenue proposal	Need ID: 1269

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
			<p>Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Damaged earth straps – 45 towers – Replacement of earth straps in line with current standard</p> <p>Corrosion of fasteners – Replace 5% of fasteners on 45 towers</p> <p>Corrosion of conductor fittings – 52 fitting replacements</p> <p>Corrosion of earthwire fittings – 34 fitting replacements</p> <p>Corrosion of insulators – 687 insulator replacements</p> <p>Damaged Stockbridge vibration dampers – 472 damper replacements</p>		
Line 12	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Corrosion of earthwire and line components at end of life.	<p>Damaged Stockbridge vibration dampers – 56 damper replacements</p> <p>Corrosion of earthwire – replacement of 3.7km of earthwire and installation of 17.6km of OPGW</p>	Included in 2018-23 Revenue proposal	Need ID: 1271
Line 13	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Buried concrete foundations – 4 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of insulators – 57 insulator replacements</p> <p>Damaged Stockbridge vibration dampers – 92 damper replacements</p> <p>Corrosion of earthwire – replacement of</p>	Included in 2018-23 Revenue proposal	Need ID: 1272

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
			1.2km of earthwire		
Line 27	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 10 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Damaged earth straps – 10 towers – Replacement of earth straps in line with current standard</p> <p>Corrosion of fasteners – Replace 5% of fasteners on 45 towers</p> <p>Corrosion of conductor fittings – 52 fitting replacements</p> <p>Corrosion of earthwire fittings – 34 fitting replacements</p> <p>Corrosion of insulators – 15 insulator replacements</p>	Included in 2018-23 Revenue proposal	Need ID: 1273
Line 28	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 1 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 3 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Damaged earth straps – 5 towers – Replacement of earth straps in line with current standard</p> <p>Corrosion of conductor fittings – 81 fitting replacements</p> <p>Corrosion of earthwire fittings – 80 fitting replacements</p>	Included in 2018-23 Revenue proposal	Need ID: 1274

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
			Corrosion of insulators – 47 insulator replacements Damaged spiral vibration dampers – 31 damper replacements		
Line 31/32	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 9 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 47 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Damaged earth straps – 47 towers – Replacement of earth straps in line with current standard</p> <p>Corrosion of tower members – Replace 2% of minor members on 47 towers</p> <p>Corrosion of fasteners – Replace 5% of fasteners on 47 towers</p> <p>Corrosion of insulators – 1905 insulator replacements</p> <p>Damaged Stockbridge vibration dampers – 1092 damper replacements</p> <p>Damaged spiral vibration dampers – 91 damper replacements</p>	Included in 2018-23 Revenue proposal	Need ID: 1275
Line 39	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 5 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 14 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment</p>	Included in 2018-23 Revenue proposal	Need ID: 1276

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
			of drainage channel Damaged earth straps – 14 towers – Replacement of earth straps in line with current standard Corrosion of fasteners – Replace 3% of fasteners on 14 towers Corrosion of earthwire fittings – 34 fittings replacements Corrosion of insulators – 570 insulator replacements Corrosion of earthwire – replacement of 6km of earthwire Damaged Stockbridge vibration dampers – 336 damper replacements Damaged spiral vibration dampers – 684 damper replacements		
Line 14	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Corrosion of steelwork and line components at end of life. Reduction in security of supply.	Buried concrete foundations – 13 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel Corrosion of earthwire fittings – 16 fittings replacements Corrosion of insulators – 167 insulator replacements Corrosion of earthwire – replacement of 10km of earthwire Damaged spiral vibration dampers – 27 damper replacements	Included in 2018-23 Revenue proposal	Need ID: 1280
Line 88	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> </ul>	Corrosion of steelwork and line components at end of life. Reduction in security of supply.	Buried concrete foundations – 69 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel Corrosion of tower main members – 59	Included in 2018-23 Revenue proposal	Need ID: 1317

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
	<ul style="list-style-type: none"> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>		<p>towers - Abrasive blast cleaning of steelwork to remove any corrosion product and application of Zinga paint on 5% of main members per tower</p> <p>Corrosion of tower members – Replace 5% of minor members on 59 towers</p> <p>Corrosion of conductor fittings – 17 fittings replacements</p> <p>Corrosion of earthwire fittings – 11 fittings replacements</p> <p>Corrosion of insulators – 19 insulator replacements</p> <p>Damaged Stockbridge vibration dampers – 132 damper replacements</p>		
Line 21	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Corrosion of tower members – Replace 15% of crossarm members on 6 towers</p> <p>Corrosion of fasteners – Replace 10% of fasteners on 16 towers</p> <p>Corrosion of conductor fittings – 95 fittings replacements</p> <p>Corrosion of earthwire fittings – 30 fittings replacements</p> <p>Corrosion of insulators – 40 insulator replacements</p> <p>Corrosion of earthwire – replacement of 13km of earthwire</p> <p>Damaged Stockbridge vibration dampers – 135 damper replacements</p> <p>Damaged spiral vibration dampers – 90 damper replacements</p>	Included in 2018-23 Revenue proposal	Need ID: 1333
Line 8	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and</li> </ul>	Corrosion of steelwork and line components at end of life.	Corrosion of tower members – 12 towers – Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint – entire tower	Included in 2018-23 Revenue proposal	Need ID: 1341

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
	property damage <ul style="list-style-type: none"> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Reduction in security of supply.	Corrosion of fasteners – Replace 5% of fasteners on 9 towers Corrosion of conductor fittings – 33 fittings replacements Corrosion of earthwire fittings – 21 fittings replacements Corrosion of insulators – 286 insulator replacements Corrosion of earthwire – replacement of 4km of earthwire Damaged Stockbridge vibration dampers – 209 damper replacements		
Line 90	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Corrosion of steelwork and line components at end of life. Reduction in security of supply.	Ground line corrosion – 6 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion Buried concrete foundations – 2 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel Corrosion of fasteners – Replace 3% of fasteners on 6 towers Corrosion of insulators – 6 suspension insulator replacements Corrosion of insulators – 96 tension insulator replacements	Included in 2018-23 Revenue proposal	Need ID: 1347
Line 24	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost</li> </ul>	Corrosion of steelwork and line components at end of life. Reduction in security of supply.	Ground line corrosion – 16 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion Buried concrete foundations – 6 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product,	Included in 2018-23 Revenue proposal	Need ID: 1348

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
	effective		<p>application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of tower members – 14 towers – Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint – waist diaphragm and arm support chord</p> <p>Corrosion of tower members – 3 towers – Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint – entire tower</p> <p>Corrosion of fasteners – Replace 3% of fasteners on 17 towers</p> <p>Corrosion of insulators – 63 suspension insulator replacements</p> <p>Corrosion of insulators – 102 tension insulator replacements</p> <p>Corrosion of earthwire – replacement of 5.6km of earthwire</p>		
Line 22	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 67 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 86 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of tower members – 60 towers – Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint – 5% main members</p> <p>Corrosion of tower members – 6 towers – Abrasive blast cleaning of steelwork to remove any corrosion product, application</p>	Included in 2018-23 Revenue proposal	Need ID: 1349

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
			<p>of Zinga paint – entire tower</p> <p>Damaged earth straps – 10 towers – Replacement of earth straps in line with current standard</p> <p>Corrosion of fasteners – Replace 1% of fasteners on 86 towers</p> <p>Corrosion of conductor fittings – 163 fittings replacements</p> <p>Corrosion of earthwire fittings – 76 fittings replacements</p> <p>Corrosion of insulators – 117 suspension insulator replacements</p> <p>Corrosion of insulators – 42 tension insulator replacements</p> <p>Corrosion of earthwire – replacement of 70km of earthwire</p> <p>Damaged Stockbridge vibration dampers – 454 damper replacements</p> <p>Damaged spiral vibration dampers – 209 damper replacements</p>		
Line 25/26	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 24 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 42 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of tower members – 11 towers – Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint – entire tower</p> <p>Damaged earth straps – 26 towers – Replacement of earth straps in line with</p>	Included in 2018-23 Revenue proposal	Need ID: 1350

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
			<p>current standard</p> <p>Corrosion of fasteners – Replace 7% of fasteners on 66 towers</p> <p>Corrosion of insulators – 90 suspension insulator replacements</p> <p>Corrosion of insulators – 66 tension insulator replacements</p> <p>Damaged Stockbridge vibration dampers – 626 damper replacements</p> <p>Damaged spiral vibration dampers – 52 damper replacements</p>		
Line 18	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Buried concrete foundations – 6 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of tower members – 13 towers – Abrasive blast cleaning of steelwork to remove any corrosion product and application of Zinga paint – entire tower</p> <p>Damaged earth straps – 16 towers – Replacement of earth straps in line with current standard</p> <p>Corrosion of conductor fittings – 134 fittings replacements</p> <p>Corrosion of earthwire fittings – 14 fittings replacements</p> <p>Corrosion of insulators – 172 suspension insulator replacements</p> <p>Corrosion of earthwire – replacement of 10km of earthwire</p> <p>Damaged Stockbridge vibration dampers – 254 damper replacements</p>	Included in 2018-23 Revenue proposal	Need ID: 1351

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
Line 17	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 24 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 20 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of fasteners – Replace 5% of fasteners on 35 towers</p> <p>Corrosion of conductor fittings – 27 fittings replacements</p> <p>Corrosion of earthwire fittings – 12 fittings replacements</p> <p>Corrosion of insulators – 212 suspension insulator replacements</p> <p>Corrosion of earthwire – replacement of 25km of earthwire</p> <p>Corrosion of earthwire – installation of 50km of OPGW</p> <p>Damaged Stockbridge vibration dampers – 240 damper replacements</p>	Included in 2018-23 Revenue proposal	Need ID: 1352
Line 16	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 14 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 8 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of tower members – 13 towers – Abrasive blast cleaning of steelwork to</p>	Included in 2018-23 Revenue proposal	Need ID: 1353

