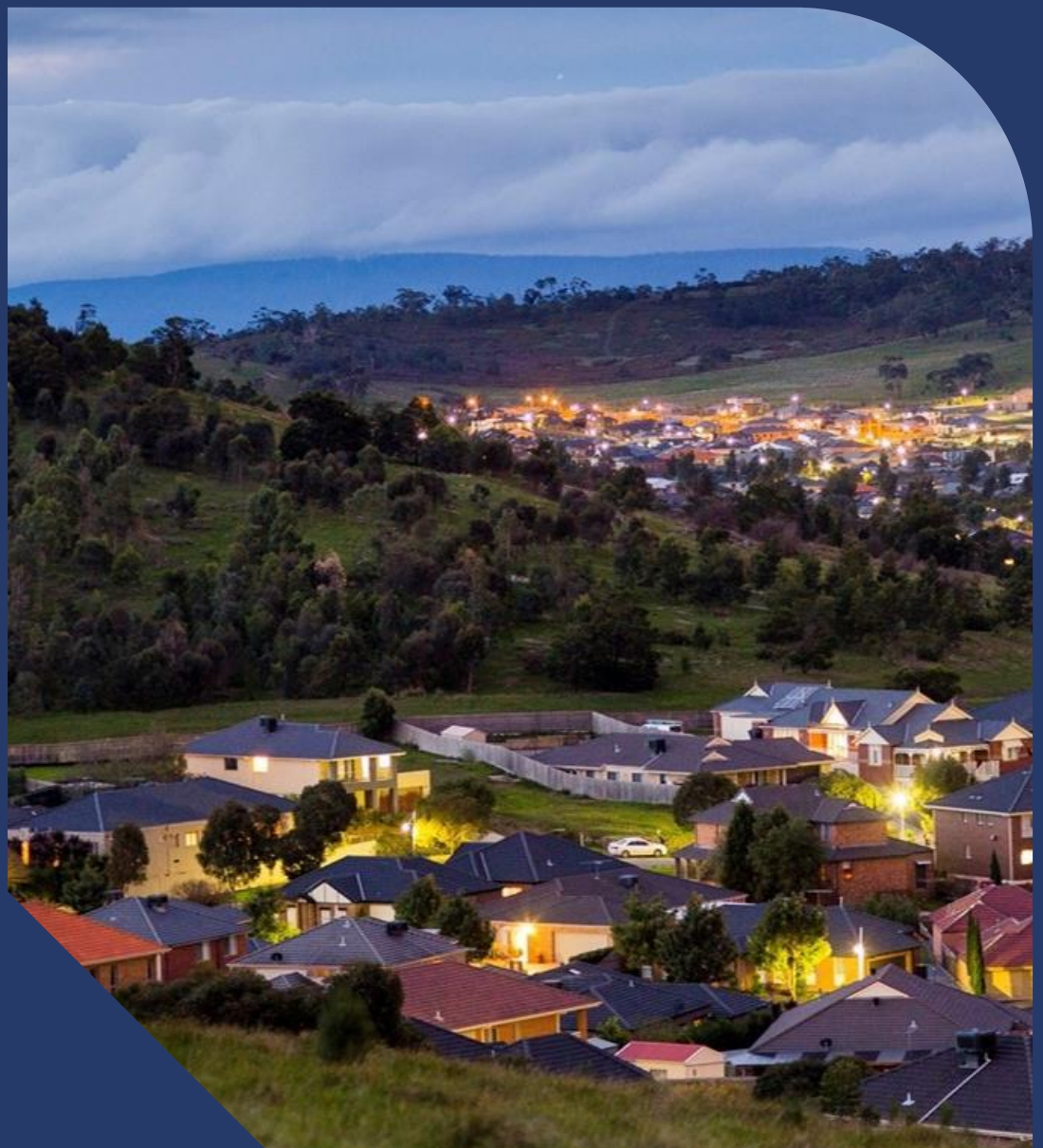


# AusNet

## Transmission Line Structures

Asset Management Strategy



**Document number:** AMS 10-77

---

**Issue number:** 4

---

**Status:** Approved

---

**Approver:** [ C.I.C ]

---

**Date of approval:** 24-Oct-2025

---



# Table of Contents

<b>Abbreviations and Definitions</b>	<b>i</b>
<b>1. Executive Summary</b>	<b>1</b>
1.1. Asset Management Strategy	1
<b>2. Introduction</b>	<b>2</b>
2.1. Purpose	2
2.2. Scope	2
2.3. Asset Management Objectives	2
<b>3. Asset Description</b>	<b>3</b>
3.1. Function	3
3.2. Population	3
3.3. Age	10
<b>4. Asset Performance</b>	<b>11</b>
4.1. Suspended Failures	11
4.2. Functional Failures	13
4.3. History of tower strengthening works	16
4.4. Performance Summary	17
<b>5. Asset Health</b>	<b>18</b>
5.1. Overall Tower Condition	20
5.2. Steelwork Condition	21
5.3. HYTS-APD Tower Condition	24
<b>6. Related Matters</b>	<b>33</b>
6.1. Tower Resilience	33
6.2. Extreme Wind Studies	34
6.3. Impact of Victorian Transmission Plan	35

6.4. Fall Arrest Systems/ Safe Method of Climbing	35
6.5. Tower Footings Submerged in Water	36
6.6. Corrosion Mitigation Below Ground, Cathodic Protection	36
6.7. Corrosion Mitigation at Ground Level, SOXS	36
6.8. Corrosion Mitigation for Low/Medium Corrosivity Zones	37
6.9. Corrosion Mitigation for High-Corrosivity Zone	37
6.10. Tower Refurbishment vs Tower Replacement	37
<b>7. Proposed Program of Work</b>	<b>39</b>
7.1. Approach	39
7.2. Economic Viability	40
7.3. Output Validation	40
7.4. Proposed Program	41
7.5. On-going Programs	44
<b>8. Asset Strategies</b>	<b>45</b>
8.1. New Assets	45
8.2. Inspection	45
8.3. Maintenance	45
8.4. Tower resilience	45
8.5. Spares	46
8.6. FAS Installation	46
8.7. Replacement and Refurbishment	46
<b>9. Resource Reference</b>	<b>47</b>
<b>10. Schedule of Revisions</b>	<b>48</b>
<b>Appendix A – Corrosivity Zones</b>	<b>50</b>
<b>Appendix B – Bushfire Consequences</b>	<b>51</b>
<b>Appendix C – Fall Arrest Installation Program</b>	<b>52</b>
Tower FAS	52
Terminal Station Racks, FAS	52
<b>Appendix D – Refurbishment and Corrosion Mitigation Works</b>	<b>53</b>
Proposed Refurbishment program, 2027-2032	53
On-going Corrosion Mitigation Works	53
<b>Appendix E – Tower Member Replacement Program</b>	<b>54</b>
<b>Appendix F - C5 Steelwork Condition Score,</b>	<b>55</b>
Tower Worst Steel Condition, “Above Waist”	55

---

Tower Condition, Over-all	55
<b>Appendix G – Replace vs Refurbish Strategy (HYTS-APD stage 1 and 2)</b>	<b>56</b>
1 Summary	56
2 Introduction	56
3. Life Extension Cost Considerations	56
3.1 The Cost Model	57
3.2 Coating	60
4. Strategy Comparisons and Considerations	61
4.6 Cost Breakdown Spreadsheet	62
5 Analysis Output	63
6.1 Refurbish or Replace	66
<b>Appendix H - HYTS-APD Condition Assessment</b>	<b>70</b>

# Abbreviations and Definitions

TERM	DEFINITION
AFAP	As Far As Practicable
[C.I.C]	[ C.I.C ]
ARI	Annual Recurrence Interval
CAPEX	Capital Expenditure
CoF	Consequence of Failure
CP	Cathodic Protection
DDTS	Dederang Terminal Station
ERS	Emergency Restoration System
FAS	Fall Arrest System
FMI	Field Mobile Technologies
HST	Heavy Strain Tower
HSU	Heavy Suspension Tower
HTS	Heatherton Terminal Station
HYTS	Heywood Terminal Station
ICCP	Impressed Current Cathodic Protection
LIDAR	Light Detection and Ranging
LSU	Light Suspension Tower
LST	Light Strain Tower
MSS	Murray Switching Station
MTBF	Mean Time Between Failure
MWTS	Morwell Terminal Station
Noti	Notification (SAP system language)
PoF	Probability of Failure
ROTS	Rowville Terminal Station
SVTS	Springvale Terminal Station
TRN	Transposition Tower
TRR	Transmission Revenue Reset
VEC	Victorian Electrolysis Committee

# 1. Executive Summary

This document presents AusNet's asset management strategy for the Victorian regulated electricity transmission network's line structures. The strategy addresses challenges associated with an ageing fleet of 14,039 overhead assets, comprising Towers (91%), Racks (7.2%), and Poles (1.8%), operating across voltage levels from 66kV to 500kV.

With many structures exceeding 50 years in service, the network faces growing risks from ageing, corrosion (particularly in coastal and industrial areas), and increasingly severe weather events. These risks underscore the need for ongoing condition assessments, proactive maintenance, vulnerability assessments and targeted replacement programs to maintain reliability, resilience and safety obligations.

A risk-based assessment was conducted, considering consequences of failure such as safety, environmental impact, community disruption, and market reliability. Based on this, an economic replacement program is proposed, including tower replacement and refurbishment due to corrosion, reinforcement of towers vulnerable to extreme wind events, and installation of fall arrest systems to improve worker safety.

Through these targeted investments and risk-based asset management practices, AusNet aims to secure Victoria's electricity transmission system's long-term reliability, safety, and resilience.

## 1.1. Asset Management Strategy

AusNet's strategy focuses on proactively managing risk, ensuring safety, and maintaining reliability through a targeted program of replacements, refurbishments, maintenance actions, condition assessments, and resilience contingency response planning across the asset lifecycle stages.

The strategy promotes proactive asset management by adopting advanced condition assessment technologies, such as UAVs with LiDAR and 3D modelling (PLS Tower), to enhance structural evaluations. It applies risk-based prioritisation, focusing on asset condition, performance, and failure consequences to support informed decision-making. The strategy also incorporates climate risk considerations to strengthen network resilience and contingency response planning.

AusNet is proposing a targeted program for the upcoming regulatory period to manage structural risk within acceptable levels. Key initiatives include replacing corroded steel towers and components, reinforcing towers to enhance network resilience, and improving worker safety through fall arrest systems. All replacement works will comply with AS/NZS 7000 and modern material standards to achieve long-term asset performance.

This comprehensive, asset management strategy allows AusNet to manage its fleet in a manner that upholds stakeholder expectations for safety, reliability, cost-effectiveness, and environmental responsibility.

## 2. Introduction

### 2.1. Purpose

The purpose of this document is to define the asset management strategies for the Victorian electricity transmission network's population of transmission line structures.

### 2.2. Scope

This asset management strategy covers all transmission line structures in AusNet's regulated electricity network operating at 66 kV or higher in Victoria. It applies to structures on-line easements, as well as towers, transmission poles, and rack (termination) structures within stations.

The strategy excludes structure footings<sup>1</sup>, structures supporting stations assets, assets forming the electricity distribution network, communication towers or masts, and those belonging to AusNet's unregulated asset base.

The strategies outlined in this document are focused exclusively on sustaining the performance of existing equipment, enhancements to quality or supply capacity fall outside the scope of this document.

### 2.3. Asset Management Objectives

The asset management objectives and strategic pillars, as outlined in the AMS 01-05 Strategic Asset Management Plan, are as follows:

Trusted to bring the energy today and build a cleaner tomorrow							
Strategic Pillars					Ambition		
Safely deliver our customer's energy needs today				Create the energy network of tomorrow	Enable the transition to a net zero future	Be a leader in asset management practice	
Asset Management Objectives					Enabling AMOs		
<b>Safety:</b> Minimise risk to our people, contractors, customers and communities AFAP across our networks	<b>Reliability:</b> Meet the reliability expectations of our customers and communities, and meet our reliability targets	<b>Resilience:</b> Improve the resilience of our network to adapt to a changing climate and energy system environment	<b>Compliance:</b> Comply with all legislation, regulations, relevant standards and industry codes	<b>Planning and decision-making:</b> Deliver valued planning and network outcomes through optimising asset lifecycle management	<b>Sustainability:</b> Build stakeholder trust and deliver social value. Reduce our environmental impact. Operate efficiently to sustain financial value creation.	<b>Competency and capability:</b> Develop asset management capability and competency in the organisation	<b>Continuous improvement:</b> Continually improve asset management maturity for effective delivery of services

<sup>1</sup> AMS 10-78 Transmission Line Structure Footings

# 3. Asset Description

## 3.1. Function

Transmission line structures support conductors and ground wires at safe distances, ensuring reliable power delivery and public and environmental safety. These structures are typically made from engineered components for long-term durability, most commonly using lattice or tubular steel, with some built from reinforced concrete or timber.

## 3.2. Population

The transmission network consists of a total of 14,039 transmission line structures currently in service across AusNet's regulated electricity network in Victoria. These include towers, poles, and rack structures designed to support both conductors and ground wires, thereby ensuring reliable power delivery and maintaining safety standards. The network employs a diverse mix of structure types, including steel lattice towers, steel, concrete or timber poles, and rack constructions, each suited to specific technical requirements and operational environments.

Transmission structures are categorised by design into Heavy Strain Towers (HST), Heavy Suspension Towers (HSU), Light Strain Towers (LST), and Light Suspension Towers (LSU), reflecting differences in mechanical strength, application, and placement within the network.

Analysis of the current structure fleet reveals that steel lattice towers overwhelmingly dominate the network, accounting for 90.99% of all transmission structures. Rack structures make up 7.20%, typically used for transitions within terminal stations and specialised applications, while poles represent a modest 1.81%, generally supporting conductors over shorter spans or in areas requiring streamlined construction and maintenance. Figure 1 shows the population of structures across the different types.