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
			<p>remove any corrosion product and application of Zinga paint – entire tower</p> <p>Corrosion of fasteners – Replace 5% of fasteners on 40 towers</p> <p>Corrosion of conductor fittings – 30 fittings replacements</p> <p>Corrosion of earthwire fittings – 19 fittings replacements</p> <p>Corrosion of insulators – 379 suspension insulator replacements</p> <p>Corrosion of earthwire – replacement of 8km of earthwire</p> <p>Damaged Stockbridge vibration dampers – 191 damper replacements</p>		
Line 93	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 3 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p> <p>Buried concrete foundations – 1 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of fasteners – Replace 3% of fasteners on 3 towers</p> <p>Corrosion of insulators – 18 suspension insulator replacements</p> <p>Corrosion of insulators – 18 tension insulator replacements</p>	Included in 2018-23 Revenue proposal	Need ID: 1407
Line 23	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Ground line corrosion – 3 towers - Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion</p>	Included in 2018-23 Revenue proposal	Need ID: 1408

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
	<ul style="list-style-type: none"> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>		<p>Buried concrete foundations – 1 towers - Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel</p> <p>Corrosion of fasteners – Replace 6% of fasteners on 23 towers</p> <p>Corrosion of conductor fittings – 7 fittings replacements</p> <p>Corrosion of earthwire fittings – 5 fittings replacements</p> <p>Corrosion of insulators – 72 tension insulator replacements</p>		
Line 2M	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Corrosion of tower members – 12 towers – Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint – waist diaphragm and arm support chord</p> <p>Corrosion of tower members – 4 towers – Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint – entire tower</p> <p>Corrosion of fasteners – Replace 10% of fasteners on 36 towers</p> <p>Corrosion of conductor fittings – 50 fittings replacements</p> <p>Corrosion of earthwire fittings – 8 fittings replacements</p> <p>Corrosion of insulators – 27 suspension insulator replacements</p> <p>Corrosion of insulators – 78 tension insulator replacements</p> <p>Corrosion of earthwire – replacement of 11km of earthwire</p> <p>Damaged Stockbridge vibration dampers –</p>	Included in 2018-23 Revenue proposal	Need ID: 1411

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
			76 damper replacements Damaged spiral vibration dampers – 50 damper replacements		
Line 20	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion and line components at end of life.</p> <p>Reduction in security of supply.</p>	Corrosion of insulators – 203 suspension insulator replacements	Included in 2018-23 Revenue proposal	Need ID: 1427
Line 11	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion and line components at end of life.</p> <p>Reduction in security of supply.</p>	<p>Painting of tension structures and suspension structures not suitable for replacement. Replacement of tension structure insulators and fittings by June 2018.</p> <p>Replacement of suspension structures.</p>	<p>Complete by June 2018.</p> <p>Included in 2018-23 Revenue proposal</p>	Need ID: DCN220 1600
<p>The following transmission lines:</p> <ul style="list-style-type: none"> <li>63</li> <li>51</li> <li>01</li> <li>2</li> <li>3</li> <li>07</li> <li>64</li> <li>65</li> <li>66</li> </ul>	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Improve OPEX Performance</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Long remote lines.</p> <p>Market constraints</p> <p>Increased maintenance requirements in very remote locations</p>	Expand the travelling wave fault locator system in locations that will achieve efficiencies and market benefits (refer need statement).	Installation of Travelling wave fault locators at the identified sites by December 2017	<p>Need No: 426</p> <p>Need Statement: NS 9522</p> <p>Option Evaluation Report: OER-7030</p> <p>NCIPAP 2014/15 – 2017/18 Section 3.6</p>

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
<ul style="list-style-type: none"> <li>83</li> <li>84</li> <li>88</li> <li>85 and 86</li> <li>8C and 8E</li> <li>87</li> <li>89</li> </ul>					
Snowy Lines: 01, 2, 64, 65, U1, U3, U5, U7	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Improve CAPEX Performance.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Mid span joint failures on Silmalec conductor	Develop systems to allow reinforcement of mid span joints from helicopter using longline method.  Reinforce mid span joints.	All mid span joints that can be accessed from ground have been replaced.  Scoping of reinforcement options and methodology has commenced.  Included in 2018-23 Revenue proposal.	Need ID: 1290 (2016 – 2018) and 1590 (2019 – 2023)
Snowy Lines: 01, 2, 64, 65, 66, L1, L3, L5, M1, M3, M5, M7, M9, M11, M13, U1, U3, U5, U7	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Improve CAPEX Performance.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Deadend failure on Silmalec conductor	Develop systems to allow replacement or reinforcement of deadend on Silmalec conductor.	Easily accessible dead ends have been replaced.  Scoping of replacement/reinforcement options and methodology has commenced.  Included in 2018-23 Revenue proposal.	Need ID: 1290 (2016 – 2018) and 1590 (2019 – 2023)
Snowy Lines: 01, 2, 64, 65, 66, L1, L3, L5, M1, M3, M5, M7, M9, M11, M13, U1, U3, U5, U7	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Maintain network reliability.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	“ELGRA” Vibration dampers on Silmalec conductor are ineffective.	Replace vibration dampers on Silmalec conductor.	Included in 2018-23 Revenue proposal	Need ID: 1290 (2016 – 2018) and 1590 (2019 – 2023)

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
Snowy Lines: 64, 65, 66	Manage Transmission Line related staff safety risks to As Low As Reasonably Practicable (ALARP)/So Far As Is Reasonably Practicable (SFAIRP).	Collapsible crossarms may not be adequate to support maintenance loads	Determine maximum loadings. Design reinforcements. Order an appropriate number of reinforcement sets that will be kept in the store. The reinforcements will then be installed as and when required.	Ongoing	Working group minutes
Lines with grillage structures:  1 36 U1 10 4 U3 11 5 U5 16 65 U7 17 66 21 18 8 24 2 88 2M 90 9 35	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Ground line and buried steel tower corrosion Reduction in security of supply.	Concrete encasement of buried steel in aggressive soil corrosion areas. Replacement/installation of sacrificial anodes in other areas.	Included in 2018-23 Revenue proposal	Need ID: 1523
Lines with asbestos paint	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> </ul>	Asbestos paint in poor condition presents people safety and environment risk	Removal of asbestos paint using solvents.	Included in 2018-23 Revenue proposal	Need ID: 1164
330kV composite wood pole lines: 86	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Wood rot beneath sleeve of composite wood poles. Reduction in security of supply.	Replacement of wood pole line with concrete or steel structures to increase line security. Use of larger conductor to achieve market benefits.	Included in 2018-23 Revenue proposal	Need ID: 1555

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
Steel lattice towers	Improve CAPEX Performance	Corrosion of steel towers to the extent that refurbishing is no longer possible.	Monitor corrosion of steel towers to ensure assets not suitable for replacement shall not get to condition where refurbishment is not possible	Ongoing	Asset Condition Data Collection
330 kV lines with SC/GZ earthwire	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Maintain network reliability</li> </ul>	Corrosion of steel earthwire	<p>Continue to inspect and monitor the identified issues with steel earthwire corrosion.</p> <p>Include in regulatory submissions for renewal when appropriate.</p>	<p>Ongoing during routine maintenance.</p> <p>Selected earthwire replacements to be included in 2018-23 Revenue proposal</p>	<p>Transmission Line Maintenance Plan</p> <p>Transmission Line and Easement Condition Data Collection</p>
All assets – Conductors and fittings	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> </ul>	Corrosion of fittings and conductors	<p>Continue to inspect and monitor the identified issues.</p> <p>Include in regulatory submissions for renewal when appropriate.</p>	<p>Ongoing during routine maintenance.</p> <p>Selected fitting replacements to be included in 2018-23 Revenue proposal.</p>	<p>Transmission Line Maintenance Plan</p> <p>Transmission Line and Easement Condition Data Collection</p>
330 kV lines strung with OPGW:	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Maintain network reliability</li> </ul>	Excessive fitting wear on OPGW on spans with high wind/weight span ratios.	Routine climbing inspections of identified high wind/weight span towers to monitor effectiveness of remedial action (fitting modifications).	New design fittings installed. No OPGW fitting wear detects of the new design have been reported to the asset manager.	<p>Transmission Line Maintenance Plan</p> <p>Transmission Line and Easement Condition Data Collection</p>
Low spans on 330 kV assets	Manage Transmission Line related people safety risks to ALARP/SFAIRP.	Low spans with clearances that breach design standards at credible line loads.	Remediate low spans as per guideline “Low Span Assessment – Risk Management Approach”. Transmission line modifications are to be to design temperature with AS7000 clearances.	Ongoing and included in 2018-23 Revenue proposal	<p>Need No's:</p> <p>DCN532</p> <p>DCN533</p> <p>593</p> <p>595</p> <p>597</p> <p>1556</p> <p>“Low Span Assessment – Risk</p>

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
					Management Approach"
Lines 3 and 6	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> <li>Improve OPEX Performance</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Emergency wood poles are designed as temporary structures to lower design criteria reducing line security of supply	Replace emergency structures with new permanent structures.	Complete by June 2023	Need ID: 1686
330 kV Wood poles at Bayswater and Mount Piper	Improve OPEX Performance	Obsolete asset still requires maintenance	Dismantle 330 kV wood pole lines at Bayswater and Mount piper. These poles are no longer needed since the 500 kV conversion of Bayswater to Mount Piper. To be completed by 2018.	Complete by June 2023	Need ID:1678
Lines 12, 13, 76 and 78	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> </ul>	Corrosion of steel poles at pole section joints	Remediation of corrosion at joints.	Complete by June 2023	Need ID:1723
Single circuit 330kV lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> </ul>	Designed to lower set of design criteria than current structure designs. Failures in extreme wind events. Reduction in security of supply.	Strategic and targeted strengthening of structures in areas where system security is at risk.	Complete by June 2023	
All 330kV Lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> </ul>	Hazard trees causing transmission line faults	Identification and scoping of hazard tree risk. Removal of hazard trees where required.	Ongoing	

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
	<ul style="list-style-type: none"> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> </ul>				
All 330kV Lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Improve OPEX Performance</li> </ul>	Unauthorised encroachments on easements present a safety risk to maintenance staff and the public	Identify encroachments and order their removal where required.	Ongoing	Easement development guidelines
All Transmission Line Assets	<ul style="list-style-type: none"> <li>Improve CAPEX Performance</li> <li>Improve OPEX Performance</li> </ul>	Asset condition data of insufficient quality and detail to support decision making.	Improve asset data quality through SLAs and the implementation of AIM (Asset Inspection Manager)	AIM has been rolled out to Transmission Lines. Data will become available progressively.	N/A

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### 7.3.3 330 kV Maintenance Program

For the 330 kV Transmission Line assets the maintenance program consists of the following:

- Routine inspections (as per Table 11).
- Corrective (or "defect") maintenance addressing out of specification conditions. The need to conduct corrective maintenance is usually identified during a routine inspection.
  - Where possible and practical, these defects are addressed at the same time as the inspection.
  - Otherwise, these are prioritised on a basis as per "Maintenance Plan - Transmission Line Assets".
- Easement maintenance as detailed in the Maintenance Plan – Easements and Access Tracks.

Section 7.1 details the 2016 changes to maintenance plan.

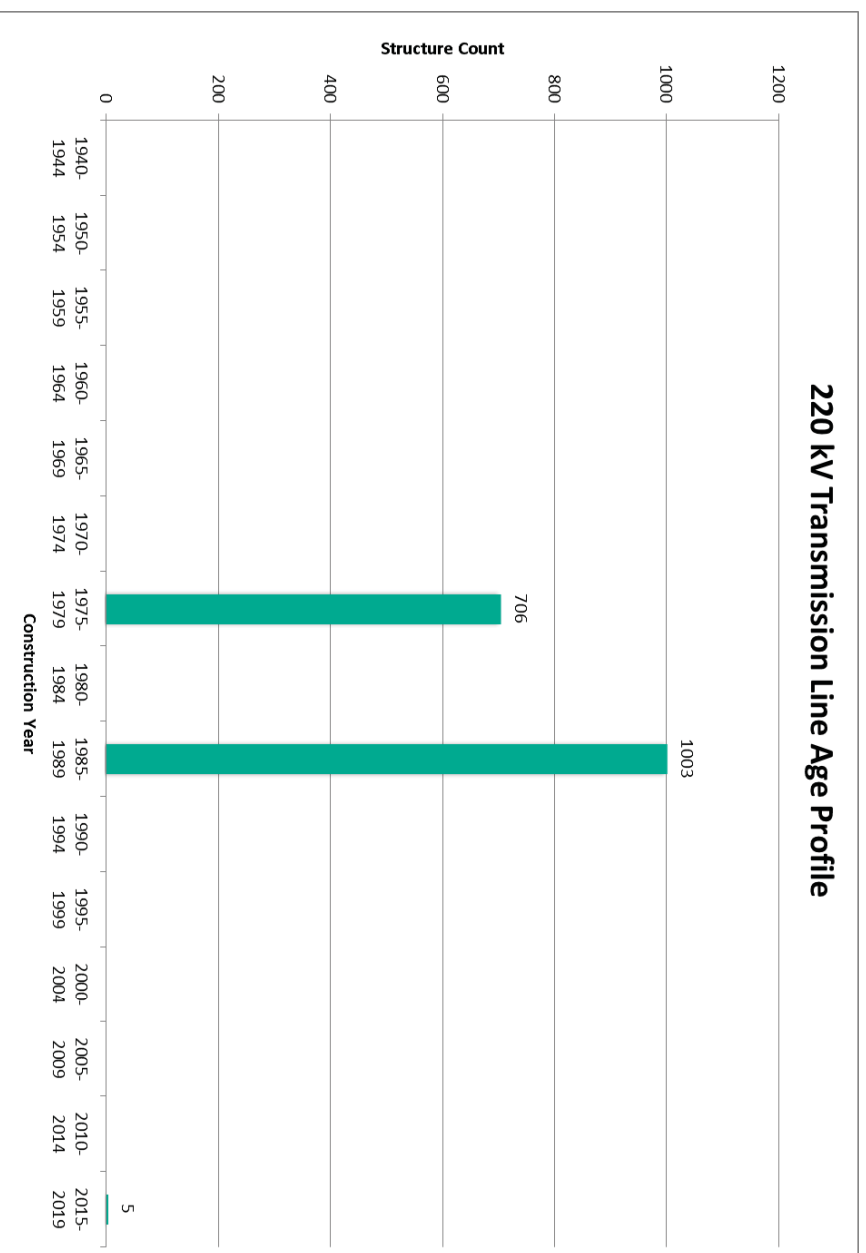
## 7.4 220 kV Transmission Lines Asset Review

### 7.4.1 Population Review

The 220 kV network makes up approximately 7% of TransGrid's transmission line asset base by circuit kilometres. It has approximately 670 km of transmission lines which are supported by over 1,700 structures. The 220 kV network is located inland and is almost entirely supported by steel tower structures, which have a nominal lifespan of 75 years. The first elements of TransGrid's current 220 kV network were commissioned in 1975. There are 14 emergency wood pole structures on the 220 kV network, erected in 1988 and 2011 after storm failures. The wood pole structures that were erected on Line X2 in 2009 after a storm failure have now been removed with permanent concrete pole structures installed in similar locations to the original steel towers. They are not included in the regulated asset base as the regulated asset base assumes the original all steel tower construction.

The age profile of TransGrid's 220 kV transmission line assets is shown in Figure 11.

Figure 12: 330 kV Transmission Line Age Profile.



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## 7.4.2 220 kV Transmission Line Emerging Issues, and Renewal and Maintenance Initiatives

The specific issues relating to the 220 kV transmission lines are discussed below with respect to the three main transmission line elements:

### Fittings

The 220 kV fittings are in a good condition overall and no current or emerging issues have been identified.

### Electrical conductors

The 220 kV conductors are in a good condition overall and no current or emerging issues have been identified.

### Structures

The current and emerging issues relating to 220 kV structures are as follows:

The 220 kV structures are in a good condition overall and no current or emerging issues have been identified with respect to health, obsolescence or compliance. Line X2 was built with black steel, resulting in surface rust remaining constant over the past 35 years, but there has been little loss of member cross-section.

Following the failure of steel towers on line X5/1 and X2 during storms, temporary emergency wood pole structures were erected to quickly return the 220 kV lines to service. These temporary wood pole structures are not designed to remain permanently in service on 220 kV lines and have an increased probability of failure, reducing the security of supply. These wood pole structures have substantially increased maintenance requirements over steel towers, which given the remote location requires substantial resources to complete. Permanent concrete pole structures have been installed on Line X2. The remaining emergency structures on X5/1 are planned to be removed and replaced in November 2016.

These structures are very remote, making fault response very time consuming due to travelling times and the length of lines required to be inspected. Line X2 is radial, so a failure results in the requirement to run expensive backup diesel generation at Broken Hill. The local solar farm is unable to generate while the city is islanded. The expansion of the travelling wave fault location system to these lines would provide significant market benefits and labour cost savings. It was also a recommendation from the committee of enquiry into the X2 structure failure.

The 220kV structures have a history of failure since construction. A total of 19 have failure since the lines entered service. Failures have been the result of extreme wind events, exceeding the tower design wind speed of 140km/h. A review at the time of the failures determined that a design capable of withstanding wind speeds up to 200km/h was more suitable given the location of the transmission lines, resulting in strengthening of 147 structures at road crossings and public areas. Given the criticality of the radial line to Broken Hill, the transmission line may benefit from additional strengthening works to increase the security of supply.

### 7.4.2.1 220 kV Renewal Initiatives

The following renewal initiatives are planned from the date of this plan until June 2023. Details on the specific assets are noted in Table 14.

- > Low Spans - TransGrid's low span strategy going forward has been to prioritise spans using a risk based approach. Network Planning have provided temperatures that the lines may reach in credible contingency scenarios. The low spans at this temperature are then determined. A risk assessment is then conducted on these spans taking into account traverseability, land use and extent of clearance violation (both violation height and violation area). The high and medium spans will then be remediated to the design temperature while the low and very low classifications will only be remediated if the cost of doing so would be considered reasonable for the benefit gained. Where low spans are not remediated to the design temperature, engineering and administrative controls will be implemented.

A grandfathering principle applies when determining the clearance requirements, so old lines do not have to comply with new standards unless they are modified. This may mean that a span which is non-compliant with AS7000 clearances may actually be compliant to the standard at the time it was built.

### 7.4.2.2 220 kV Maintenance Initiatives

The following maintenance initiatives are planned from the date of this plan until June 2023. Details on the specific assets are noted in Table 14.

- > Expand the travelling wave fault locator system to include Lines X2, X5/1 and X5/3.
- > Replace emergency wood pole structures with lattice or single concrete/steel pole structures.
- > Strengthening of structures to increase reliability of supply, as deemed appropriate.

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Emerging issues on associated easements are:

- > Hazard trees on easements.
- > Unauthorised easement encroachments.

#### **7.4.2.3 220 kV Disposal Initiatives**

There are no 220kV disposal initiatives.