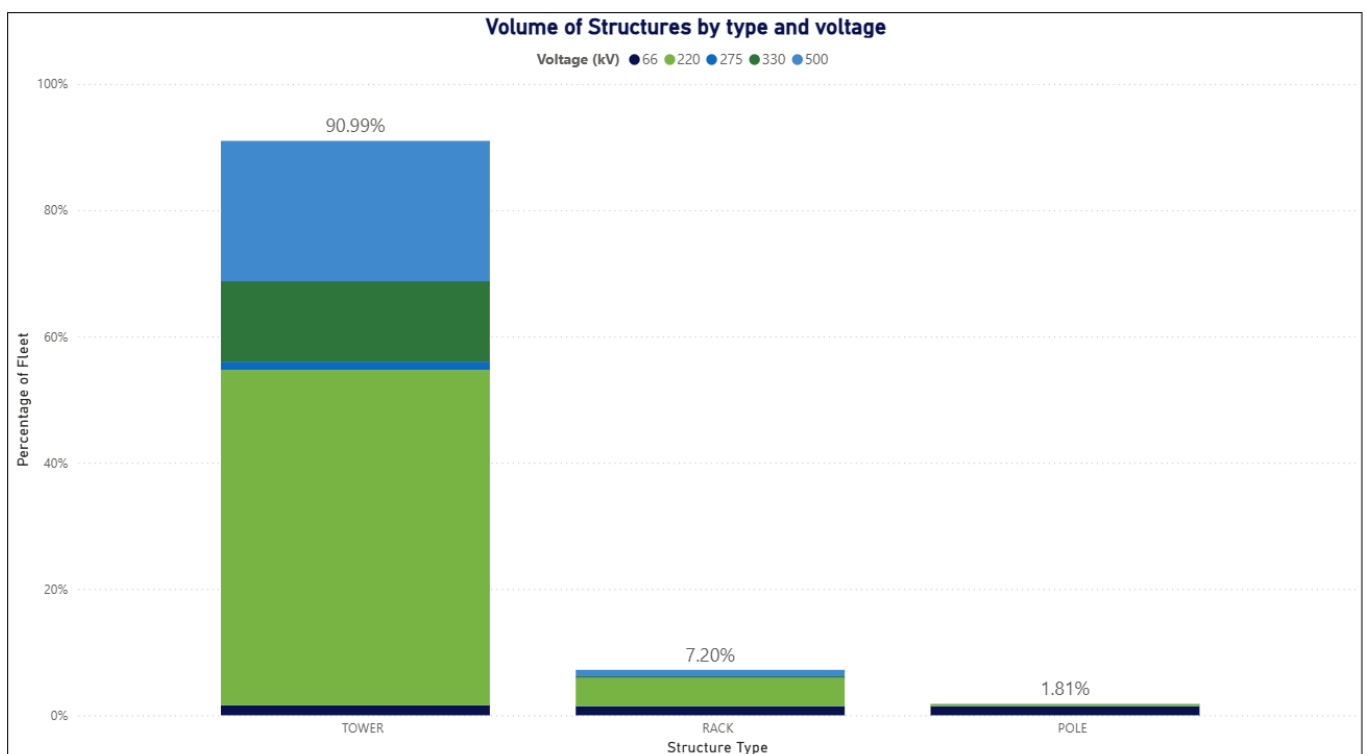


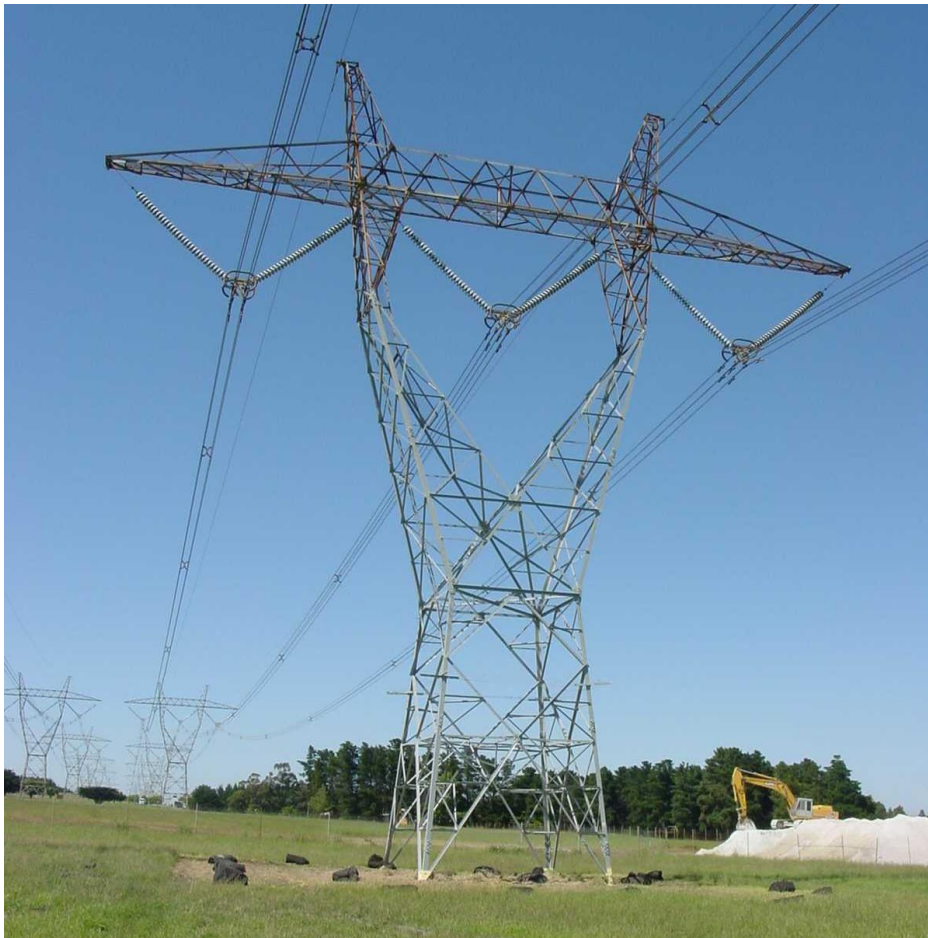
Figure 1: Structure Types in AusNet's Network

Within the steel lattice tower category, there is further differentiation by voltage class: 220 kV structures comprise the largest segment at 58.38%, followed by 500 kV towers at 24.40%, 330 kV towers at 13.99%, 66 kV towers at 1.77%, and 275 kV towers at 1.46%. This distribution highlights the prevalence of high-voltage transmission infrastructure in the network, reflecting the operational demands and geographic coverage of AusNet's regulated transmission system.

Most transmission poles are 66kV poles (56%), (31%) are 220kV poles, 10% support 330kV circuits and 3% are 500kV. Increasingly poles are being strategically introduced to the network in urban areas due to their simple construction, suitability for constrained urban corridors and reduced inspection needs. The 66kV poles are the oldest in the network and are found at Latrobe Valley. These poles are included in the corrosion mitigation program starting this period and will extend to the next period. This is further discussed in section 7.5.

### 3.2.1. Towers

Steel lattice structures make up approximately 91% of structure types on the transmission network. Lattice structures consist of angled galvanised steel members connected with bolts. These structures generally support either single-circuit or double-circuit lines comprised of three phase conductors<sup>2</sup> per circuit. The phase conductors are protected from lightning strike by single or multiple ground wires<sup>3</sup> situated on the peaks of the structures. Some structures support subsidiary distribution lines operating at 66 kV situated below the tower crossarms or the tower body. The structures are electrically insulated from the live conductors using insulators<sup>4</sup>. Figure 2 displays an image of a typical steel lattice structure (500 kV single circuit flat-delta suspension).



**Figure 2: Transmission line steel lattice structure**

<sup>2</sup> AMS 10 – 79 Transmission Line Conductors.

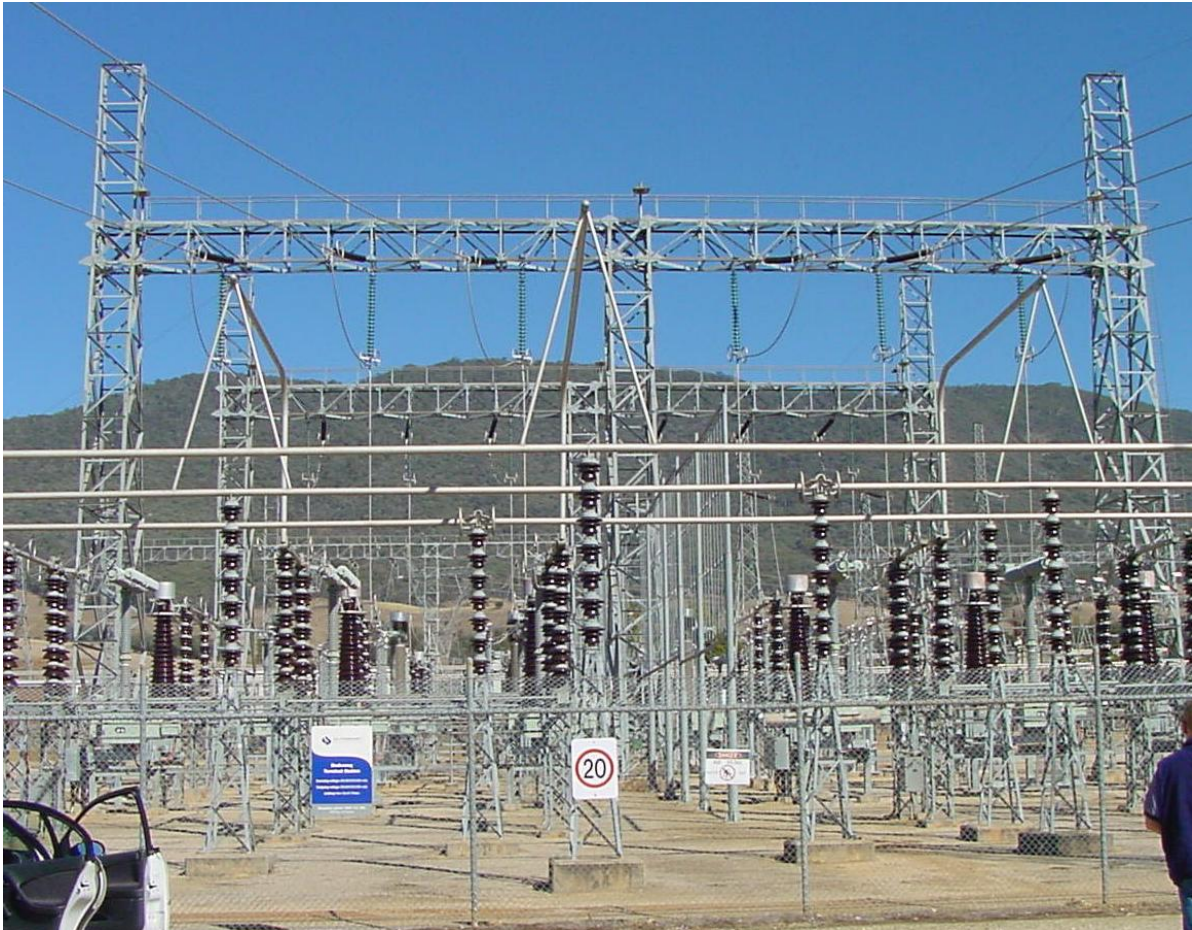
<sup>3</sup> AMS 10 – 79 Transmission Line Conductors.

<sup>4</sup> AMS10 – 75 Transmission Line Insulators.

### 3.2.2. Rack Structures

The primary function of rack structures is to facilitate the transition of phase conductors from overhead line structures to electrical plant situated in terminal stations. Rack structures consist of steel lattice members connected by fasteners or tubular hollow sections bolted or welded together. Most rack structures are situated within terminal stations; however, there are several rack structures known as portal structures which are situated within line easements.

Portal structures are used when a line transitions as an under-crossing line. Figure 32 displays a transmission line rack structure at Dederang Terminal Station (DDTS).



**Figure 32: Transmission Line Rack Structure**

### 3.2.3. Poles and Ground Wire Masts

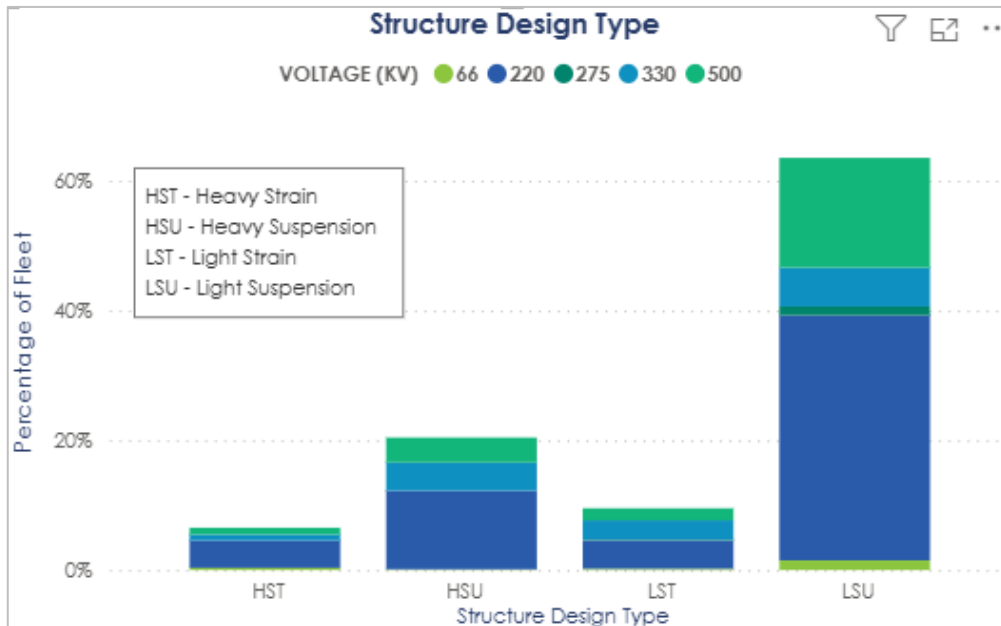
Steel, concrete and wood poles make up just 1.81% of the transmission network fleet and are mainly used to support phase conductors over short distances, often near terminal stations or power stations in the La Trobe Valley. Increasingly, steel lattice towers are being replaced by steel poles for simple construction and maintenance. The decision to use poles rather than towers depends on the practicality and specific locational needs.

In the transmission fleet, 56% of transmission poles support circuits operating at 66 kV, while 220kV represent 31% the population, with 10% supporting 330kV circuits and 3% belong to the 500kV fleet.

There are approximately 60 ground wire masts located within terminal stations, these are steel lattice structures designed to protect electrical plant and infrastructure from lightning strike. On some stations, poles are used to support ground wires that are strung across short distances to protect plant.

### 3.2.4. Design Characteristics

Transmission structures are further categorised based on design characteristics, which define the mechanical load the structure can support. Figure 43 displays the proportion of the structure fleet within each design category by operating voltage.



**Figure 43: Structures volumes by design category and voltage**

Strain structures carry a combination of vertical and horizontal loads from conductors and hardware, allowing conductors to be terminated or strained off with the structures in line with the conductor axis. Light strain structures, (LST, 9%) are used where there is a moderate deviation angle in the circuit or where additional support is required to reduce risks such as those at road and rail crossings. Heavy strain structures (HST, 6%) offer greater reinforcement and are used where circuits enter or exit terminals or power stations, or along line easements where circuits deviate sharply.

Suspension structures carry vertical loads from conductors and hardware, ensuring that ground clearance requirements are met between strain structures. Light suspension (LSU, 65%) are used when there is moderate, or nil turn off angle in the circuit easement alignment. Heavy suspension structures (HSU, 20%) are designed to carry more vertical loads and longer conductor spans and can accommodate larger circuit deviations compared to light suspension towers.

Transposition structures (0.2%) are required to balance the impedance of circuits which traverse long distances. The process of transposition is required to balance network voltages. Transposition is achieved by interchanging the phase conductors of the circuit at every one third increments of the total line length.

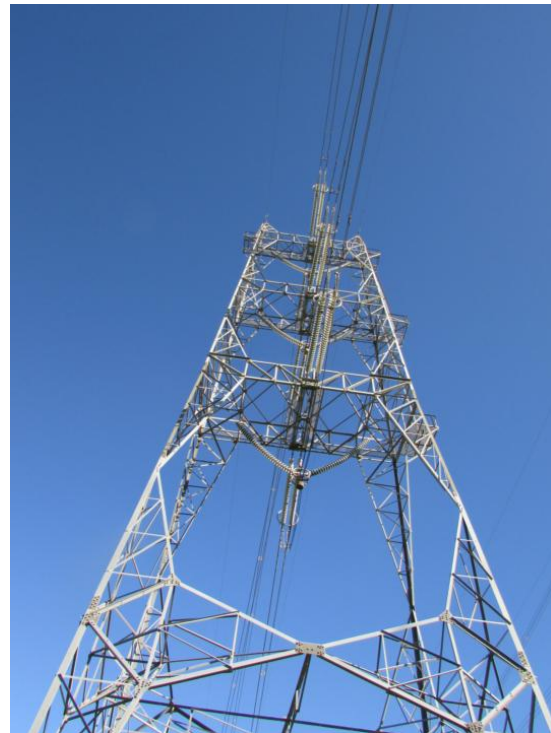
Examples of 330 kV strain tower, 220 kV suspension tower and 500 kV transposition towers are shown in figures 5, 6 & 7.



**Figure 54: DDTS-SMTS No. 1 330 kV strain tower**



**Figure 65: ROTS-SVTS 220 kV suspension tower**



**Figure 7: HWTS-CBTS No. 4 500 kV transposition tower**

### 3.2.5. Environmental Factors

The transmission line network is subject to a range of environmental conditions that influence the rate and severity of corrosion affecting critical infrastructure. Of all environmental considerations, two factors have the most significant impact on corrosivity: salt deposition, particularly prevalent in coastal zones, and airborne pollutants resulting from heavy industrial activity. To manage the long-term reliability and safety of the network, AusNet has implemented a robust corrosivity classification system for its transmission line assets, allowing for targeted and prudent management of corrosion risks.

In 2013, AusNet undertook a comprehensive empirical study<sup>5</sup> to assess atmospheric corrosivity experienced across its network. This study involved installing corrosion coupons bare angle steel samples on 15 towers strategically distributed in diverse regions. These coupons were exposed to natural environmental conditions, and four were collected annually for laboratory analysis. The weight loss of each coupon, attributable to corrosion, was measured and translated into a corresponding loss in member sectional area, providing a direct indication of corrosion rate for the steel structures.