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**Table 14: 220 kV Emerging Issues, and Renewal and Maintenance Initiatives**

Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
<p>The following transmission lines:</p> <ul style="list-style-type: none"> <li>X2</li> <li>X5/1</li> <li>X5/3</li> </ul>	<ul style="list-style-type: none"> <li>Maintain network reliability</li> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP</li> <li>Improve OPEX Performance</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Long remote lines.</p> <p>Market constraints</p> <p>Increased maintenance requirements in very remote locations</p>	<p>Expand the travelling wave fault locator system in locations that will achieve efficiencies and market benefits</p>	<p>Installation of Travelling wave fault locators at the identified sites by December 2017</p>	<p>Need No: 426</p> <p>Need Statement: NS 9522</p> <p>Option Evaluation Report: OER-7030</p> <p>NCIPAP 2014/15 – 2017/18 Section 3.6</p>
<p>Emergency structures on X2 and X5/1</p>	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Improve OPEX Performance</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Increased failure probability of emergency wood pole structures. These structures are very remote</p>	<p>Replace emergency wood pole structures (17 remaining from a total of 21) with lattice or single concrete/steel pole structures.</p>	<p>Emergency structures on X2 have been replaced. The remaining 17 structures on X5/1 are planned to be replaced by December 2016.</p>	<p>Need ID: DCN 176</p>
<p>220 kV Low Spans</p>	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP.</li> </ul>	<p>Remediate low spans as per guideline "Low Span Assessment – Risk Management Approach". Transmission line modifications are to be to design temperature with AS7000 clearances.</p>	<p>Low spans with clearances that breach design standards at credible line loads.</p>	<p>Included in 2018-23 Revenue proposal</p>	<p>Need ID: 1556</p>
<p>All 220kV Lines</p>	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> </ul>	<p>Structure failures in high wind events exceeding design capacity.</p> <p>Reduction in security of supply.</p>	<p>Strengthening of structures as deemed appropriate</p>	<p>Complete by June 2023</p>	

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
All 220kV Lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> </ul>	Identification and scoping of hazard tree risk. Removal of hazard trees where required.	Hazard trees causing transmission line faults	Ongoing	
All 220kV Lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Improve OPEX Performance</li> </ul>	Identify encroachments and order their removal where required.	Unauthorised encroachments on easements present a safety risk to maintenance staff and the public	Ongoing	
All Transmission Line Assets	<ul style="list-style-type: none"> <li>Improve CAPEX Performance</li> <li>Improve OPEX Performance</li> </ul>	Improve asset data quality through SLAs and the implementation of AIM (Asset Inspection Manager)	Asset condition data of insufficient quality and detail to support decision making.	AIM has been rolled out to Transmission Lines. Data will become available progressively.	N/A

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### 7.4.3 220 kV Transmission Line Maintenance Program

For the 220 kV Transmission Line assets, the structures are predominately steel towers, except for the handful of emergency wood pole structures and concrete poles (which replaced the emergency structures on Line X2). The maintenance program consists of the following:

- Routine inspections (as per Table 11) – except aerial inspections are completed once every 2 years.
- Corrective (or “defect”) maintenance addressing out of specification conditions. The need to conduct corrective maintenance is usually identified during a routine inspection.
  - Where possible and practical, these defects are addressed at the same time as the inspection.
  - Otherwise, these are prioritised on a basis as per “Maintenance Plan - Transmission Line Assets”.
- Easement maintenance as detailed in the Maintenance Plan – Easements and Access Tracks.

The replacement of the emergency structures on Line X2 has removed the requirement to complete underground inspections to check for termite attack. At time of replacement the maintenance would have been overdue. The emergency structures on X5/1 are planned to be replaced by December 2016. All 220 kV structures will then be made of steel or concrete. The underground inspection requirements have been removed from the Maintenance Plan.

The 220kV network is very remote with very little vegetation. Aerial inspections only occur once every two years, where it is an annual task on most other lines.

Section 7.1 details the 2016 changes to maintenance plan.

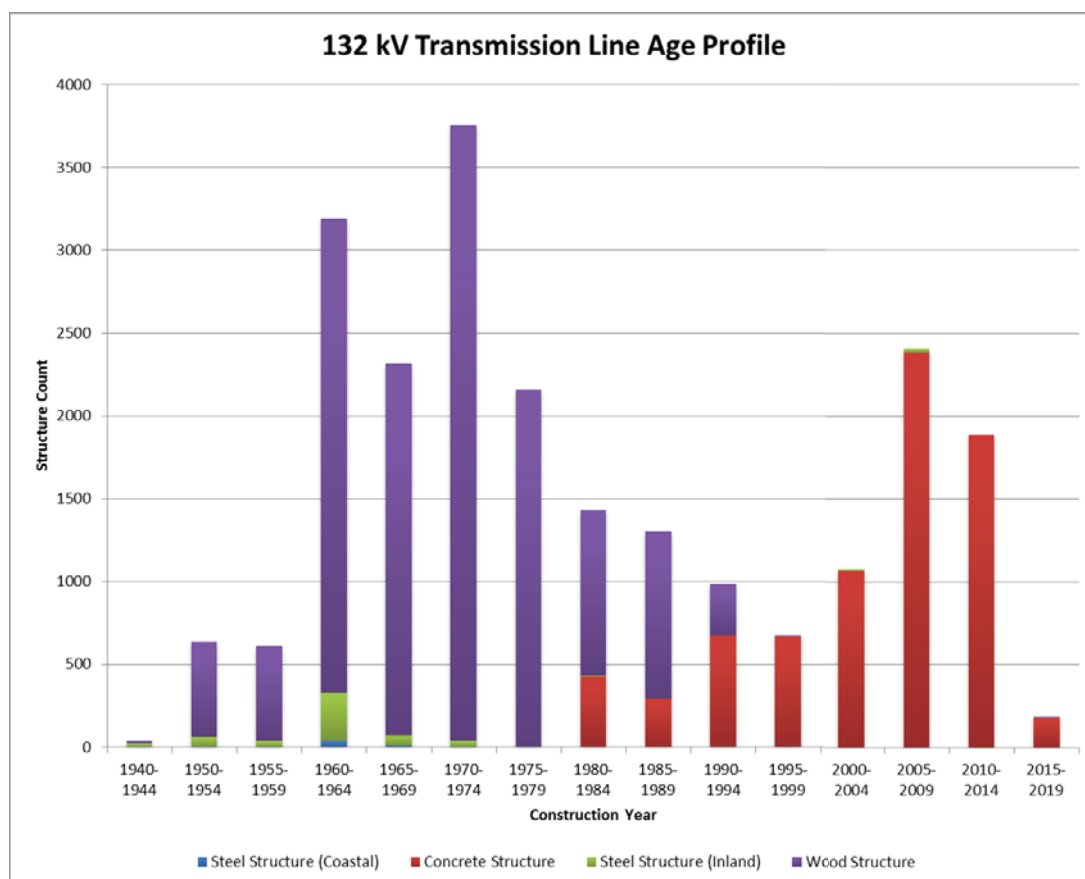
## 7.5 132 kV Transmission Lines Asset Review

### 7.5.1 Population Review

The 132 kV network makes up approximately 44% of TransGrid’s transmission line asset base by circuit kilometres. It has over 5,700 km of transmission lines which are supported by over 22,600 structures. The network is comprised of a combination of structures including 599 steel structures, 7,576 concrete pole structures and 14,467 wood pole structures. TransGrid’s 132 kV network is comprised of both inland and coastal infrastructure. The first elements of TransGrid’s current 132 kV network were commissioned in 1940.

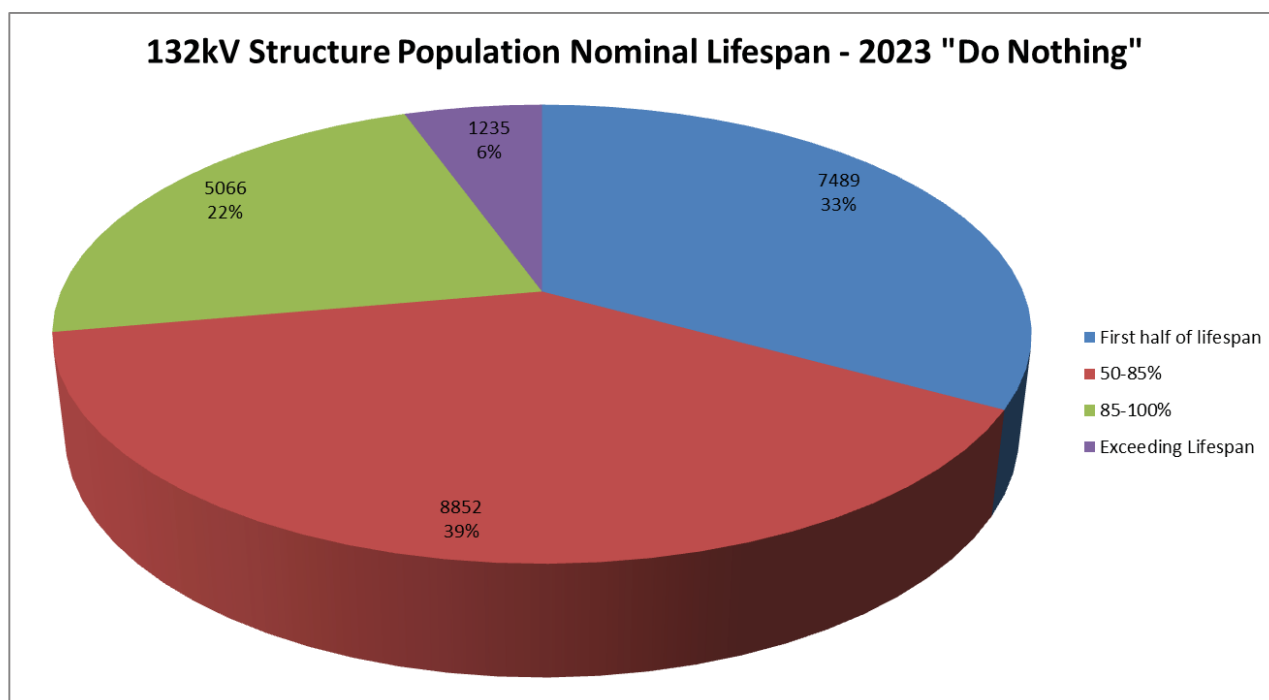
The age profile of TransGrid’s 132 kV transmission line assets is shown in Figure 13.

Figure 13: 132 kV Transmission Line Age Profile



The above age profile shows that prior to the 1990s, the majority of TransGrid's 132 kV installations were wood pole structures and since the 1990s the majority of installations have been concrete pole structures. Notwithstanding any intervening actions, over the 2023 period, the above age profile will result in the outcome shown in Figure 14.

Figure 14: 132 kV Transmission Line Age versus Nominal Lifespan



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This age distribution shows that around 28% of TransGrid's 132 kV transmission line assets are approaching or exceeding their nominal lifespan; which indicates that these assets are likely to be subject to deteriorating health and obsolescence issues.

- > 132 kV steel structures: 97 structures approaching and 72 exceeding their nominal lifespan.
- > 132 kV wood pole structures: 4,969 structures approaching and 1,163 exceeding their nominal lifespan.

## 7.5.2 132 kV Transmission Line Emerging Issues, and Renewal and Maintenance Initiatives

### 7.5.2.1 132 kV Transmission Line Emerging Issues

The significant issues that have been identified with the 132 kV network predominantly affect the wood pole transmission lines. The nominal lifespans analysed above do not consider localised effects that also affect these networks. These include:

- > Coastal and high pollution environments: Steel structures are subject to corrosion. Although the wood poles themselves are not subject to corrosion issues, the conductors and fittings comprising the wood pole transmission lines are subject to corrosion issues in these environments.
- > Termites: Termites are a significant threat to wood poles and in certain areas where termites are prevalent the life expectancy of the poles is significantly reduced.
- > Rot: Wood poles can also be affected by rotting and in areas of high rainfall and/or high water tables the life expectancy of the poles is also significantly reduced.

The specific issues relating to the 132 kV transmission lines is listed in Table 15 with respect to the three main transmission line elements discussed below.

#### Fittings

The current and emerging issues relating to 132 kV fittings are as follows:

- > Corrosion issues range from minor to severe, where severe corrosion is more prevalent with those lines located in coastal or high pollution areas.
- > On some older lines, fittings exist that do not meet current design standards. The following three issues have been identified:
  - a. The use of "U-bolts" as a conductor clamping mechanism. This creates a stress-point at the clamp which is known to damage the conductors when exposed to prolonged conductor vibration.
  - b. The use of king / eyebolts rather than pole bands on some "flying angle" and "tension" constructions. Eyebolts are prone to pulling through under high tension, particularly when poles begin to be affected by rotting issues.
  - c. Corrosion of underground components: A number of fittings such as guy anchors and earth straps are buried in soil and suffer from corrosion problems. This is more prevalent in areas with high water tables and significant salt content, corrosive soils and marine clays.
- > There have been a number of failures of helical earthwire deadends. Electrical current can pass through the thimble instead of the earthwire jumper causing excessive heat, particularly under fault conditions. The issue is more pronounced closer to substations due to the higher fault level.
- > Older timber tension/flying angle structures have insulators attached to the pole using eyebolts. As the pole deteriorates it is possible for the eyebolt to "pull through", dropping the conductor to the ground. The use of a "pole band" attachment point would eliminate this failure mode as the insulator attachment is now supported by the entire annulus.

#### Electrical Conductors and Earthwire

The current and emerging issues relating to 132 kV conductors and earthwires are as follows:

- > Corrosion issues range from minor to severe, where severe corrosion is more prevalent with those lines located in coastal or high pollution areas.

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- > Low hanging conductor spans. These are low electrical clearance spans which do not meet design standards (grandfathered to date of construction). Only spans low at credible line loads are required to be considered.

## Structures

The current and emerging issues relating to 132 kV structures (steel lattice towers, concrete poles and wood poles) are as follows:

- > Termite infestation and damage.
- > Pole stability issues, such as for poles located in flood prone areas.
- > Rot and fungal decay.
- > Concrete pole internal steel reinforcement corrosion on line 99K.
- > Corrosion of steel tower members: A number of steel towers have degraded through loss of zinc coating and subsequent pitting of the steel. The towers located in coastal and industrial areas have suffered the greatest deterioration.
- > Under-designed line: Single pole 66kV line uprated to 132 kV simply by increasing the number of insulator discs, which is still inadequate. It is impossible to add more due to structure design. Lines with insufficient number of insulating discs are more prone to electrical “flashovers”. This is particularly common in high pollution areas where residue builds up on the insulators, and during wet weather.
  - Line 96H has only 7 discs per insulator string which gives the insulator string of 1.25 metres in length. A typical 132 kV 10 disc insulator string or composite long-rod is approximately 1.75 m. The single wood pole design means the consequence of failure is higher.
- > The North-west 132 kV network is very remote, patrolling in the event of fault is quite time consuming. In addition the terrain is quite flat, exposing the line to lightning strikes. The North East network only has a single 330 kV link from Armidale. If the 330 kV network is lost the 132 kV network becomes especially important. Line 96C has a narrow easement with very tall trees at edges which results in a high number of fault events. Travelling Wave Fault Location (TWFL) can greatly reduce patrol time and allow for faster repairs.

### 7.5.2.2 132 kV Transmission Line Renewal Initiatives

The following renewal initiatives are planned from the date of this plan until June 2023. Details on the specific assets are noted in Table 15.

- > Line 970 – Yass to Burrinjuck wood pole replacement and OPGW install project is in progress with 78 of 92 structures replaced as of September 2016. These were the oldest structures in TransGrid’s asset base. The new concrete structures will not require underground inspections and are not impacted by termites. The planned completion date of March 2017 is on-track. The line also contains two steel lattice towers at Burrinjuck which requiring strengthening of tower foundations.
- > Line 96H Coffs Harbour – Koolkhan - wood pole structure replacement (reusing conductor). The earthwire will be replaced with OPGW for strategic purposes. Possession of site was granted September 2016 and the planned completion date is December 2017.
- > Line 99F wood pole structure replacement (reusing conductor). The one earthwire will be replaced with OPGW and taller poles will be used to allow 100°C operation for strategic purposes. The planned completion date is June 2018.
- > Line 944 Wallerawang – Orange North – Targeted pole replacement (condemned poles) and low span remediation. Planned completion is March 2018.
- > Replacement of forecast defect wood poles with concrete or steel poles on lines exceeding their economic life. A total of 1,163 wood pole structures will exceed their nominal 65 year life by 2023. This accounts for approximately 8% of TransGrid’s 132kV wood pole population. Based on historical defect rates, it is estimated that 966 wood poles will require replacement in the 2019-23 regulatory period to extend the life of their respective transmission lines. This is well aligned with the quantity of poles exceeding nominal life at the end of the regulatory period. By 2028 an additional 2,110 132kV wood poles will exceed their nominal life. As the number of aging wood poles is increasing, it is imperative that replacement of forecast defective poles commence before the quantity becomes unmanageable, which will increase network risk.

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Wood poles are strategically replaced with concrete or steel (where environmental conditions permit) poles. Concrete and steel poles have a longer expected life than wood poles, have predictable deterioration patterns (i.e. do not suffer from termites, rot and fungal decay) and as such have reduced maintenance requirements and lower risk of failure. Newer chemically treated wood poles do not have the same expected life than older natural wood poles have, with significant increases in defect rates noted from 20 years of age.

- > Line 959/92Z – Sydney North – Sydney East – Steel tower and earthwire corrosion issues with targeted replacements and remediation including:
  - Ground line corrosion remediation
  - Minor member replacements
  - Earth strap replacement
  - Tower bolt and minor member replacement
  - Replacement of earthwire and conductor attachments
  - Replacement of earthwire
  - Replacement of vibration dampers.
- > Grillage foundations corrosion remediation:
  - Structures which have been classified as located in areas of aggressive soils are to have the grillage foundation dug out, and the footing steel work repaired, or reinstated where required, then concrete encased.
  - Installation of new or additional sacrificial anodes elsewhere.
- > Low Spans - TransGrid's low span strategy going forward has been to prioritise spans using a risk based approach. Network Planning have provided temperatures that the lines may reach in credible contingency scenarios. The low spans at this temperature are then determined. A risk assessment is then conducted on these spans taking into account traverseability, land use and extent of clearance violation (both violation height and violation area). The high and medium spans will then be remediated to the design temperature while the low and very low classifications will only be remediated if the cost of doing so would be considered reasonable for the benefit gained. Where low spans are not remediated to the design temperature, engineering and administrative controls will be implemented.

A grandfathering principle applies when determining the clearance requirements, so old lines do not have to comply with new standards unless they are modified. This may mean that a span which is non-compliant with AS7000 clearances may actually be compliant to the standard at the time it was built.

### **7.5.2.3 132 kV Transmission Line Maintenance Initiatives**

The following maintenance initiatives are planned from the date of this plan until June 2023. Details on the specific assets are noted in Table 15.

- > Where wood pole transmission lines are identified with accelerated defect rates, wood pole structures are replaced with either concrete or steel pole structures on an as needs basis, eventually leading to a line renewal with concrete or steel poles. This removes risks of further decay due to rot or termites. Line schedules for the following high defect lines are being designed:
  - Line 99J – Yanco to Griffith
  - Line 94K – Wellington to Parkes – complete
  - Line 96L – Tenterfield to Lismore
  - Line 96F – Tomago to Stroud
  - Line 99A – Uranquinty to Finley
  - Line 99D – Yanco to Darlington Point
- > Targeted helical deadends close to substations require either of the following:

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- Replace deadend with compression deadend
- Insert disc insulator between deadend and pole to ensure current path is via the jumper and bonding.
- > Eyebolt attachments
  - Replacement of insulator eyebolt attachments with pole band attachments on targeted high risk spans.
  - For the remaining structures, the Maintenance Plan has been modified to explicitly state that structures with eyebolt insulator attachments are to be climbed the full length under outage conditions, during the climbing inspection, to check for conditions that may lead to pull through.
- > Line 96T and 96R earthwire raisers – Due to rot issues, replace remaining wooden earthwire raisers with steel earthwire raisers. Planned completion is June 2023.
- > Installation of Travelling Wave Fault Locator will be installed on 132 kV lines which are long, remote, high fault frequency or have significant customer impacts. Installation of TWFL has been approved as part of the Network Capability Incentive Parameter Action Plan (NCIPAP) 2014/15 – 2017/18 for the following 132 kV lines: 97G, 96C, 969, 9U3 and 96M.
- > On older lines with conductor clamp style suspension units, it is possible that this clamp may have done damage to the conductor underneath. The damaged conductor is not an issue if contained within the suspension unit. If replacement poles are to be installed in a new location then conductor must be inspected before the new suspension unit is installed. Pole replacement jobs shall plan for possible replacement of a length of conductor on all three phases if damage is noted.

The maintenance initiatives directly drive the routine maintenance regimes which are detailed within the Transmission Line Maintenance Plan.

Emerging issues on associated easements are:

- > Hazard trees on easements.
- > Unauthorised easement encroachments.