Over the three-year duration of the study, AusNet identified three distinct corrosivity zones within its network, in accordance with the AS 4312 "Atmospheric Corrosivity in Australia" standard. These zones are:

- Zone 1: Low Corrosivity – Areas with minimal exposure to corrosive agents, typically inland regions with low salt and pollution levels.
- Zone 2: Medium Corrosivity – Regions with moderate salt or pollution exposure, such as areas adjacent to industrial sites or less-exposed coastal zones.
- Zone 3: High Corrosivity – Locations subject to significant salt deposition or industrial pollution, such as coastal corridors and zones near major emission sources.

Each transmission asset is assigned a corrosivity classification based on its location and exposure, enabling AusNet to prioritise inspection, maintenance, and protective measures accordingly. The empirical data from the corrosion coupon study underpins these classifications, ensuring they are evidence-based and tailored to the actual environmental conditions experienced by the network.

The annual corrosion rates for each AusNet corrosivity zone, expressed in micrometres (µm) per year, are outlined in Table 1 below. This information is critical for asset management and informs asset management strategies, maintenance schedules, material selection, and the design of future infrastructure to withstand varying environmental challenges. Note: Table 1 provides a direct comparison between AusNet corrosivity zones, and the corresponding categories defined in the AS 4312 "Atmospheric Corrosivity in Australia" standard, offering a useful reference for benchmarking network conditions against national guidelines.

AusNet Corrosivity Zone	CORROSION RATE, µM / YEAR	AS 4312 Corrosivity Zone
1 (Low)	1.3 to 25	C2
2 (Medium)	26 to 50	C3
3 (High)	51 to 80	C4

**Table 1: AusNet Corrosivity Zones**

Analysis of tower population within Victoria's Medium Corrosivity Zone 2 reveals that not all areas within the same zone are affected equally. Specifically, structures situated along the Southwest corridor from Cressy Terminal Station to Heywood including the HYTS - SESS, HYTS - TRTS, and MOPS - MLTS 500 kV lines are subject to higher levels of corrosion compared to Zone 2 towers in the Latrobe Valley near Hazelwood.

This highlights that even within a single corrosivity zone, local environmental conditions can lead to varying degrees of corrosion exposure among assets. This heightened corrosion in the Southwest is primarily attributed to airborne salt carried inland by prevailing coastal winds, which accelerates the deterioration of tower steelwork in these areas.

<sup>5</sup> [ C.I.C ]; ACA Corrosion Technologist, *AusNet Services Corrosion Mapping, January 2014 – January 2016*

Additionally, a small proportion of towers (0.23%) along the Heywood to [ C.I.C ] (HYTS-APD) 500 kV lines, are in the High Corrosivity Zone 3. These towers supply electricity to the aluminium smelter plant along Victoria's Southwest coast, where environmental conditions further intensify corrosive effects.

These observations underscore the focus of the upcoming replacement program for the 2027-32 regulatory reset period, which will prioritise tower and member replacements within the Southwest corridor, with priorities set according to asset corrosion levels. AMS 10-75: Transmission Line Insulators also supports this targeted strategy.

Figure 8 presents the proportion of transmission structures distributed across the three corrosivity zones. A spatial map showing the locations of transmission line assets within all three corrosivity zones is provided in Appendix A. Of the total structures, 53% are in the Corrosivity Zone 1 (Low), while 47% are situated within the Corrosivity Zone 2 (Medium) and 0.23% of towers are in Corrosivity Zone 3 (High).

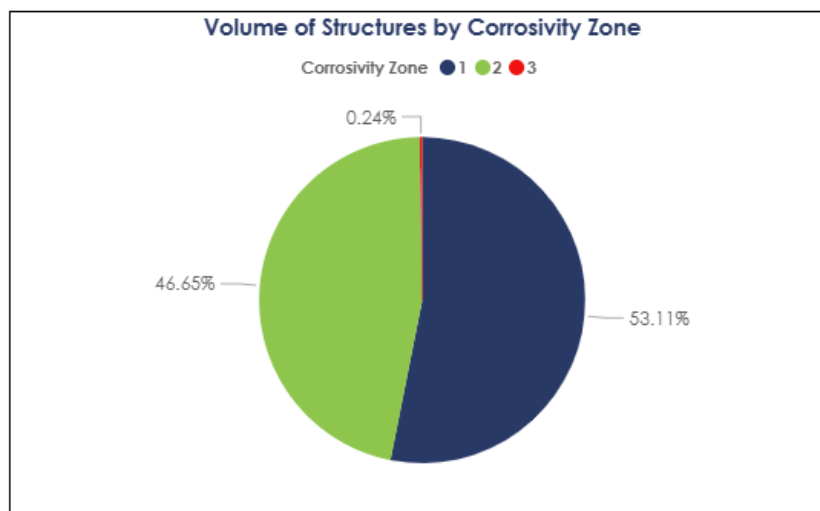


Figure 8: Volume of structures by corrosivity zone

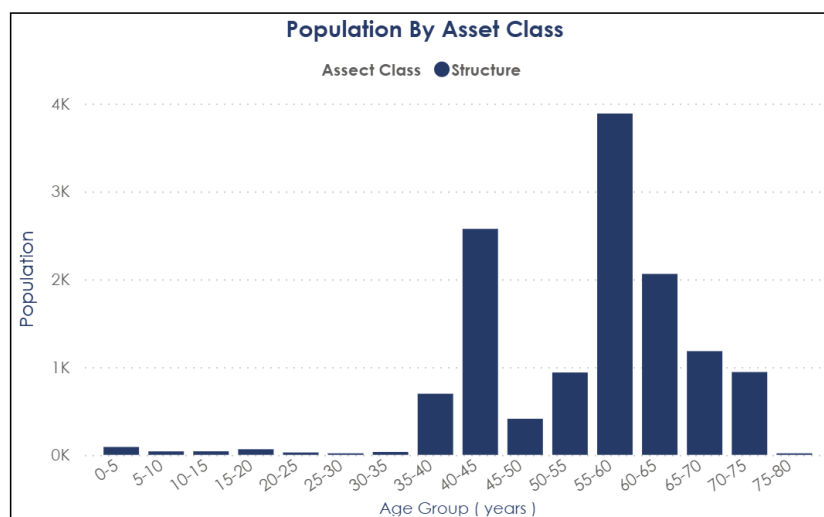
### 3.3. Age

The Victorian transmission network began with 220 kV lines connecting Melbourne and major cities in the northwest and northeast to Latrobe Valley generators, with construction starting in 1950. Later, 330 kV lines linked Victoria with New South Wales between the late 1950s and early 1980s. The addition of 500 kV lines from Latrobe Valley to Melbourne increased capacity for growing demand and industrial support in Southwest Victoria. As shown in Table 2, transmission line structures have an average age of about 49 years.

VOLTAGE CLASS	AVERAGE AGE
500 kV	46
330 kV	57
275 kV	37
220 kV	61
66 kV	45
<b>Overall Avg.</b>	<b>49.2</b>

**Table 2: Average Structure Age by Voltage**

Figure 99 shows the age distribution of transmission line structures, noting the peaks at 40–45 and 55–60 years, when the majority of the respective 500kV and 220kV networks were established. The profile indicates that some towers have reached their nominal 70 year regulatory service life, with a very significant volume expected to approach the threshold within the next 15 years. While AusNet's asset management approach is not age-based, this trend highlights the importance of monitoring the condition of this aging fleet. Asset condition remains the primary driver for intervention decisions, rather than age, and is discussed in section 5.



**Figure 9: Structure Service Age Profile**

# 4. Asset Performance

Performance assessments are a critical element of lifecycle management for transmission line structures. These assessments provide vital information on the current state and performance of structure components, enabling informed decision-making regarding maintenance, repair, and replacement. Understanding how assets perform over time allows for proactive management, reducing the risk of unexpected failures. The assessment employed by AusNet involves analysing failure trends and any significant impacts resulting from failure, which provides valuable insights into the health and reliability of the assets.

## 4.1. Suspended Failures

Defects that are detected and repaired before they cause a functional failure (i.e. catastrophic failure resulting to a circuit outage) are defined as a suspended failure. Rectification of suspended failures is referred to as "Corrective maintenance".

AusNet follows a line patrol and inspection procedure which objectively assesses the condition of transmission line components and identifies assets which are no longer fit to remain in service. Components of transmission line structures deemed not fit for service are replaced by raising ZA Notifications (Notis) in the Enterprise Asset Management System, SAP, and then assigning a priority rating which represents the number of days the maintenance crew has to replace that component.

As shown in Figure 10, over the past 11 years, approximately 4,109 suspended failures have occurred, often involving corroded, bent or missing members and bolts. From 2024 to 2025, notifications increased sharply as C4/C5 condition members and bolts became defective since their last inspection in 2018/19. The rapid change from poor condition to defect status is mainly attributed to the highly corrosive environment.

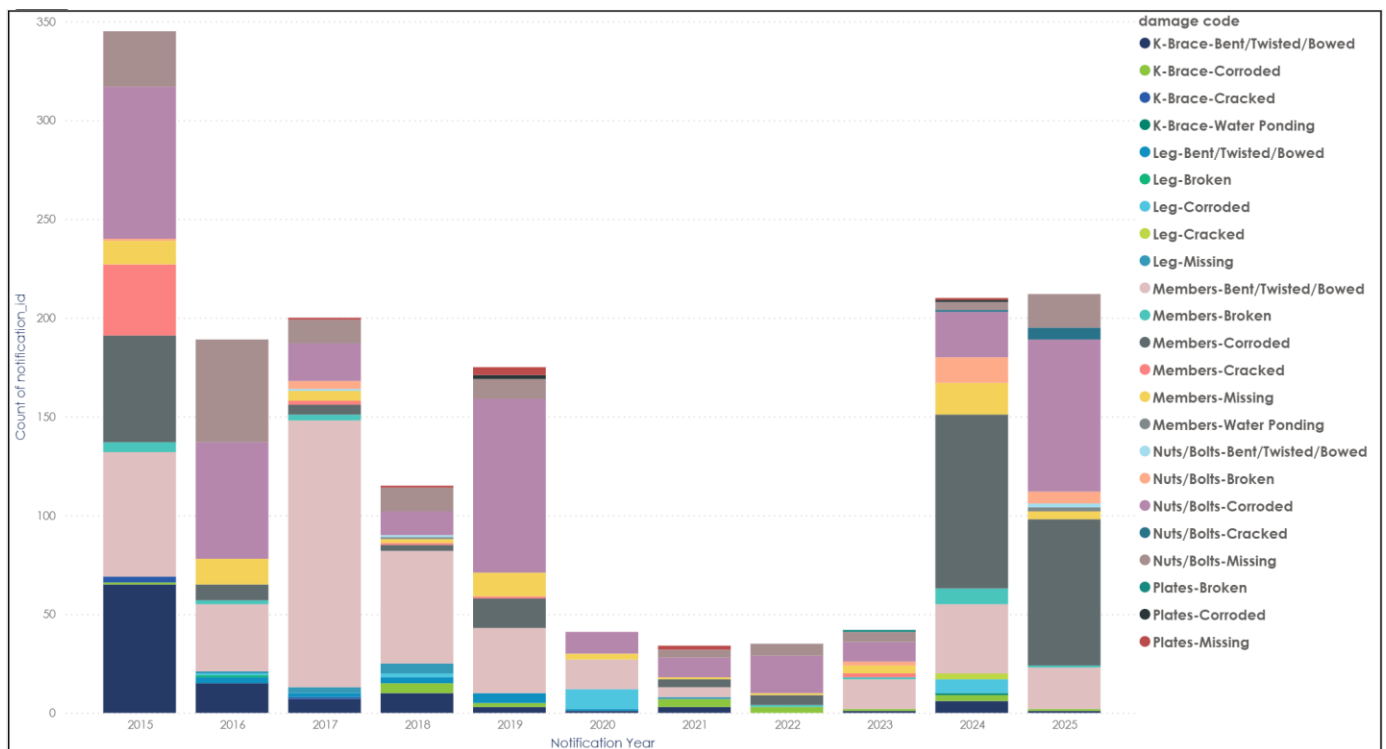
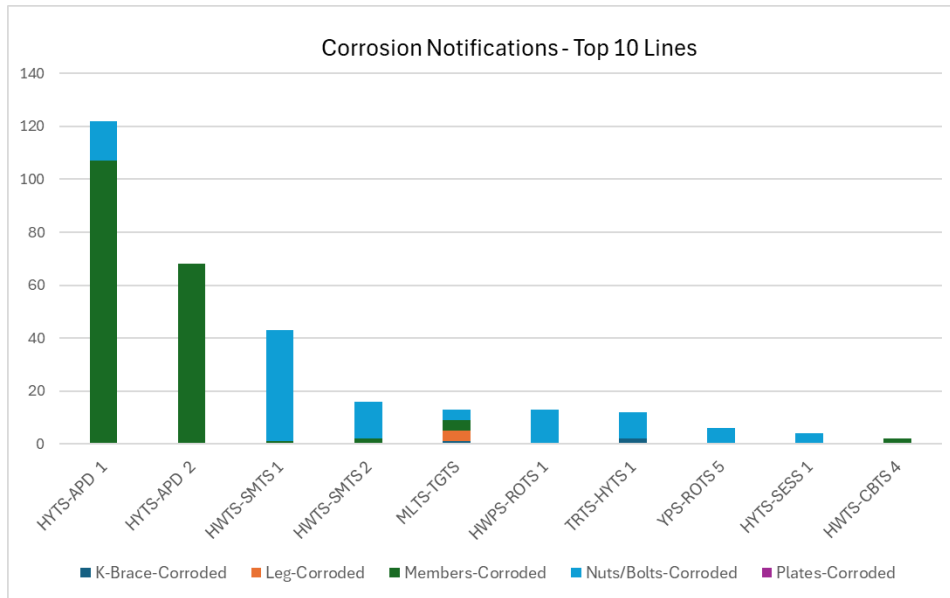


Figure 10: Structure suspended failures

Most structures referenced in these notifications are located in the Southwest region of Victoria, specifically along the 500 kV transmission lines, including the HYTS–APD 500 kV circuits<sup>6</sup>. A significant number of the defects raised are due to the high corrosion levels along these lines highlighting the network’s significant corrosivity and consequently the rapid deterioration of C4/C5 member condition to defect status.

A deeper analysis of the corrosion related notifications is shown below in Figure 11. This shows that almost two thirds (64%) were raised along the HYTS-APD circuits, with almost 70% coming from circuits along the Southwest (i.e., HYTS-SESS, TRTS-HYTS and HYTS-APD).



**Figure 11: Drill down on “Corrosion” Notifications**

In the 2027-32 regulatory period, AusNet plans a CAPEX program to replace C4/C5 members in the network’s southwest to prevent future spikes. (See Appendix E for tower locations.)

Further analysis of the data shown in Figure 10, shows bent or bowed steel members and legs account for 44% of suspended failures in transmission structures. Analysis of these issues identifies causes such as impacts from vehicles or agricultural equipment, the use of lower sections for supporting external equipment, or stacking items against the structure. Bracing members may also buckle or bend when loads exceed their design limits. Most incidents are absorbed by the structure due to the redundancy provided by bracing designs.

The next 15% of suspended failures are attributed to missing parts due to vandalism and/or theft. All transmission line structures have anti-climbing barriers to discourage unauthorised access, but the lower sections are still at risk of theft because some assets are installed in remote areas. In these very rare events, the Land Management Group of AusNet conducts community drives to engage the public and request assistance to secure the assets and report any suspicious activities to the proper authorities.

To further understand the condition of the tower fleet, AusNet is increasing the use of technology such as aerial drones and LiDAR (Light Detection and Ranging) to create a 3D image and structural model which can be used for condition/defect assessment, as well as structural analysis of the tower.

<sup>6</sup> Analysis of 2023 - 2025 data indicates 50% of all notifications raised were on TRTS-HYTS-APD circuits.

## 4.2. Functional Failures

A functional failure of a structure occurs when it can no longer safely support the flow of electricity between terminal stations. This includes any event that compromises the required mechanical support to maintain safe clearances between live components and the ground or nearby objects, as defined by regulatory standards.

### Condition Based Failures

Historically, there has been no condition based functional failure in AusNet's tower fleet. The 51 functional failures experienced in the transmission network since 1959 have all been caused by extreme wind events overloading the structures' design withstand capability.