#### **7.5.2.4 132 kV Disposal Initiatives**

Dismantling and disposal of the short sections of 132 kV wood pole lines at Canberra substation. These structures were made redundant when the 330kV line between Canberra and Williamsdale was commissioned. These structures are now defunct however still require maintenance.

**Table 15: 132 kV Emerging Issues, and Renewal and Maintenance Initiatives**

Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
Line 96T and 96R	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<ul style="list-style-type: none"> <li>Decay in timber earthwire raises can lead to failure. Multiple defects already addressed.</li> </ul>	<ul style="list-style-type: none"> <li>96T – Replace remaining 422 earthwire raisers by June 2023.</li> <li>96R– Replace remaining 558 earthwire raisers by June 2023.</li> </ul>	Completion by June 2023.	Need ID: 1588 and 1589.
Helical OHEW deadends near substations	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Leakage current through thimble causing deadend failure.	Insulate deadend at pole to ensure fault current path down jumper, not through thimble or replace with compression deadend at structures close to substations by June 2023. Other helical deadends will be monitored through routine maintenance.	Completion by June 2023.	Need ID: 1671 MWG Minutes.
Wood pole tension / angle structures with eyebolts	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Eyebolts can “pull through” the timber pole dropping conductor or earthwire.</p>	<p>Replace eyebolt fittings with pole band type fittings on identified high risk spans.</p> <p>Remaining structures will be monitored through routine maintenance.</p>	Completion by June 2023.	Need ID: 1669
Line 944	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and</li> </ul>	<p>Poles in poor condition.</p> <p>Unable to repair conductor faults</p> <p>Low spans</p>	Replacement of condemned poles with concrete pole structures. Structures shall be suitable for stringing with a larger conductor in the future.	DG1 issued. Planned completion March 2018.	Need: 1305

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
	<ul style="list-style-type: none"> <li>property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Reduction in security of supply.	Remediation of low spans		
Line 959/92Z	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	<p>Corrosion of steelwork and line components at end of life.</p> <p>Corrosion of steel earthwire.</p> <p>Reduction in security of supply.</p>	<p>Buried concrete foundations – 2 towers</p> <p>- Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel and 1 tower dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint, concrete scabbling and installation of double plate, establish drainage channel where feasible or concrete encase legs to prevent future corrosion</p> <p>Damaged earth straps – 3 towers – Replacement of earth straps in line with current standard</p> <p>Corroded steel members – Replace 5% of minor members on 5 towers.</p> <p>Corroded bolts – Replace 10% of tower bolts on 11 towers.</p> <p>Corrosion of conductor fittings – 39 fitting replacements (hot and cold end)</p> <p>Corrosion of earthwire fittings – 32 fitting replacements</p> <p>Corrosion of SC/GZ earthwire – replace 24 km of earthwire (12 km route length)</p> <p>Damaged conductor vibration dampers – 144 damper replacements</p>	<p>Included in 2018-23 Revenue proposal</p> <p>Need ID: 1346</p>	

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
Wood pole lines: <ul style="list-style-type: none"> <li>94X</li> <li>99J</li> <li>948</li> <li>966</li> <li>993</li> <li>995</li> <li>9U3</li> <li>976/2</li> <li>97B</li> <li>97A</li> <li>99P</li> <li>97L</li> <li>97G/3</li> <li>96L</li> <li>96F</li> <li>94K</li> <li>99A</li> <li>99D</li> </ul>	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> </ul>	Wood pole structures at end of life Reduction in security of supply.	Allowance for replacement of forecast defect wood pole structures with concrete pole structures on lines at end of their economic life.	Included in 2018-23 Revenue proposal	Need ID: 1558
Lines with grillage structures: 970 9R5 990 97K 9R6 995 99X	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability.</li> <li>Pursue STPIS revenue where cost effective.</li> </ul>	Ground line and buried steel tower corrosion Reduction in security of supply.	Concrete encasement of buried steel in aggressive soil corrosion areas. Replacement/installation of sacrificial anodes in other areas.	Included in 2018-23 Revenue proposal	Need ID: 1523
The following transmission lines: <ul style="list-style-type: none"> <li>97G</li> </ul>	<ul style="list-style-type: none"> <li>Maintain network reliability</li> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP</li> </ul>	Long remote lines. Market constraints Line with high fault rate.	Expand the travelling wave fault locator system in locations that will achieve efficiencies and market benefits.	Installation of Travelling wave fault locators at the identified sites by December 2017.	Need No: 426 Need Statement: NS 9522 Option Evaluation Report:

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
<ul style="list-style-type: none"> <li>96C</li> <li>969</li> <li>9U3</li> <li>96M</li> </ul>	<ul style="list-style-type: none"> <li>Improve OPEX Performance</li> <li>Pursue STPIS revenue where cost effective</li> </ul>				OER-7030  NCIPAP 2014/15 – 2017/18 Section 3.6
Steel lattice towers	Improve CAPEX Performance	Corrosion of steel towers to the extent that refurbishing is no longer possible.	Monitor corrosion of steel towers to ensure assets not suitable for replacement shall not get to condition where refurbishment is not possible	Ongoing	Asset Condition Data Collection
All assets – Conductors and fittings	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Corrosion of fittings and conductors	Continue to inspect and monitor the identified issues.	Ongoing during routine maintenance.	Transmission Line Maintenance Plan Transmission Line and Easement Condition Data Collection
132 kV wood pole lines <ul style="list-style-type: none"> <li>94K</li> <li>96L</li> <li>96F</li> <li>99A</li> <li>99D</li> <li>99J</li> </ul>	Improve OPEX Performance	Wood pole lines with high defect rates	Provide line schedules to enable defect replacement of wood pole structures with concrete pole structures	The following Line schedules have been provided: <ul style="list-style-type: none"> <li>94K</li> </ul> The following are overdue: <ul style="list-style-type: none"> <li>96L</li> <li>96F</li> <li>99A</li> <li>99D</li> <li>99J</li> </ul>	IWR-Ad hoc Line Schedules
132 kV wood pole lines	Improve OPEX Performance	Termites and rot in timber structures	Carry out pole staking trial on Lines 94K and 944. The trial will use a selection of the four leading designs. The aim of pole staking is to delay a wood pole replacement.	Pole staking trial completed and report provided June 2016.	Asset Manager direction to Field Services

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
Line 99F – Uranquinty to Yanco	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> </ul>	Wood pole line with high defect rate	Replace wood poles on Line 99F with concrete structures. Upgrade to 100°C design temperature to account for future growth.	PAD issued August 2016. To be completed by June 2018.	DCN-143
Line 970 – Yass to Burrinjuck	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> </ul>	Wood pole line with high defect rate well beyond end of life. Steel tower structures require foundation strengthening.	Replace all wood pole structures to with concrete pole design. Strengthening of foundations.	78 of 92 structures replaced (as of Sep 16) Practical Completion scheduled March 2017.	DCN-130
Line 99K	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP.</li> <li>Minimise environmental harm and property damage.</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> </ul>	Corrosion of concrete pole internal steel reinforcement	Remediation or replacement of pole structure	Completion by June 2023.	Need ID: 1724
132 kV Low Spans	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP.</li> </ul>	Low spans with clearances that breach design standards at credible line loads.	Remediate low spans as per guideline “Low Span Assessment – Risk Management Approach”. Transmission line modifications are to be to design temperature with AS7000 clearances.	Complete by June 2018.	Need ID: DCN129 DCN131 DCN243 594 596 598

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Assets	Asset Management Objective	Emerging Issues	Strategic Initiative	Forecast Expenditure	Reference Documents
					699 (Combined with OPGW installation)
Older 132 kV conductor	Manage Transmission Line related people safety risks to ALARP/SFAIRP.	Suspension clamp "U-bolt" damages conductor under clamp.	Damaged conductor not an issue if contained within the suspension unit. If replacement poles are to be installed in a new location then conductor must be inspected before new suspension unit installed. Jobs shall plan for possible requirement for replacement of a length of conductor.	Ongoing during corrective maintenance and capital works.	Line 993 conductor sample TL&CD design advice
All 132kV Lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related bushfire risks and people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Maintain network reliability</li> <li>Pursue STPIS revenue where cost effective</li> <li>Improve OPEX Performance</li> </ul>	Hazard trees causing transmission line faults	Identification and scoping of hazard tree risk. Removal of hazard trees where required.	Ongoing	
All 132kV Lines	<ul style="list-style-type: none"> <li>Manage Transmission Line related people safety risks to ALARP/SFAIRP</li> <li>Minimise environmental harm and property damage</li> <li>Improve OPEX Performance</li> </ul>	Unauthorised encroachments on easements present a safety risk to maintenance staff and the public	Identify encroachments and order their removal where required.	Ongoing	
All Transmission Line Assets	Improve CAPEX Performance Improve OPEX Performance	Asset condition data of insufficient quality to support decision making.	Improve asset data quality through SLAs and the implementation of AIM (Asset Inspection Manager)	AIM has been rolled out to Transmission Lines. Data will become available progressively.	N/A

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### 7.5.3 132 kV Transmission Line Maintenance Program

The revised procedure for remediation of non-urgent (P3 and above) defects, requires the Service Provider to consult with the Asset Manager when the expected cost of remediation is expected to be over \$5,000. This has allowed the Asset Manager to have more input in remediation solutions. For example, on a number of occasions a condemned timber structure was able to be replaced with a concrete pole structure after seeking design input and assessing the risk of failure while the concrete pole was procured. The new structure will not require ongoing underground inspections as termite and rot risk has been eliminated.

For the 132 kV Transmission Line assets the maintenance program consists of the following:

- Routine inspections (as per Table 11).
- Corrective (or “defect”) maintenance addressing out of specification conditions. The need to conduct corrective maintenance is usually identified during a routine inspection.
  - Where possible and practical, these defects are addressed at the same time as the inspection.
  - Otherwise, these are prioritised on a basis as per “Maintenance Plan - Transmission Line Assets”.
- Easement maintenance as detailed in the Maintenance Plan – Easements and Access Tracks.

Section 7.1 details the 2016 changes to maintenance plan.

## 7.6 66 kV Transmission Lines Asset Review

### 7.6.1 Population Review

There are only five 66 kV structures in the TransGrid network. The structures are a concrete pole construction and formally became ownership of TransGrid after renewal of the connection agreements prior to the lease transaction in 2015. The structures are relatively young with the installation dates being 2002 (three structures at Molong) and 2012 (two structures at Glenn Innes).

The majority of the 21 km circuit length is strung on 132 kV double circuit structures with a TransGrid 132kV circuit on the other side. These double circuit structures are covered under section 7.5.

### 7.6.2 66 kV Transmission Line Emerging Issues, and Renewal and Maintenance Initiatives

There are no emerging issues, renewal or maintenance initiatives for the 66kV structures.

### 7.6.3 66 kV Transmission Line Maintenance Program

The maintenance on these structures will be as per a 132 kV concrete pole line.

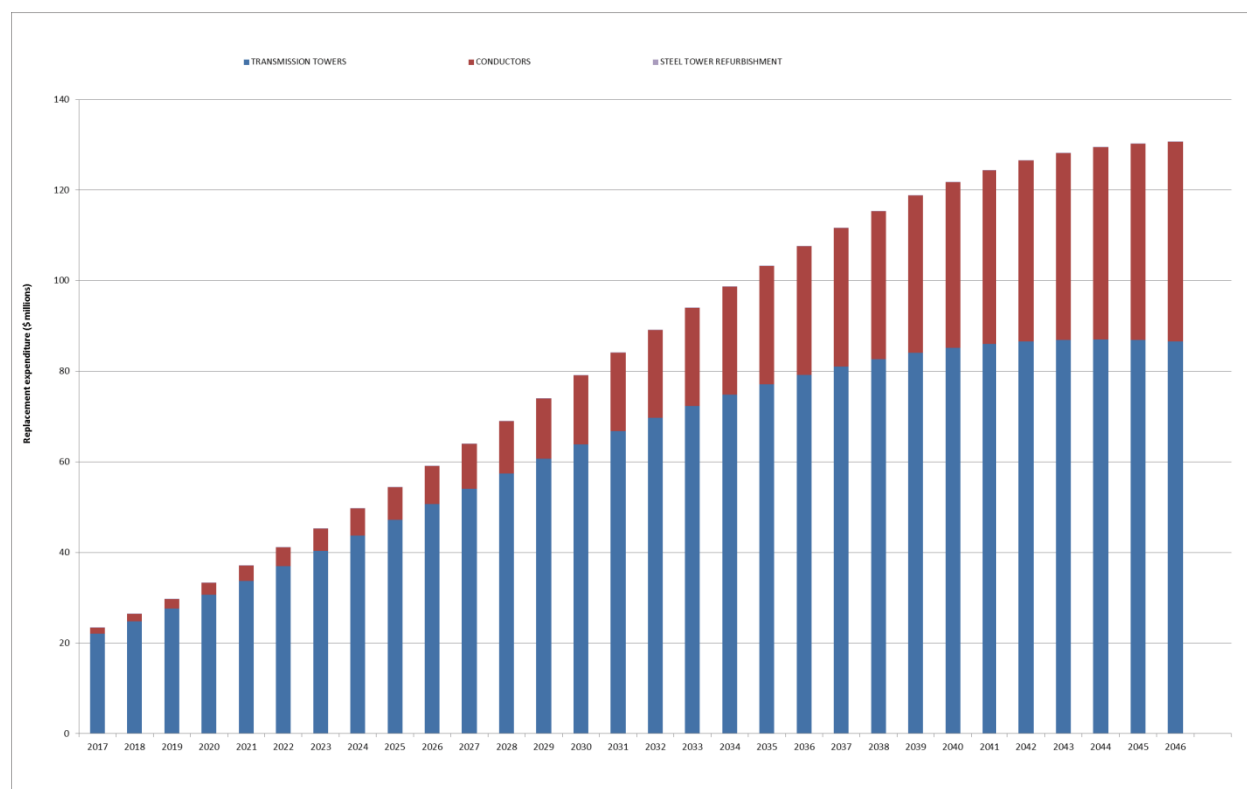
## 8. Future Outlook

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### 8.1 Forecast Expenditure

Figure 15 below shows the future renewal, disposal and maintenance expenditure on an aged based assumption in 2016/17 dollars.

**Figure 15: Long Term Forecast Capital Expenditure Based on Age**



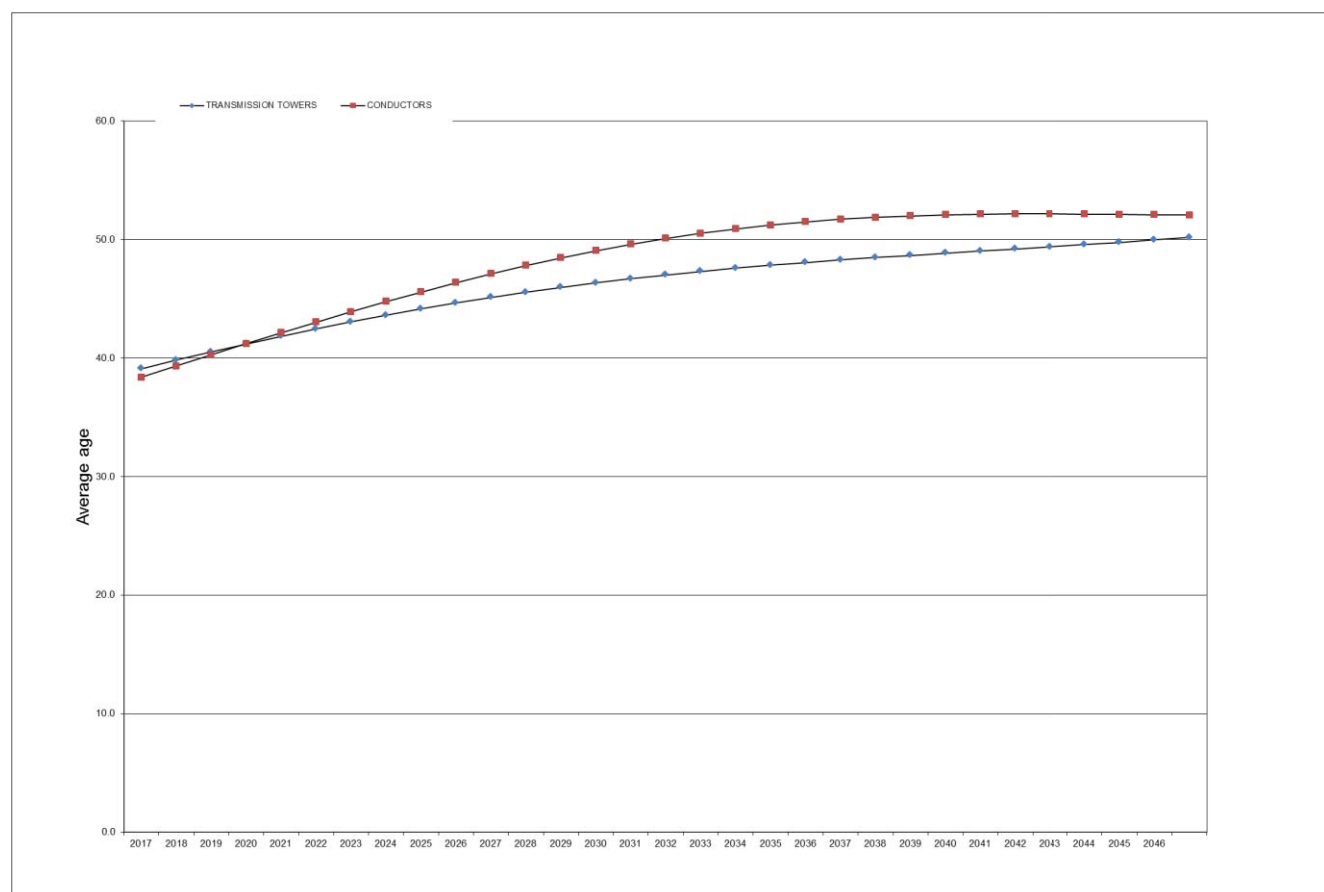
This graph should be taken as a guide only as expenditure on transmission line assets is condition based. For example in the 2018-23 regulatory period TransGrid has proposed \$325.2M in transmission line capital expenditure. The forecast spend in the REPEX model is \$183.9M. This reason for the departure is due to a handful of unique issues that fall outside the model. These are:

- Tower asbestos paint remediation (\$40.1M).
- Line 86 Renewal (\$66.2M) – wood pole 330 kV line – rot under metal pole raiser sleeves which can go undetected. This also includes conductor replacement (\$12.8M) prior to its end of life to achieve market benefits (subject to RIT-T). This line was built in 1982, so would not normally be expected to reach end of life until 2047.
- Tower grillage foundations (\$62.2M) – On inland towers, nominal life 75 years, if located in aggressive soils the grillage require earlier action when the above ground members are forecast for remediation.

When these three projects are removed the capital program is \$156.7M, \$27.2M below the age based forecast.

The proposed long term age based capital forecast would result in an average age profile as shown in Figure 16.