### Overload Failures

All in service functional failure modes have involved structural collapse resulting from severe weather events. Figure 12 and Table 3 present the historical record of structural functional failures within the Victorian transmission network.

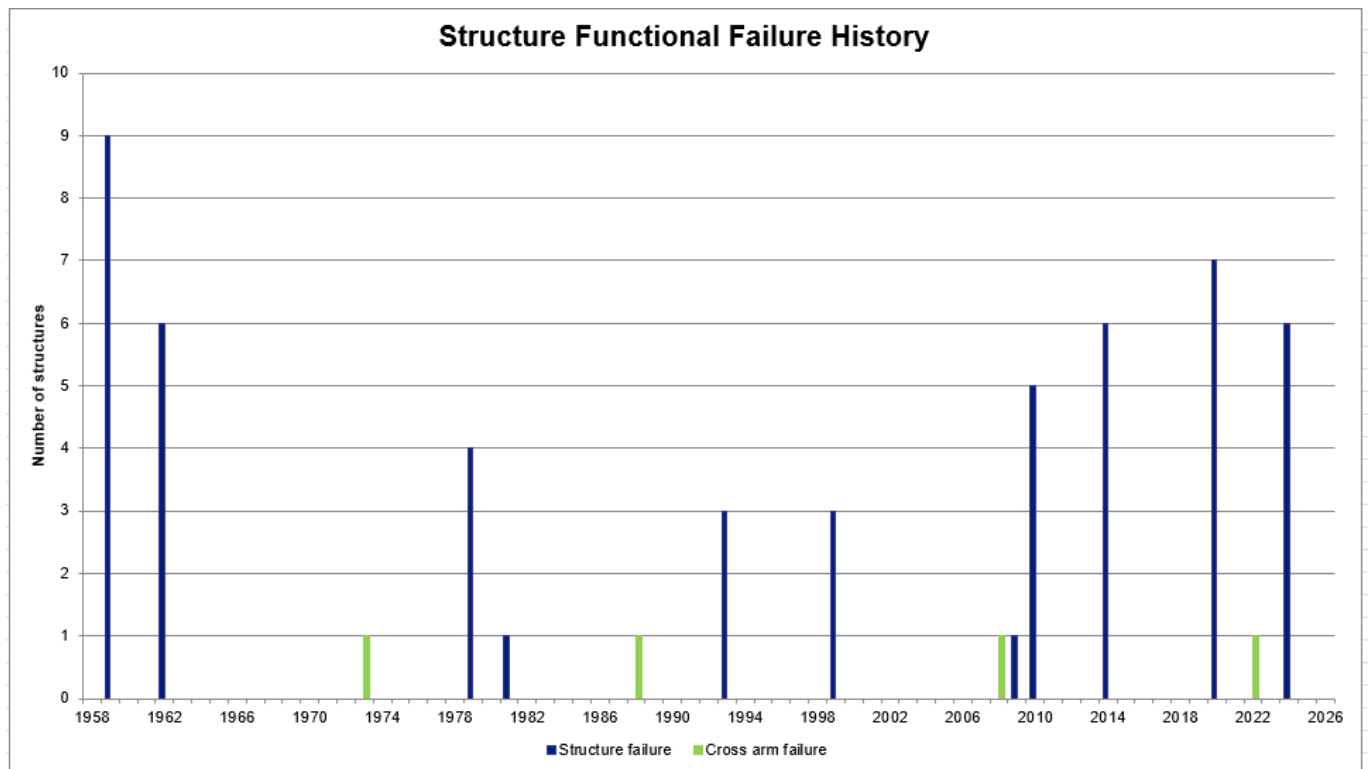


Figure 12: Structure functional failure history

Over 66 years, twelve incidents have caused 51 structures to fail, often triggering multiple collapses. The most severe occurred in 1959 on the Geelong-Colac 220 kV line, resulting in eight tower failures. The Bendigo-Kerang 220 kV line has had four collapse incidents since 1961, attributed to inadequate tower design for high winds, with 18 towers failing in 1979, 1993, 2010, and 2014. All affected structures were in good condition, rated C1 to C3 (Very Good to Average Condition).

On 31st of January 2020, an extreme weather event called a severe convective downburst impacted the transmission line near Cressy, a few kilometres from Geelong. The extreme wind event caused the collapse of six 500kV double circuit towers and damaged a seventh tower. The six towers collapsed in a direction that was perpendicular to the easement while the seventh tower was twisted along its superstructure.

The most recent event occurred on the 13th of February 2024, when a severe storm cell developed near Ballarat and moved in a southeasterly direction towards Moorabool, crossing the transmission line near Anakie in Geelong, approximately 15 km north of Moorabool Terminal Station (MLTS). The intensity of the wind was so strong that it

brought down six single circuit suspension 500kV towers that belonged to two adjacent circuits (i.e., three towers collapsed per circuit) spaced roughly 50 metres apart. Notably, all towers failed at the superstructure level, without any damage to the footings.

The two most recent two tower collapses in the transmission network involved circuits previously considered among the fleet's strongest. These were designed for wind speeds of 44.5 m/s using an SECV code, the wind speed is comparable to modern standards<sup>7</sup>. In total, twelve 500kV towers spanning three distinct transmission lines (i.e., one transmission line is a double circuit construction) were brought down by severe convective downdraft winds with estimated wind speeds between 47-54m/s. CIGRE studies<sup>8</sup> indicate that convective downdraft winds can reach velocities as high as 80 m/s, significantly exceeding typical wind speeds observed during severe weather events.

YEAR	NUMBER OF TOWERS	CAUSE	TOWER TYPE	VOLTAGE	LOCATION
1959	1	Extremely high winds	Suspension tower	220 kV	Yallourn-Melbourne
1959	8	Extremely high winds	Suspension towers	220 kV	Geelong-Colac
1962	6	Tornado	Suspension towers	220 kV	Geelong-Colac
1979	4	Severe Thunderstorm	Suspension towers	220 kV	Bendigo-Kerang
1981	1	Windstorm	Suspension tower	330 kV	Murray - Dederang No.2
1993	3	Severe Thunderstorm	Suspension towers	220 kV	Bendigo-Kerang
1999	3	High intensity wind gusts	Suspension towers	330 kV	Dederang- South Morang No.2
2009	1	North-westerly winds plus convection effect of bushfires	Suspension tower	330 kV	Dederang- South Morang No.1
2010	5	Microburst wind during severe Thunderstorm	Suspension towers	220 kV	Bendigo-Kerang
2014	6	Severe Thunderstorm	Suspension towers	220 kV	Bendigo-Kerang
2020	7	Downdraft wind during severe Thunderstorm	Suspension towers	500 kV	Moorabool-Heywood
2024	6	Wet Microburst wind during severe Thunderstorm	Suspension towers	500kV	Sydenham – Moorabool 1 and 2

**Table 3: Structure collapse incidents**

Figure 13 shows the Mean Time Between Failures (MTBF) of transmission line structures in Victoria, showing progressive decline in recent years to the current 6.3 years. The initial improvement since the early 1960s was due to an increasing population size of higher strength structures which were designed to the SECV Code<sup>9</sup>, in acknowledgement of the inadequacies in early design standards.

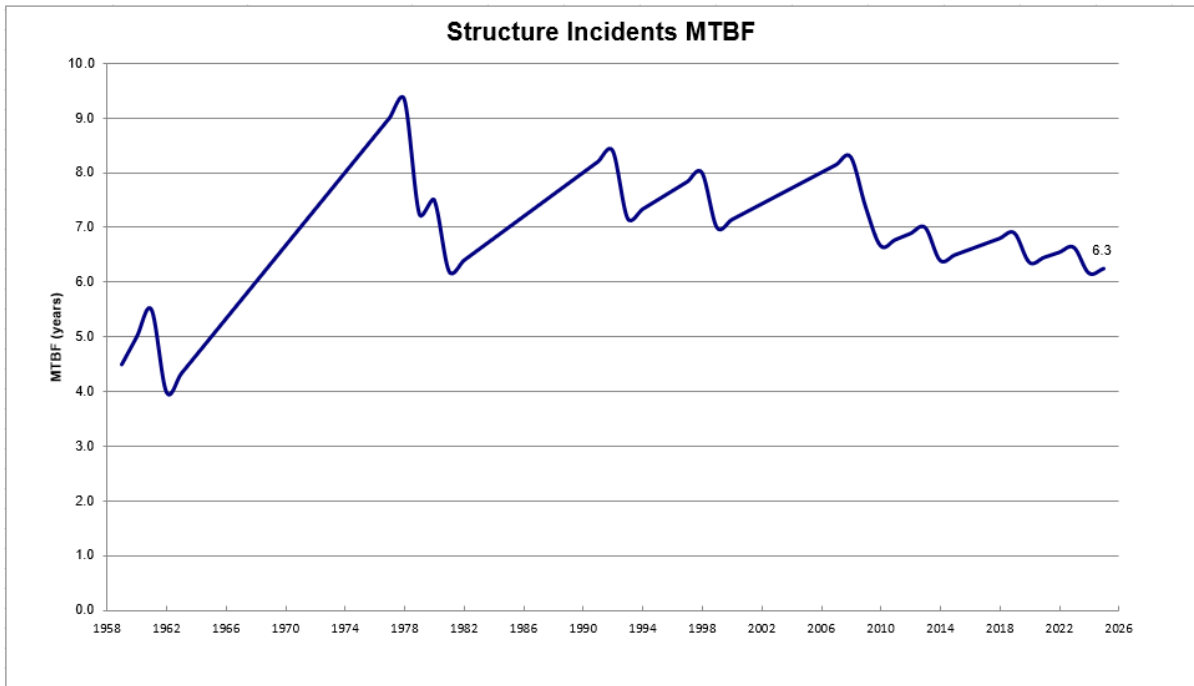
Since 2011, AusNet has conducted tower strengthening works across road/rail crossings where historical tower failures have occurred. Recognising that upgrading all transmission structures is not economically viable, AusNet has focused

<sup>7</sup> For reference, AS/NZS 7000 requires transmission structures along Victoria to be designed to a Regional Wind Speed that has a 1 in 400 annual recurrence interval (ARI). This equates to a wind speed of 44.5 m/sec as per the current Wind Code, AS/NZS 1170.2.

<sup>8</sup> CIGRE TB485 2012, *Table 1 Characteristic of High Intensity Wind*, identifies downdraft as having gust wind velocity between 50 -80 m/sec.

<sup>9</sup> The State Electricity Commission of Victoria, *Code of Practice for the Design of Transmission Structures and Foundations* was introduced in 1960s which used wind pressures appropriate for Australia, and utilised load factors which resulted to stronger structures.

its efforts on these critical locations. These proactive measures<sup>10</sup> are designed to reduce the safety risks associated with towers built to outdated standards. By reinforcing structures at high-risk crossings, AusNet is enhancing public safety and infrastructure resilience where it matters most.



**Figure 13: Transmission Line Structures, Mean Time Between Failure**

<sup>10</sup> Since 2011 tower strengthening works were done on towers that are adjacent to major road crossing/ rail crossing along BETS-KGTS 220kV line, 330kV lines along DDTS-SMTS 1, DDTS-SMTS 2, MSS-DDTS 1, and MSS-DDTS 2.

## 4.3. History of tower strengthening works

Victoria is a Zone III<sup>11</sup> wind load area which includes synoptic (gales) and convective (downburst, microburst) winds. Extreme winds have been the root cause of all structure collapse events triggering compression failures of supporting members on suspension structures. The Victorian transmission network extends across two wind regions<sup>12</sup> including A0 and A5. Region A5 comprises an area that extends 200 km from the coast to Bendigo and A0 covers the rest of the state. Figure 28 displays Australia's wind regions.

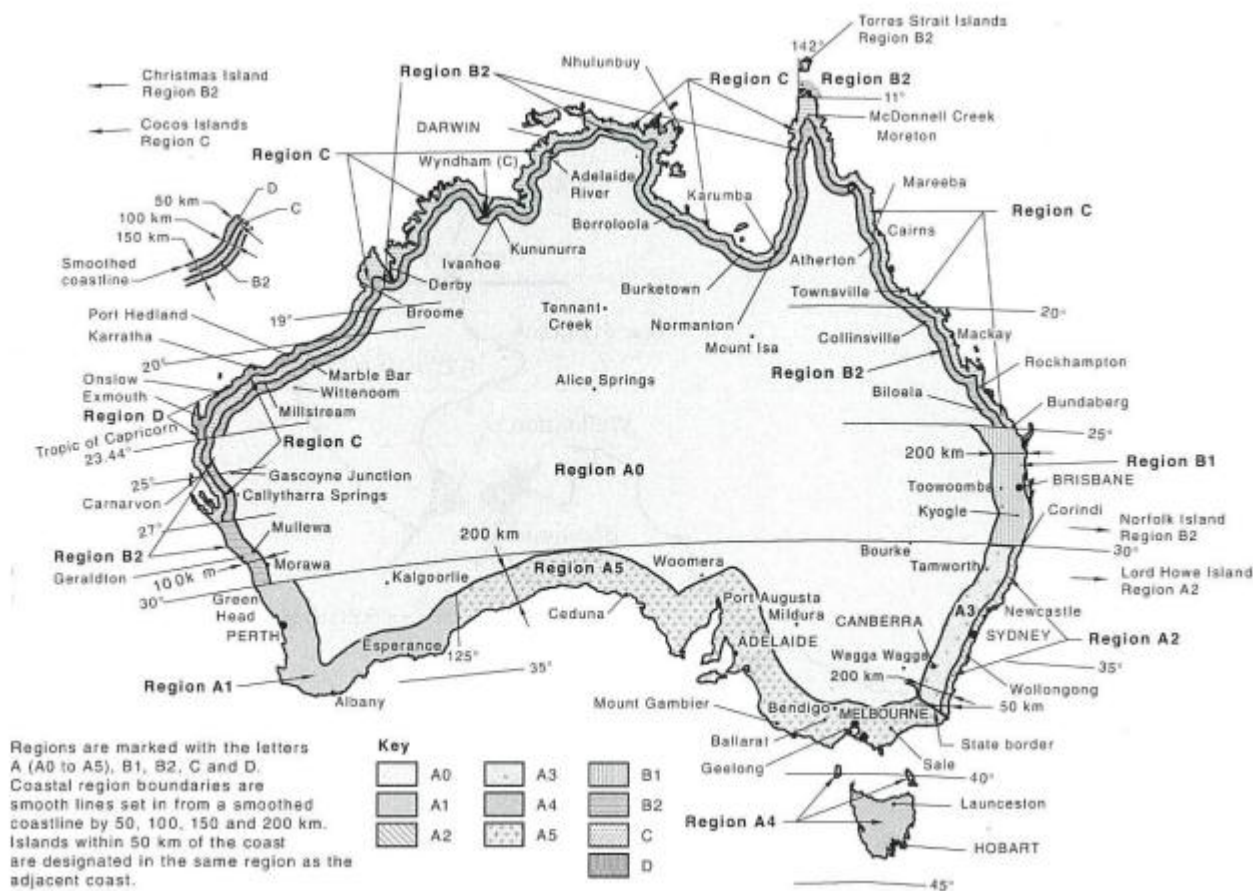


Figure 14: AS/NZS 1170.2 - Wind Regions<sup>13</sup>

A program of strengthening works has resulted in the upgrade of multiple light suspension structures in areas of exposure to extreme wind conditions. Strengthening works first began in the 1970's and have been performed on structures situated on several lines including Dederang to Glenrowan 220 kV, Glenrowan to Shepparton 220 kV, Shepparton to Bendigo 220 kV, Keilor to Geelong 220 kV and Moorabool to Kerang 220 kV.

In 2013, eleven structures along the Bendigo to Kerang 220 kV line were replaced with new structures designed using the latest design standard AS/NZS 7000 to correct unacceptable failure risks over major roads. Three years after this

<sup>11</sup> AS/NZS 7000:2010 Overhead Line Design – Detailed Procedures.

<sup>12</sup> AS/NZS 1170.2:2021 Structural Design Actions – Wind Actions. Standard AS/NZS 1170.2 details wind actions by classifying Australia into four different regions comprising A (divided into subregions A1 to A5), B, C and D and provides these regions with a wind speed value for each average recurrence interval. For the same return period, different spatial regions of the Australian continent have different regional wind speeds with basic wind speeds increasing in magnitude from region A to D.