Figure 16: Long Term Forecast Average Age

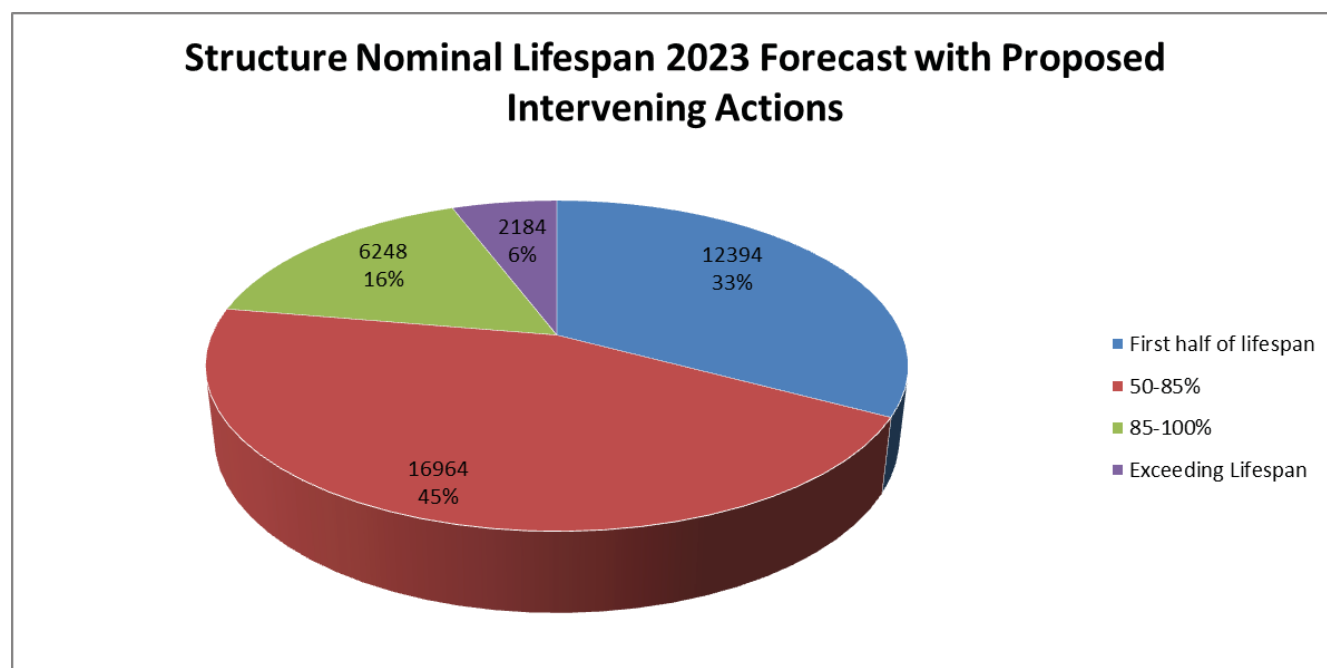


It is clear that even with the large capital expenditure in the long term forecast, the average age of the tower assets are still increasing albeit at a slower rate. This will need to be addressed through strategies which increase the life of assets or replace old assets with new assets at a sustainable rate. The conductor age will plateau.

## 8.2 Anticipated Changes to the Asset Base

Anticipated changes to the transmission line asset base as at June 2023 will result in the lifespan profile as per Figure 17.

Figure 17: 2023 Forecast with proposed intervening actions.



The major changes are as follows:

- > There are no committed augmentations to TransGrid's transmission line asset base expected within the current regulatory period (to 2018).
- > The proposed SANI connection between New South Wales and South Australia is expected but has not been included in the figure as the preferred option has not yet been finalised.
- > Pole replacement projects on the following two lines converting from wood to concrete poles
  - Line 96H – Coffs Harbour – Koolkhan
  - Line 970 – Yass to Burrinjuck
  - Line 99F – Uranquinty to Yanco
  - Line 86 – Tamworth to Armidale (subject to regulatory approval)
- > Known structures to be replaced (286 in total) as part of low span rectification on the following lines:

963	959	992
968	92Z	993
969	14	97K
9U3	17	945
96L	948	94T
96R	94X	96P
96T	94M	964
965	94M/1	
966	94M/2	

Note low spans on Southern Towers, Southern Poles. Northern Towers, and Lines 01, 2, 4 and 5 are yet to be fully scoped so the number of structures to be replaced is unknown.

- > Line 11 – Suspension structures replacements as part of footing or steelwork condition – assumed 127.
- > The age profile classification for grillage structures with proposed concrete encasement have not been changed due to aging of other tower components.
- > The age profile classification for steel towers with proposed remediation, such as member and fitting replacements, have not been changed due to aging of other tower components.

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## 9. Spares

Spares are items of serviceable equipment that are booked into and stored in TransGrid's storage facilities for maintenance and project purposes. This document does not cover the spares required for project purposes.

TransGrid has purchased a range of strategic spare equipment to improve the organisations ability to restore supply and system security in a timely manner, following the major failure of an in-service unit.

The spares strategy for Transmission Line assets, including required holding is described in the document "Transmission Lines Spares Policy"

## 10. Asset management capability and continual improvement

At present, asset condition data is of insufficient detail and/or quality to support decision making. Until June 2016, the inspections and maintenance were to be recorded using the inspection tablet, which uploaded the results to Ellipse. Useability of this tablet was very poor and lineworkers often reverted to paper based checksheets. If checksheet details are loaded, getting reports back out is a complicated process. Further, the checksheets recorded condition as a binary OK/not OK which is insufficient in determining condition and emerging issues.

TransGrid's asset information strategy calls for continual improvement of the scope and quality of current and accumulated asset information.

The development of the "Transmission Line and Easement Condition Data Collection" procedure has been completed and the implementation will address these issues by reporting condition of components with a 1 to 10 score. Since June 2016, inspection and maintenance results have been collected with the new AIM system. AIM will improve the recording of issues and defects, which have previously been an issue. The 2016 maintenance changes required the next climbing inspection to take place when the next ground inspection would have come due. Given the maximum period between ground inspections was three years, it is expected that we will have 100% of the asset condition data by June 2020.

It was highlighted during the first RIN process that some data is poor and no longer representative. Data cleansing of TSS (TransGrid's geographic information system) was completed for the 2014/15 RIN. For the 2015/16 RIN some further data cleansing was required to fully implement the ownerships formalised as part of the lease transaction and structure replacements which were noted in the system.

The new Ellipse data rules have been developed and implemented allowing the system to be fit for purpose to store transmission line asset information and complete RIN schedules.

An extensive review of Ellipse "Standard Jobs" is currently underway as the resource estimates differ significantly from actuals.

The table below describes the strategic asset management capabilities initiatives for the Transmission Line fleet, and their alignment with the overarching strategies in the Asset Management Strategy and Objectives document.

**Table 16: Continual Improvement Initiatives**

Asset Management Objectives	Asset Management Actions	Enablers / Status
Deliver a successful revenue determination	1. Documentation required for RP2 submitted	All documentation completed by deadline.
<ul style="list-style-type: none"><li>ISO 55001 Compliant</li><li>Continually improve the Asset Management System</li></ul>	<ol style="list-style-type: none"><li>Asset information improvements (governance, data, reporting and systems) implemented</li><li>Asset replacement life optimised</li><li>Asset maintenance scope and frequency optimised</li><li>Asset management competency enhanced</li><li>Plant and design standards</li></ol>	<ul style="list-style-type: none"><li>Utilisation of the risk tool to provide a more granular view of the pre and post-investment risks associated with building new or replacing assets.</li><li>ALARP analysis completed for proposed RP2 renewals.</li><li>Asset data improved through the rollout of AIM for Transmission</li></ul>

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Asset Management Objectives	Asset Management Actions	Enablers / Status
	optimised	Lines assets and the Transmission Line and Easement Condition Data Collection procedure. <ul style="list-style-type: none"> <li>Overhaul of the Ellipse Data rules for transmission lines has been completed and implemented.</li> </ul>
<ul style="list-style-type: none"> <li>AS 5577 compliant</li> <li>Continually improve the Electricity Network Management System</li> </ul>	7. Formal Safety Assessments complete and externally audited	<ul style="list-style-type: none"> <li>IPART brushfire preparedness completed on an annual basis.</li> <li>Public Electricity Safety Awareness (PESA) Plan reviewed on an annual basis.</li> </ul>
Improve CAPEX performance	8. REPEX and risk scenarios understood 9. Investment governance/ prioritisation/ optimisation process enhanced	<ul style="list-style-type: none"> <li>Utilisation of the risk tool to provide a more granular view of the pre and post-investment risks associated with building new or replacing assets.</li> <li>ALARP analysis completed for proposed RP2 renewals.</li> <li>NPV analysis completed on all solutions to ensure value for money.</li> </ul>

Asset management capabilities are those elements that facilitate best practice asset management decision making. These include:

- Risk management practices.
- Asset information.
- Staff skills and competency.
- Continual improvement initiatives for the system.

## 11. Implementing the Strategies

To implement the strategic renewal and maintenance initiatives stemming from this document, actions are to be established via the:

- Transmission Line Maintenance Plan: The maintenance plan outlines the routine maintenance tasks and frequencies for each asset type.
- Capital Works Program: The capital works program outlines the approved asset renewal and disposal projects.
- Other enabler plans detailing how the asset management capability improvements are being implemented

The Transmission Lines and Cables Asset Manager is responsible for preparation of the maintenance plans and renewal and maintenance strategy and referring the renewal and disposal initiative to the network investment process. Field Services is responsible for delivering the maintenance plans as per the Service Level Agreements, and Portfolio Management group/Project Services are responsible for delivering the renewal and disposal initiatives detailed in the approved capital works program.

## 12. Monitoring and review

Implementation of the Transmission Line Renewal and Maintenance Strategy is monitored and reviewed by the Transmission Lines and Cables Asset Manager, Manager/Asset Strategy and Executive Asset Strategy Committee annually.

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## 13. Roles and Responsibilities to Develop this Asset Strategy

The roles and responsibilities of those responsible for the development of this asset strategy are as follows:

- The Asset Strategy Manager is responsible for the approval of this strategy.
- The Transmission Lines and Cables Asset Manager is responsible for the development and regular review of this strategy. The document will be reviewed biannually and as significant changes to investment needs become apparent.

## 14. Change history

Revision no	Approved by	Amendment
4	L. Wee Group Manager/Asset Planning	Formatting update.
3	L. Wee Group Manager/Asset Strategy	Review and update to deliver the 2016/17 Business Plan and further enhance the strategy. Update to new template.
2	L. Wee Group Manager/Asset Strategy	Review and update to deliver the 2015/16 Corporate Plan and further enhance the strategy.
1	Garrie Chubb Group Manager/Asset Performance	Updated to reflect the continual improvement in the “top down” approach for the line of sight to the Asset Management Strategy and the Corporate Plan and an enhanced description of the asset management decision process and the strategic initiatives to be undertaken.

## 15. References

Asset Management Strategy and Objectives

Asset Management System Description

Transmission Line Maintenance Plan

Capital Works Program list (maintained by the Portfolio Manager)

## 16. Attachments

Nil