<sup>13</sup> AS/NZS 1170.2:2021 Structural Design Actions – Wind Actions.

project, TD-3525 (XC78) upgraded 74 towers along the Dederang to South Morang 330 kV No.1 and No.2 lines to mitigate the risks associated with road crossings as well as improve the reliability of the line.

In 2024, AusNet completed the strengthening of 60 towers along the Murray Switching Station to Dederang Terminal Station (MSS-DDTS) No. 1 and 2 circuit 330 kV lines. These were strengthened with a similar objective of mitigating the risks associated with a tower failure across major roads, while improving line reliability.

Building on this, AusNet has introduced a Tower Resilience Program, which seeks cost effective opportunities to upgrade selected existing structures, to the current AS/NZS 7000 design standard, recognising that it is not feasible or economically justified to strengthen all structures across the network. The program's core objective is to enhance network resilience on lines that have the highest market impact (to consumers), a key distinction from previous tower upgrade initiatives.

AusNet proposes to upgrade 180 structures to the latest overhead line design standard AS/NZS 7000, in the 2027-32 period. The structures will be upgraded to a higher wind speed of 1 in 1000 ARI<sup>14</sup> due to the increasing frequency of occurrence of extreme wind events in Victoria. The program will focus on suspension towers which are known to be the weakest structure type in the network. The Tower Resilience Program is discussed further in Section 7.4.3.

## 4.4. Performance Summary

The tower asset class is predominantly impacted by environmental factors and weather conditions, with issues such as corrosion of structure members and bolts particularly prevalent in high corrosivity zones. These challenges were first recognised as early as 1970, prompting the development of mitigation strategies. In 2025, AusNet continues to face these issues, now exacerbated by the increasing intensity and frequency of extreme weather events. While the nature of the challenge remains consistent, it is actively managed through sound engineering judgement and viability assessments.

### 4.4.1 Corrosivity of environment

Environmental conditions, particularly in Victoria's southwest, have significantly impacted tower condition, with airborne salts accelerating corrosion. This has resulted in a high volume of defect notifications (ZA), especially on the TRTS-HYTS, HYTS-SESS, and HYTS-APD circuits. Almost two thirds (64%) of corrosion related corrective actions on steelwork and bolts are associated with the HYTS-APD 500kV lines. This is also being observed on defects volumes reported on ground wire and insulator hardware associated with these lines.

Due to widespread corrosion affecting numerous towers in this region, a program is proposed for the upcoming regulatory period, involving targeted refurbishment (member and bolt replacement) as well as full tower replacement, where deterioration is severe and refurbishment is impractical.

### 4.4.2 Design wind with stand

Tower collapse events have consistently been attributed to extreme wind conditions, particularly convective downdrafts intense, localised, short duration wind bursts not reflected in standard forecasts. These winds exceed the towers' design limits; no failures have been linked to asset condition.

To address safety risks, past efforts have focused on strengthening older transmission lines, at major road/rail crossing, which were originally designed to withstand lower wind speeds than those specified in current standards. Building on this, AusNet's Tower Resilience Program aims to upgrade selected existing structures to current standards in a cost-effective way, focusing on improving network security and resilience for the community, differentiating it from earlier tower upgrade efforts.

---

<sup>14</sup> Annual Recurrence Interval (ARI) is a statistical measure indicating the average time between events of a particular intensity, e.g., a flood with a 100-year recurrence interval is expected to occur, on average, once every 100 years. Also valid is this event has a 1% probability (1 in 100 chance) to occur in a year.

# 5. Asset Health

Transmission line structures are inspected at intervals of 3, 6, or 9 years, depending on asset criticality. Asset criticality is determined by factors such as proximity to public areas (including road and rail crossings), environmental conditions (such as corrosion rates and corrosivity zones), and the potential impact of failures or unplanned outages on market operations and customer supply.

Structure members and bolts are assessed and receive a condition score from C1 to C5, as detailed in Table 4, with brief descriptions for each parameter. Further information is available in REF: LPP 09-06: Condition Assessment of Overhead Lines. Condition scores, along with structure type, corrosivity, failure risks, and loading design, inform medium and long term asset management decisions.

CONDITION SCORE	CONDITION DESCRIPTION	BOLT & NUT	STEEL MEMBER, BRACE OR STEEL POLES	REMAINING LIFE
C1	Very Good	Very Good Condition		95%
C2	Good	First rust spots appear		85%
C3	Average	Patchy Rust		60%
C4	Poor	Extensive Surface rust		25%
C5	Very poor	Flaking Metal	Pitting or Minor section Loss	15%

**Table 4: Condition Score Methodology**

Figure 15 below provides visual examples of condition scores for legs, members, and bolts, illustrating how each component is assessed during inspections.



**Figure 15: Condition Scores Examples**

The characteristics of condition grading and follow up actions are described as follows:

C1: *Very Good condition* – The steelwork and bolt/nut/thread are 'as new' condition, with full mechanical integrity – no action required.

C2: *Good condition* – Initial occasional rust spots have appeared, but only superficial with the red specs widespread, i.e., some galvanising on the steelwork is retained – no actions required

- Steelwork has full strength, i.e., tensile, compressive and flexural capacity
- Bolt/nut/thread has started to lose its galvanising but no impact to strength

C3: *Average condition* – The rust spots/ red specs is dense and spread out along the surface – no actions required

- Member is now bare steel but still retains its strength; 'Gingering colour' has started to show
- Bolt/nut/thread has lost all galvanising, but the shape is still intact

C4: *Poor condition* – Item is now fully covered with red or brown colour, i.e. fully gingered colour, tower management planning required

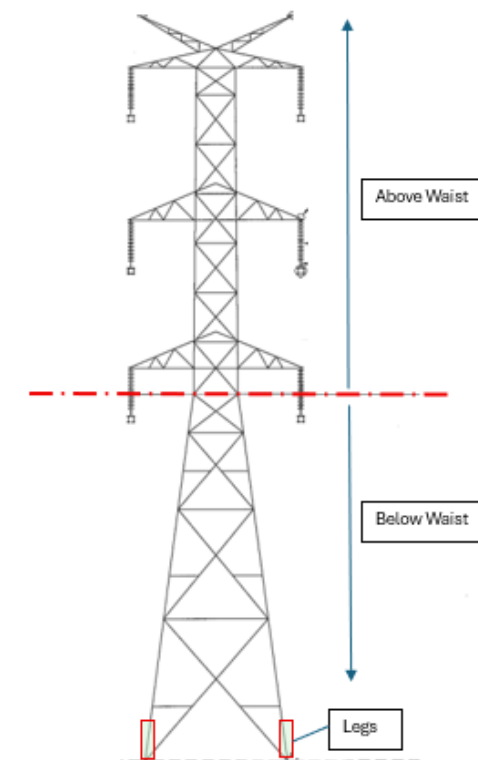
- Member has extensive 'surface rust', but no section loss
- Bolt/nut/thread is starting to lose its shape/contours, but no section loss

C5: *Very Poor condition* – Item has started to lose sectional area and intervention plan is required

- Member has developed pitting, surface lamination, starting to lose sectional area
- Bolt/nut/thread has completely lost its shape and starting to lose section (i.e., not exploded or split)

Asset considered beyond a C5 condition are raised as defects for shorter term replacement or re-assessment.

To enable the accurate assessment of a tower, the structure is divided into three main sections: tower legs, tower section below waist, and tower section above waist (refer to Figure 16 below).



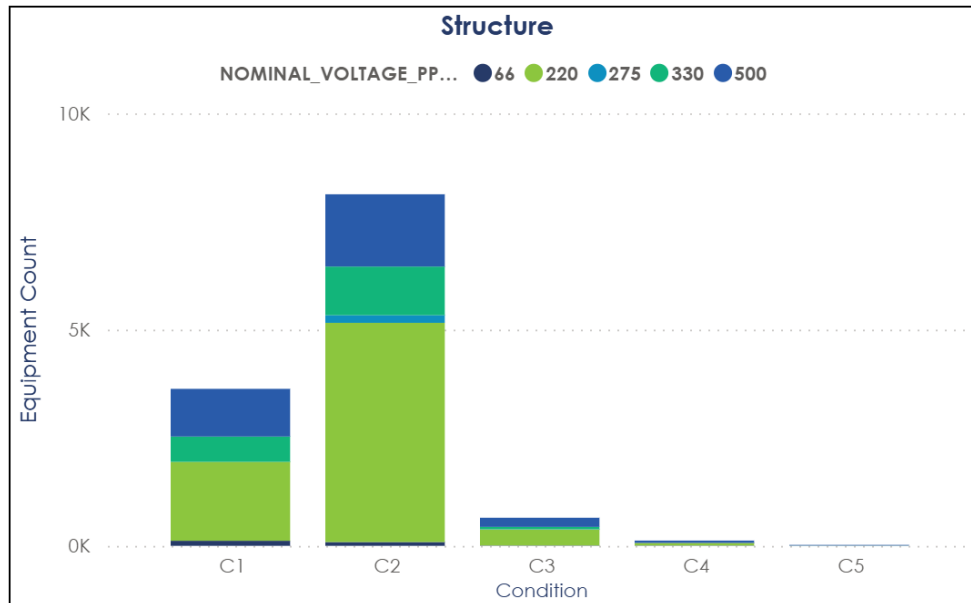
**Figure 16: Tower outline: Legs, Below Waist, Above Waist**

Each tower leg is assessed individually for condition. Each Tower section of steelwork is assessed and scored to reflect the worst condition members and bolts, along with the extent of deterioration expressed as a percentage of the overall tower steelwork. Assessments are divided into two sections: 'above the waist' (including crossarms) and 'below the waist'. These scores inform prioritisation of refurbishment and maintenance activities.

# 5.1. Overall Tower Condition

An overall tower score is created by a weighted combination of three key components: the load bearing legs and the above ground steelwork. The latter includes two parts of the tower body, both below and above the waist (including the crossarms). The purpose is a simple method to highlight those towers that have widespread poor condition that requires further investigation and management plans.

Figure 17 presents overall transmission line structure condition scores by voltage rating.



**Figure 17: Structure Fleet Condition Profile**

Out of the total tower fleet, 11,760 towers (93.17%) have been rated as having condition scores of C1 (Very Good) or C2 (Good) condition. In comparison, around 650 towers (5.15%) are assessed as C3 (Average) condition, with around 110 towers (0.95%) as C4 (Poor) condition, and approximately 21 towers (0.73%) are rated as C5 (Very Poor) condition.

Upon closer inspection of towers scored in Poor and Very Poor condition, it was found that over 80% of C4 towers and over 30% (7) of C5 towers relate to the condition of the corrosion protection painting on the legs of these towers, known as SOXS. The SOXS is a protective layer and not a load bearing component, its purpose is to preserve the underlying condition of the tower legs. In all these towers the SOXS condition has been raised as a defect however it does not represent the condition of the tower legs. Rectification is part of the ongoing corrective maintenance program, including legs re-blasted, bolts replaced as needed, and coatings reapplied. An example of a tower leg with C5 bolts and damaged SOXS before repair is shown below.



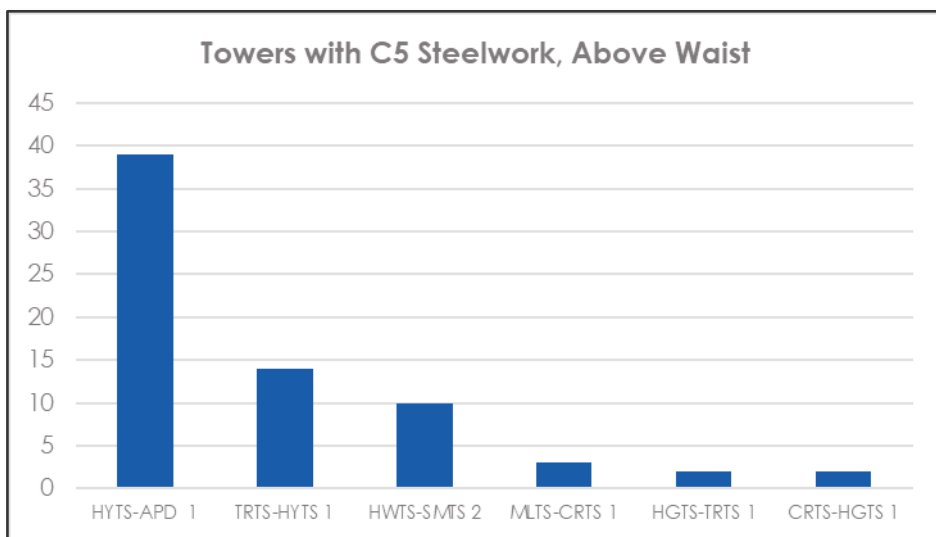
**Fig 18: Damaged SOXS, T197 MLTS-TGTS 220kV**

The remaining structures assessed as C5 are 14 of the 500 kV towers on the HYTS-APD 500kV line, located in the southwest part of the network. The legs on this line are generally in good condition due to corrosion mitigation (SOXS, however the overall very poor condition rating is driven by severe pitting, flaking, and section loss on the steelwork members and bolts.

## 5.2. Steelwork Condition

While the overall tower condition score provides a useful summary, it can mask developing localised corrosion issues. For this reason, steelwork condition is also analysed separately to allow targeted issues to be identified and addressed.

Figure 19 below presents towers with rated C5 (Very Poor) steelwork condition, 'above the waist' and grouped by circuit name. HYTS-APD 500 kV circuits represent the largest extent of C5 rated steelwork, in line with severe corrosivity in this area. This is significant as 'above waist' members typically have the smallest cross-sectional area and therefore the thinnest galvanising layer, making them more susceptible to corrosion<sup>15</sup>.



**Figure 19: Circuits with C5 steelwork "Above the Waist"**

<sup>15</sup> AS/NZS 2312 indicates that new galvanised structures should last 30-60 years, w/out the need for short-term maintenance.

As observed with the overall tower score, the towers along the HYTS-APD lines, have the highest number of C5 "Above waist" steelwork in the fleet. Although 14 towers are rated C5 overall for severe steelwork deterioration, almost 40 towers have some steelwork (above waist) rated at C5.<sup>16</sup> These lines have been operating for 45 years and have undergone several refurbishment programs.

Additional interventions are planned for C5 steelwork locations in TRR 2027-2032. Details regarding the condition HYTS-APD 500kV lines are discussed further in Section 5.3

### 5.2.1. Structure Condition vs Corrosivity Zone

Figure 20 shows the structural condition of the fleet across the three corrosivity zones in the Victorian transmission network. In Corrosivity Zone 1 (Low), most structures are classified as C1 (Very Good) and C2 (Good) condition, with a minority rated C3 (Average). In Corrosivity Zone 2 (Medium) the majority are designated as C2 condition, with small percentages rated C3 and C4 (Poor).

Structures in Corrosivity Zone 3 (High), are predominantly in C5 (Very Poor) condition, limited to the HYTS-APD 500 kV line, and specifically the towers closest to APD (and the coast). Although these towers are only 45 years old, the graph shows that environmental corrosivity primarily airborne salt from prevailing winds greatly impacts their condition and accelerates steel corrosion. The duration of exposure is more significant than the actual age of the structures.

In the upcoming period, the proposed replacement program will target those towers in Corrosivity Zone 3 (High).

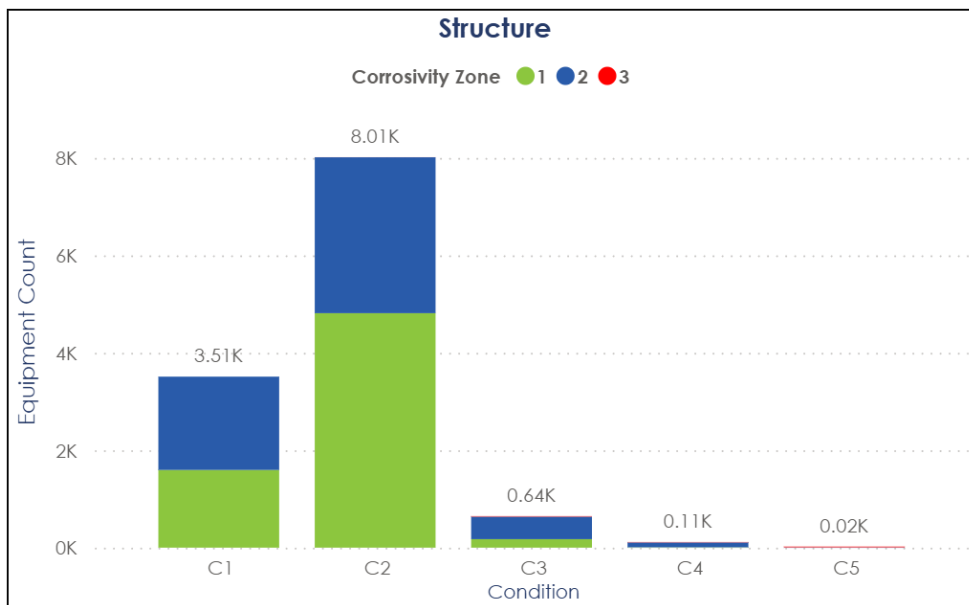
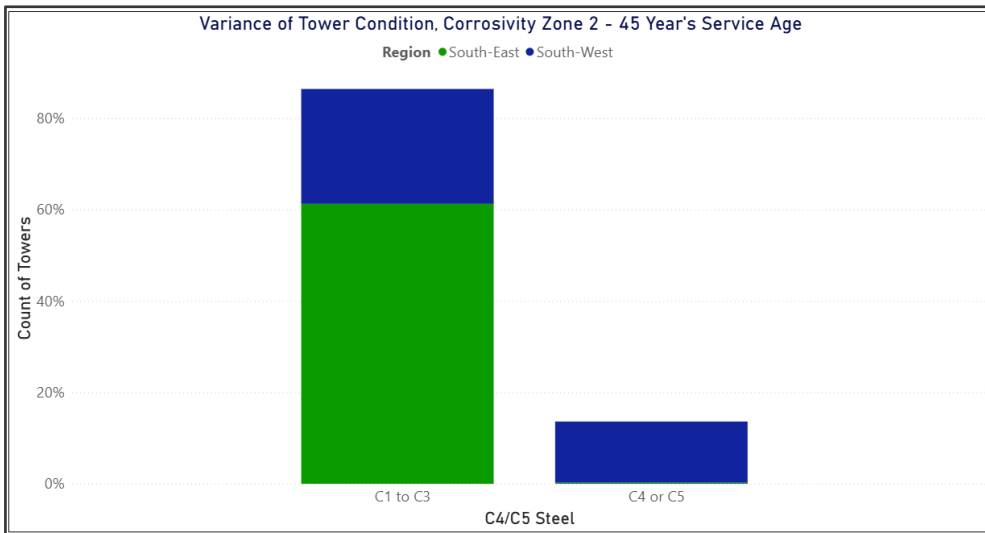


Figure 20: Structure Condition vs Corrosivity Zone

Corrosivity Zone 2 also encompasses a broad geographic area, and recent observations suggest it can be further subdivided into distinct higher and lower corrosivity regions. Analysis shows that tower conditions in the Southwest Zone 2 are in significantly worse condition than those in Southeast Zone 2. Figure 21 below illustrates this, showing 45 years old towers with C5 steelwork concentrated exclusively along Victoria's Southwest corridor. This variation is likely driven by differing pollution sources. The Southwest region is subject to salt laden air and prevailing coastal winds, which contribute to accelerated corrosion. In contrast, the Southeast, particularly the Latrobe Valley, saw industrial pollution which may have declined in recent years with industry shutdowns, contributing to slower corrosive degradation.

<sup>16</sup> Refer to Appendix F – C5 Steelwork condition, "above waist" and Overall tower condition



**Figure 21: Variance of Tower condition, Corrosivity Zone 2, 45-years' Service age**

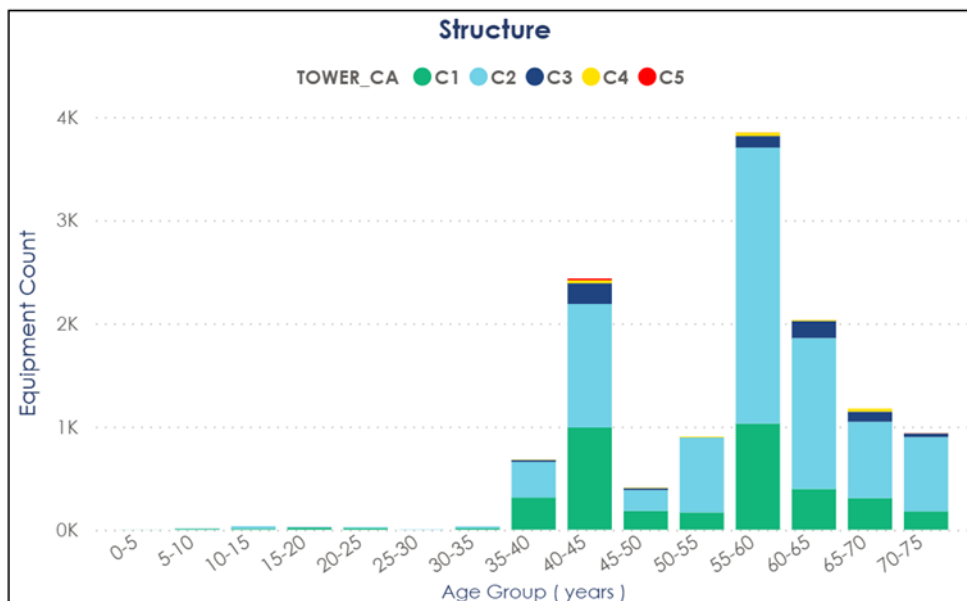
The proposed asset replacement program will prioritise the replacement of the most severely affected towers in Corrosivity Zone 3 (High) and refurbishment in Corrosivity Zone 2 along the Southwest corridor, including the replacement of individual C5 condition members.

### 5.2.2. Structure Condition vs Service Life

Figure 22 shows the condition of the tower fleet throughout its service life. C1 (Very Good) condition structures are distributed almost evenly across service age brackets 35 - 75 years, while C2 (Good) condition structures predominantly fall within the 55 - 60 years' service range. The majority of C3 (Average) condition assets are older than 40 years while C4 (Poor) condition assets typically exceed 55 years' service life with the exception on the HYTS-APD structures which are between 40 to 45 years old.

The data depicted in Figure 19 shows that most of the tower fleet is assessed as being in C1 to C2 condition across a broad spectrum of ages, indication that that structure condition is more influenced by local environment than by service life.

While Victoria generally has a benign climate that supports long asset life, localised areas particularly in the Southwestern corridor are experiencing more severe weather events and accelerated corrosion. Consequently, the HYTS-APD towers appears in the C5 (Very Poor) category at an earlier service age of 45 years.



**Figure 22: Structure Condition across Service Life**

## 5.3. HYTS-APD Tower Condition

The HYTS-APD No 1 & 2 lines, consists of 75 double circuit, and 2 single circuit towers. The line was built as the dedicated supply to [ C.I.C. ]. The smelter requires constant supply and has strict recall times during an outage on this line.

Thirty of the towers are located within Corrosivity Zone 3 with the remainder in Zone 2. All towers, except 10 towers near the HYTS end, have badly corroded members and bolts, at least C4 or C5 steelwork. The 2025 condition assessment steelwork scores have been included in Appendix H.

The overall tower condition assessment is summarised below in Figure 23,

- 14 towers assessed overall as C5 (Very Poor) condition, with a very high percentage of C5 rated critical members and bolts
- 6 towers assessed overall as C4 (Poor) condition" 5 towers have a high percentage of C5 rated critical members and bolts
- 8 towers rated overall as C3 (Average) condition", all with medium level of C5-rated critical members and bolts

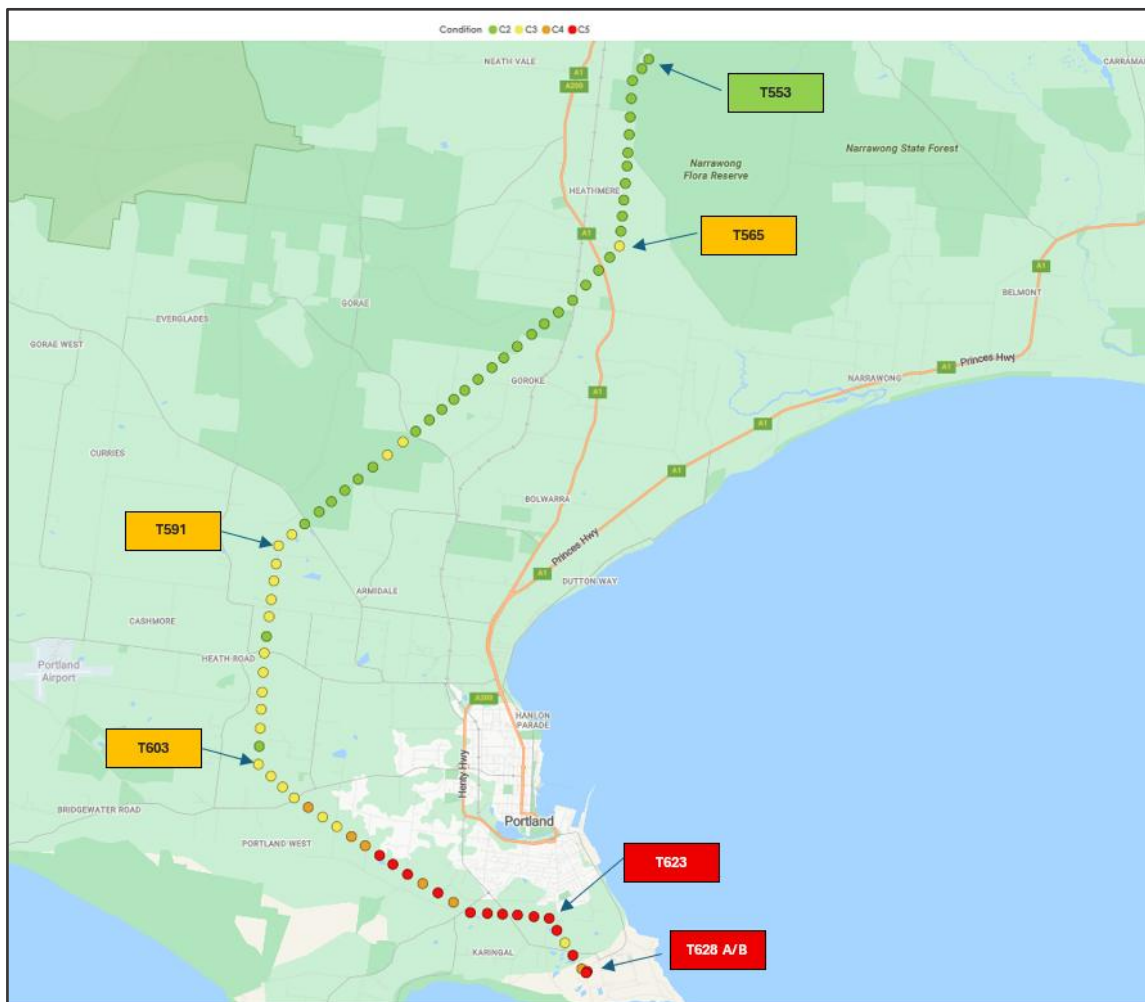


Fig 23: HYTS-APD 500kV towers' Condition Score

In 2001, the final 20 towers on the Portland end of the line were repainted after approximately 20 years of service, due to corrosion observed in the coastal environment. An inspection in 2008 revealed on average 50% coating breakdown over just 7 years, indicating the approach was ineffective and corrosion continued to progress.

Proposed repainting was further evaluated and determined to be operationally challenging, high-risk, and economically unviable. Consequently, corrosion mitigation efforts focused on individual member and bolt

replacement. Analysis confirmed that this strategy was the most cost-effective solution until comprehensive tower replacement becomes necessary. Section 6.9 provides more detail on Corrosion Mitigation for High-Corrosivity Zones.

Several refurbishment projects have been carried on these towers, the most recent in 2024, replacing 612 members and more than 3,500 bolts across 26 towers. [ C.I.C ]

A corrosion specialist performed extensive ground and drone inspections on the final 28 towers, identifying larger structural members, such as main members, top/bottom chords of crossarms/earth peaks, as the next replacement targets. Tower stability is a factor that must be considered during this work requiring the phase conductors and ground wires to be transferred onto temporary bypass structures to maintain a reliable supply to the smelter. Even when a tower can be refurbished without offloading, the implementation of the works, which require a strain-to-strain section makes a combination of refurbishment/replacement less efficient and riskier than full tower replacement.

In 2022, Energy Safe Victoria (ESV) carried out a Bushfire Mitigation (BFM) audit on parts of the Southwest region's 500kV transmission network, including the HYTS-APD line. This audit found "A significant level of deterioration due to corrosion is present in a number of the observations made by ESV"

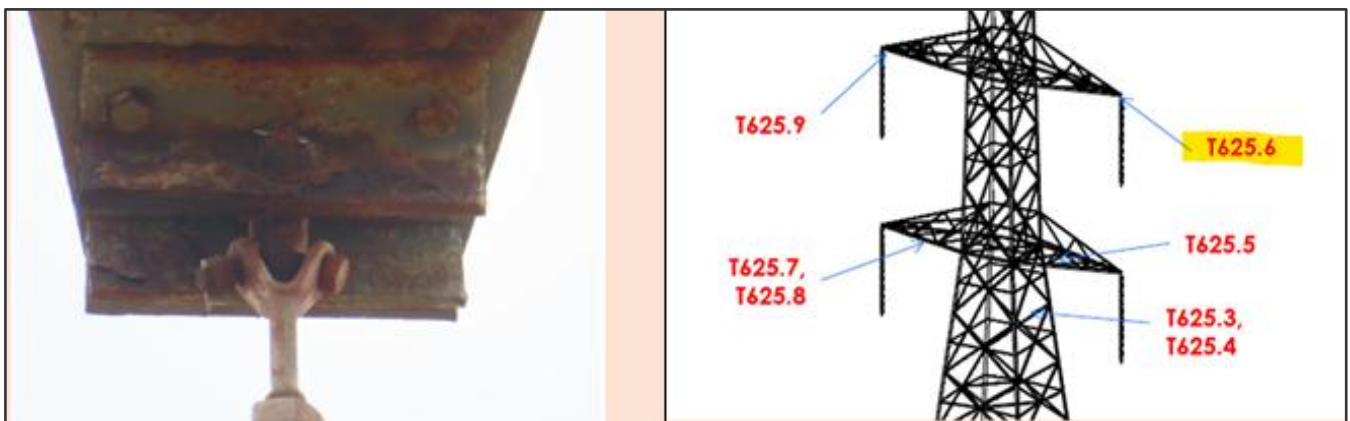
[

C.I.C

]

Communication with ESV remains active on this issue, focused on long-term management plans for the HYTS-APD line. AusNet has committed to a program of tower replacement on the HYTS-APD line, the first stage of which is expected to be completed by 2027.

Figures 24 and 25 show examples of C5 members/bolts/plates which require offloading of conductors and ground wires from the structure due to their interconnected nature with other members.



**Figure 24: T625 suspension plates, middle phase**



**Figure 25: T609 gusset plate and member of the earth peak top chord and top crossarm**

More detail is provided in the following images of each typical tower type along the HYTS-APD line, illustrating their very poor condition.

Ref: Appendix H lists the 2025 condition assessment inspection results for each tower on the HYTS-APD lines, as well as the over-all tower condition.

### **5.3.1. T628B: Single Circuit, Light Strain, Type 5C (Condition C5)**

T628B was one of the first towers painted in 2001 and has undergone multiple refurbishment works since. In 2024, both earth wire peaks were replaced under outage, rather than replacing multiple corroded members in a piece-meal manner. Multiple bracing members and conductor connection plates need replacement that require the offloading of the phase conductors and ground wires into a temporary structure.

T628B and T628A are the termination towers supporting the circuits going into the [C.I.C] switchyard. Both circuits cross an arterial road that adds to the consequence of a tower failure, due to the potential for motorists being harmed.



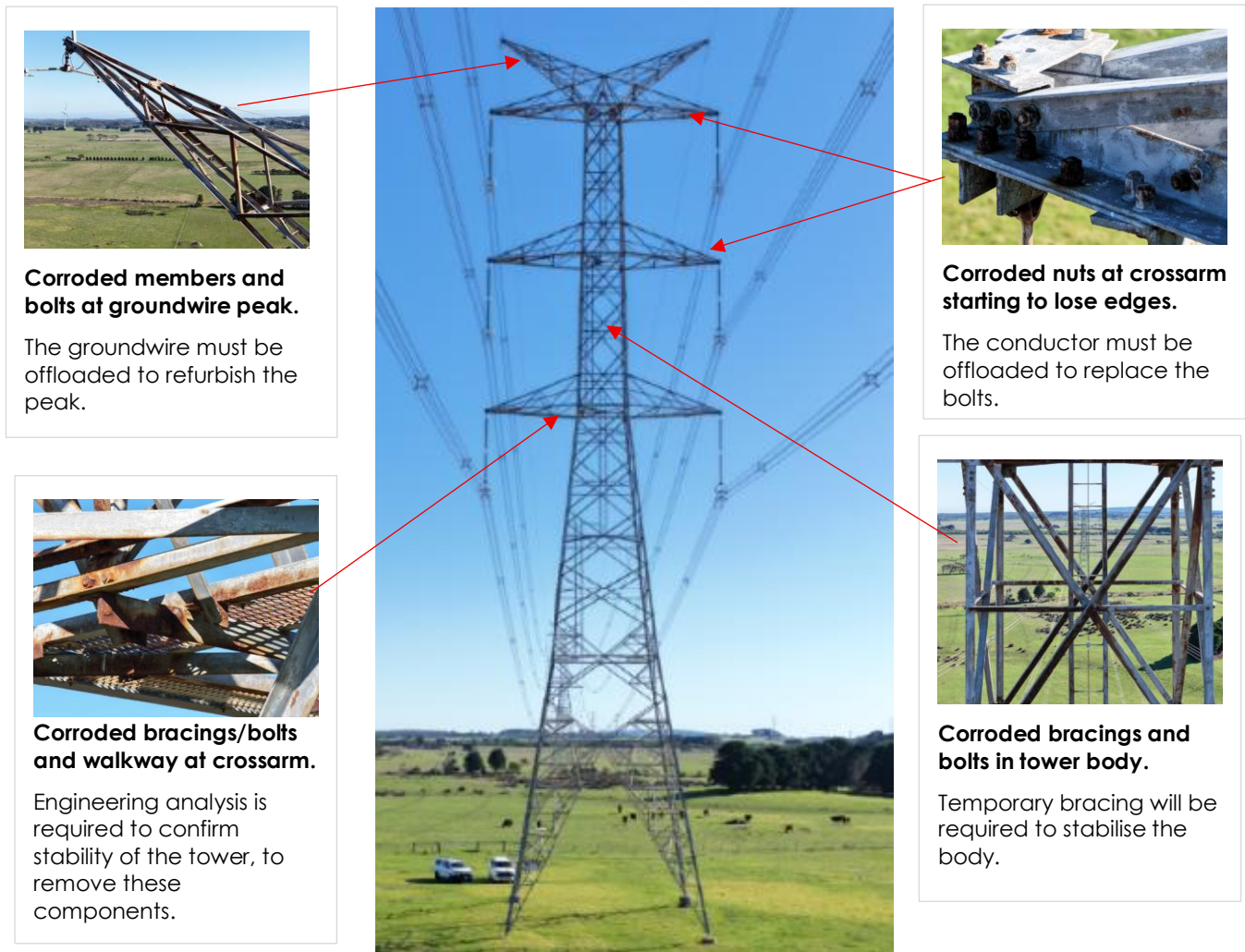
**Figure 26: T628B, corrosion of plates and interconnected members**

### 5.3.2. T610: Double Circuit, Light Suspension, Type EA (Condition C4)

T610 is a light suspension tower that was also painted in 2001. The tower is rated in C4 (Poor) condition, with its members and bolts in "Very Poor" condition.

T610 was included in the refurbishment works undertaken in 2024 wherein defective members and bolts were replaced. Images are provided below showing the status of the remaining members and bolts on the tower.

Due to the extent of poor condition members and bolts, refurbishment would require extensive temporary bracings to stabilise the body, with the conductors and ground wires needing to be offloaded to lessen the load on the structure. *These complex requirements and the inherent risks associated with refurbishment activities point to tower replacement as a better option – both in terms of worker safety and cost effectiveness.*



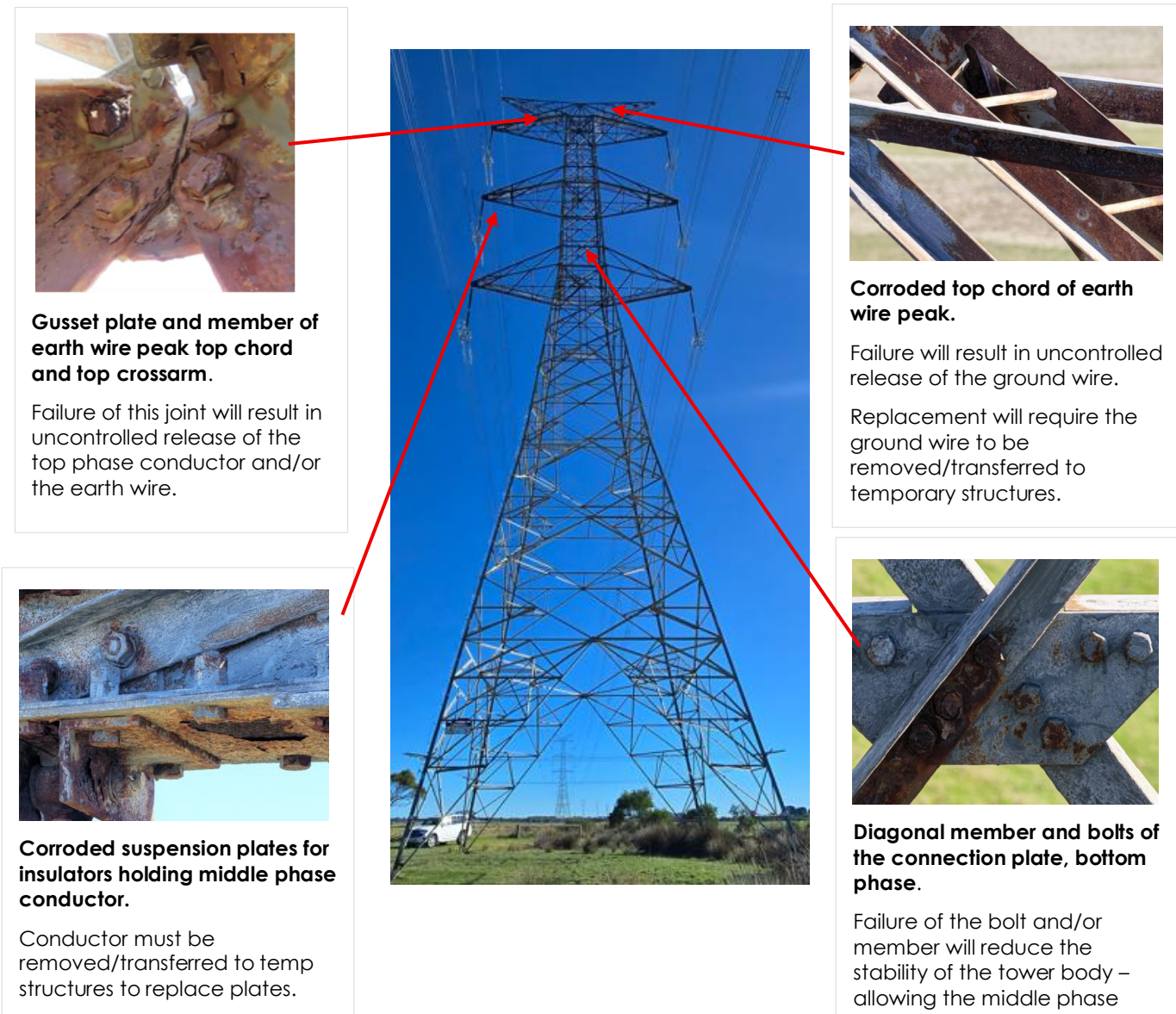
**Figure 27: T610, showing corroded members, bolts and walkway on the tower**

### 5.3.3. T609: Double Circuit, Light Suspension, Type EA (Condition C3)

T609 is a light suspension tower which is currently rated as C3 "Average" condition. The tower's critical members and bolts have been assessed to be in "Very Poor" condition (C5), although the extent is less than on towers closer to the coast.

As shown by the following photos, the corroded components of the tower have multi-member connections that will require offloading of the conductor and ground wire to safely undertake the refurbishment works. The removal of the conductors is also necessary to replace the suspension plates at the tips of the crossarms.

Being an intermediate tower that will require offloading, it is more cost efficient and much safer for line workers to replace the structure rather than have it refurbished and perform regular maintenance on the structure over its lifetime.



**Figure 28: T609, corrosion of interconnected members, bolts, and plates**

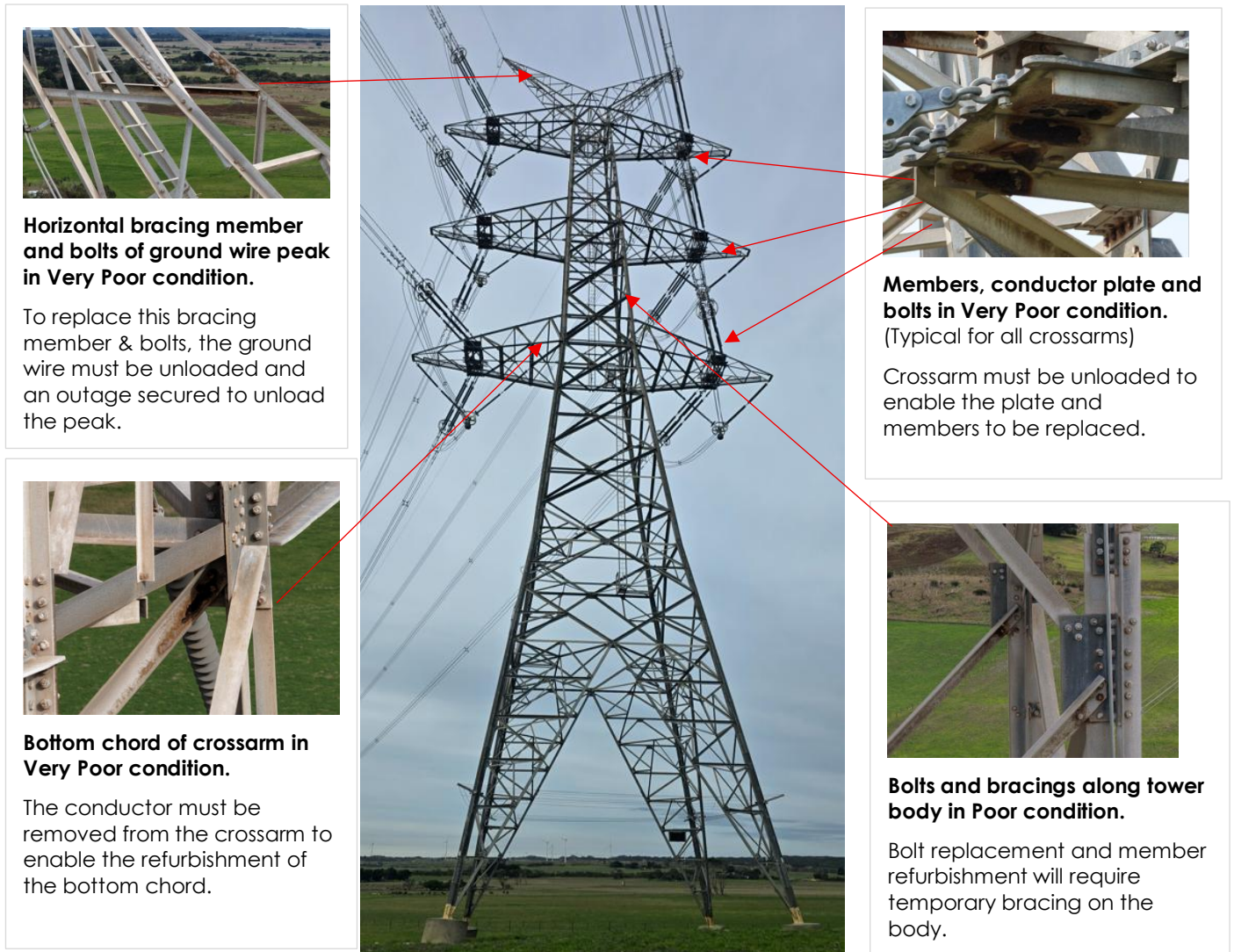
### 5.3.4. T603: Double Circuit, Heavy Strain, Type ED (Condition C3)

T603 has an angle deviation of 50 degrees and is constantly under tension from the phase conductors and ground wires. The tower is currently rated in C3 (Average) condition, with its critical members and bolts in C5 (Very Poor) condition.

Due to the tower being heavily loaded, the structure must be offloaded by transferring the phase conductors and ground wire onto bypasses prior to any work being done. This safety requirement makes tower refurbishment an expensive and high-risk activity.

*Economic analysis shows replacement is preferable to refurbishment*, as after 10 years, combined initial and maintenance costs equal those of a new structure, with further maintenance making refurbishment costlier. Appendix G details cost comparisons.

The photos below illustrate the current condition of the members and bolts on the tower.



**Horizontal bracing member and bolts of ground wire peak in Very Poor condition.**

To replace this bracing member & bolts, the ground wire must be unloaded and an outage secured to unload the peak.

**Members, conductor plate and bolts in Very Poor condition.**  
(Typical for all crossarms)

Crossarm must be unloaded to enable the plate and members to be replaced.

**Bottom chord of crossarm in Very Poor condition.**

The conductor must be removed from the crossarm to enable the refurbishment of the bottom chord.

**Bolts and bracings along tower body in Poor condition.**

Bolt replacement and member refurbishment will require temporary bracing on the body.

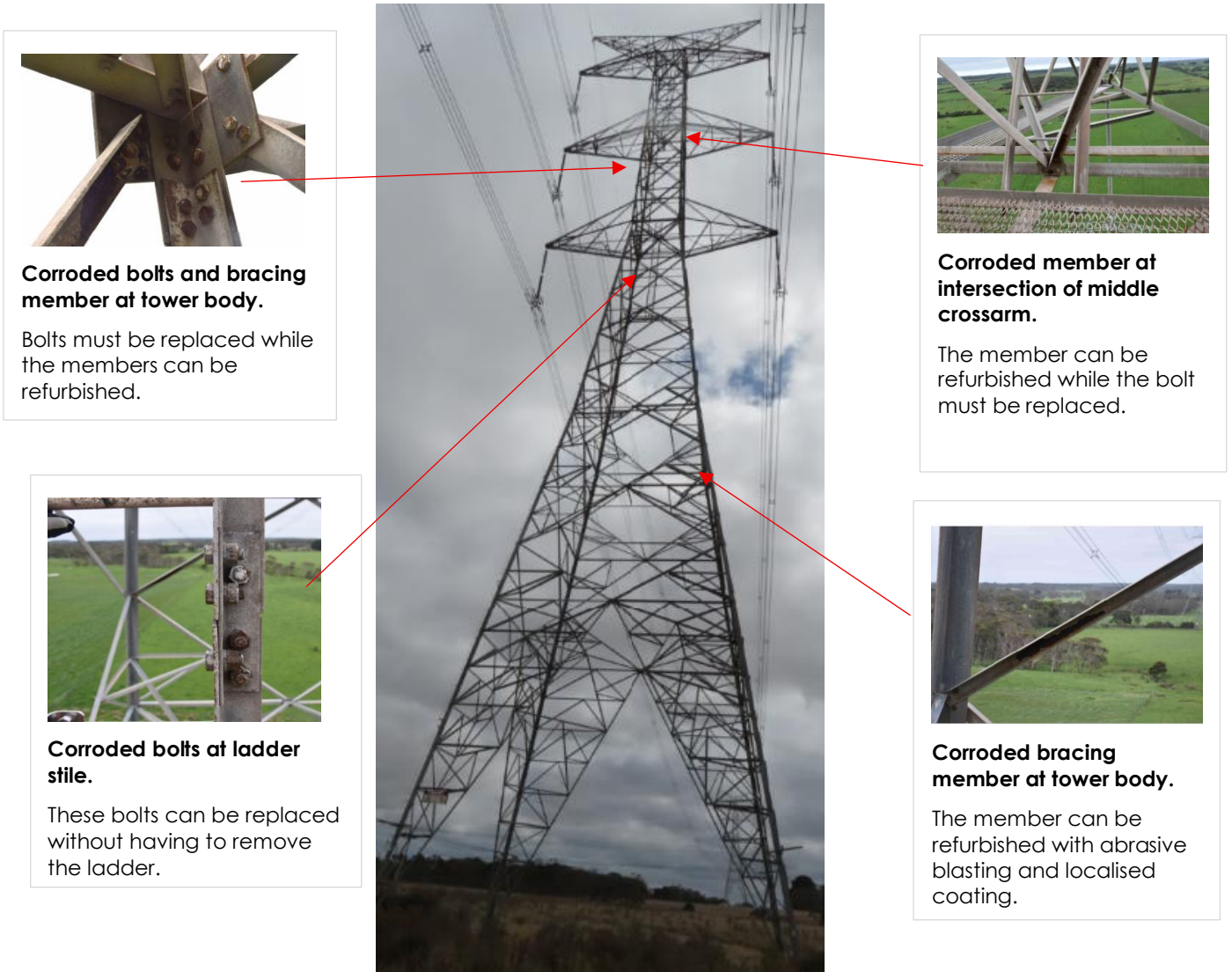
**Figure 29: T603, corrosion of conductor plates & members, bracing members, crossarm bottom chord & bolts**

### 5.3.5. T598: Double Circuit, Reinforced Light Suspension, Type ER (Condition C3)

T598 is a reinforced light suspension tower which is rated as C3 "Average" condition. A few of its members and bolts are in "Very Poor" condition (C5) although not widespread throughout the structure.

This tower is in Corrosivity Zone 2 ("Medium") and has received routine maintenance, without needing bespoke refurbishment works like the towers in Corrosivity Zone 3.

Being an intermediate tower with only a few corroded components needing replacement, and without the need to offload the conductors and ground wire, *tower refurbishment is an economic solution with the following images illustrating tower condition.*



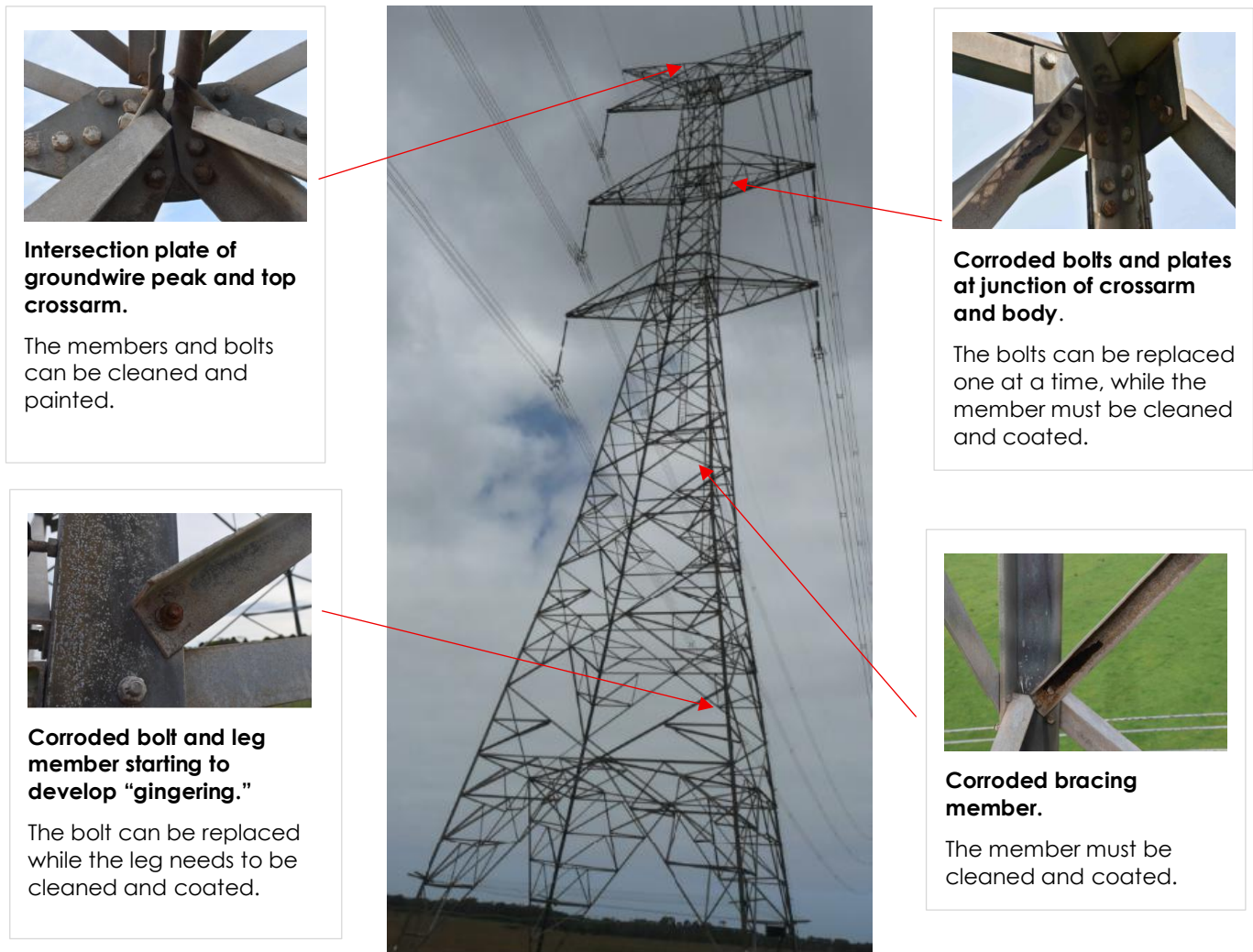
**Figure 30: T598, corrosion of plates and interconnected members**

### 5.3.6. T592: Double Circuit, Light Suspension, Type EA (Condition C3)

T592, a light suspension tower currently rated in C3 (Average) condition and located in Corrosivity Zone 2 (Medium) has a few of its members and bolts in C5 (Very Poor) condition, though these are limited and not widespread throughout the structure.

Being an intermediate tower, the corroded components can be replaced without the need to offload the conductors and ground wire, making tower refurbishment an economic and practical solution.

The following images illustrates the condition of the tower.



**Figure 31: T592, corrosion of plates and interconnected members**

AusNet's program of work for the HYTS- APD towers includes replacement of the 6 towers closest to Portland (and the coast) by 2027. Replacement of an additional 22 towers by 2029, and an individual member and bolt replacement program for an additional 36 towers along the line is proposed to be completed within the 2027-32 regulatory period.

# 6. Related Matters

## 6.1. Tower Resilience

Recent tower collapses across Victoria's transmission network have resulted from extreme, localised wind and convective downdraft events. These severe wind bursts, closely linked to thunderstorms, are highly unpredictable and are not captured by regular weather forecasts due to their localised nature.

Since the 1950s, AusNet has recorded 12 tower collapse incidents, with asset condition never identified as a contributing factor. To strengthen its response capability, AusNet has expanded its stockpile of Emergency Restoration Systems (ERS – [ C.I.C ]) and spare components, enabling rapid restoration in the event of multiple concurrent failures. Additionally, AusNet maintains mutual aid agreements with other Australian Transmission Network Service Providers (TNSPs), ensuring access to extra equipment if required for larger scale incidents.

Since 2011, AusNet has reinforced circuits that have experienced tower collapses and were originally designed to outdated standards. These upgrades, aligned with AS/NZS 7000, have so far prioritised towers at major road crossings to address public safety risks. However, no strengthening has yet been undertaken specifically to mitigate market impacts or enhance overall system security.

AusNet worked with the Australian Energy Market Operator (AEMO) to determine which towers were most critical for reducing market disruption and maintaining system security. Additional towers were identified by AusNet based on historical failures asset knowledge. The lines considered included the KGTS-BETS 220kV Line, BATS-BETS 220kV, MSS-DDTS 1 and 2 330kV, MLTS-HYTS 500kV double circuit corridor, SYTS-MLTS 1 & 2 500kV, SMTS-SYTS 1 & 2 500kV, and LYPS-HWTS 1, 2, & 3 circuits.

In partnership with the Bureau of Meteorology (BOM), AusNet also commissioned an investigation into the risk of severe convective wind gusts to the transmission network in Victoria, using the advanced BARRA-C2 regional reanalysis model. This high-resolution model enabled detailed simulation of thunderstorm-related downdraft winds impacting the transmission network. (For more on this study, refer to next section)

AusNet's resilience study assessed tower wind strength on critical lines using AS/NZS 7000, identifying the reinforcement needed to withstand 1,000-year ARI wind events (46 m/s). A cost-benefit analysis was undertaken to compare strengthening costs with potential market impacts from outages, based on the wind event probability. Tower strengthening was prioritised such that the weakest towers were identified for strengthening first, with upgrades continuing until it was no longer economically justified.

Based on an economic assessment, the tower resilience program has identified 180 structures across the eight priority circuits for upgrade to the current AS/NZS 7000 standard. These upgrades are economically justified and are expected to significantly bolster network reliability during extreme wind events. Notably, these towers will be designed to withstand wind speeds with an Annual Recurrence Interval (ARI) of 1 in 1000 years, substantially exceeding the Australian Standard's 1 in 400 ARI requirement. AusNet has adopted this higher standard in response to recent high intensity wind incidents affecting the network.

Further information on the program and its outcomes can be found in the Tower Resilience Study report<sup>17</sup>.

---

<sup>17</sup> ANT TRR 2027-32 - Tower Resilience Study - Summary Report - Rev 1

## 6.2. Extreme Wind Studies

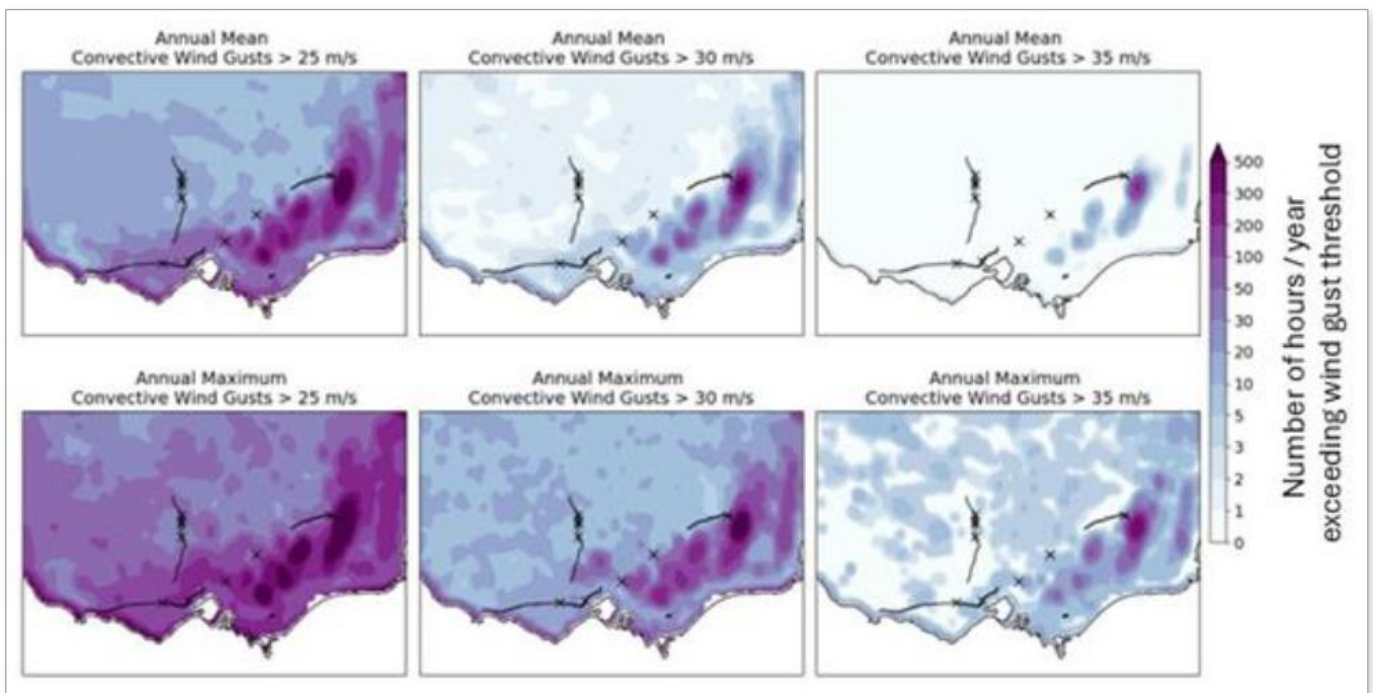
Localised convective downdraft wind events and their potential for extreme wind speeds are not represented in weather forecasts due to limitations in current modelling capabilities and the highly localised nature of these events, which often go unobserved.

To enhance understanding, AusNet commissioned the Bureau of Meteorology to study extreme wind events, focusing on their probability of occurrence and likely locations relative to the transmission network. This study utilised Bureau's BARRA-C2 weather model, featuring high spatial resolution suitable for simulating thunderstorms and the associated severe convective downbursts that can occur during such weather patterns.

The study found that the latest weather models showed a correlation between predictions of very high wind speed convective downbursts and historical tower collapse events, except for those on the BETS-KGTS Line in northern central Victoria. Although this line has experienced four tower collapses, it exhibited the lowest overall hazard exposure compared to other lines.

The modelling indicated that transmission lines along the coast, particularly in Southwest Victoria, where the two most recent events have occurred (between Sydenham and Heywood), have uniform exposure to severe convective wind events (approximately one event per year exceeding 35 m/sec wind speeds within 5 km of certain sections). The northeastern section of MSS-DDTS 330kV circuits recorded the highest exceedance counts for each threshold; however, the steep terrain in the area may result in an overestimation of actual hazard exposure along the line. Figure 32 presents a spatial representation of mean occurrence and maximum gusts modelled from approximately 40 years of weather data.

The weather analysis concluded that there have been notable improvements in modelling over the past five years, yet for localised downburst wind events, further advances in data collection and model development are necessary to reliably assess frequency and magnitude for fully informed design standards and network risk assessments. Ongoing monitoring of advancements in modelling and observational data continues to support future updates to asset management strategies and risk evaluations.



**Figure 32: Modelled number of hours/year that downdraft wind gusts exceed 25,30 & 35m/s – by location.** Darker purple/blue indicates more wind.

## 6.3. Impact of Victorian Transmission Plan

VicGrid recently released the Victorian Transmission Plan which outlines the programs that are necessary for Victoria to transition to 65% renewable energy by 2030 and 95% by 2035. It is a strategic initiative aimed at developing transmission and renewable energy infrastructure in Victoria.

Two Victorian Transmission Planning (VTP) projects interact with the structures' replacement program.

### **Bendigo - Kerang 220 kV line**

A new high-capacity double circuit line from Kerang/New Kerang to Bendigo is planned for completion by 2035. This overlaps with proposed Network resilience tower strengthening on the same route. AusNet has reassessed these works due to the VTP project and, finding them economically unjustified during the 2027-2032 regulatory period, has removed them from the TRR submission.

### **HYTS - APD 550 kV line uprating**

The second project related to upgrading the existing 500 kV double circuit lines from Portland to Heywood, including station plant enhancements to restore original line capacity by 2038. AusNet expects no overlap between the VTP and asset replacement works for HYTS-APD lines. While current conductors support planned offshore wind generation, capacity is limited by secondary station components; the VTP will address this independently of TRR projects.

## 6.4. Fall Arrest Systems/ Safe Method of Climbing

Tower climbing is AusNet's primary approach for inspecting and assessing the condition of its structures. Inspections occur every 3, 6, or 9 years, with over 1,550 towers typically climbed annually. Station racks and ancillary structures, including ground wire masts and termination masts, are also climbed every six years for assessment, with more than 170 racks climbed each year. Climbing frequency increases at sites requiring corrective maintenance or asset replacement projects.

The electricity sector has not recorded any falls from towers among on duty workers, while the general construction industry in Victoria has reported a higher rate of such incidents. Falls from towers can lead to serious injury or fatality.

Occupational Health and Safety Regulations 2007, No. 54 – Part 3.3 and the "as far as practicable" principle in the Electricity Safety Act have led AusNet to implement additional safety controls for climbing. The approved method involves the use of double lanyards. Risk based and economic analyses supported the introduction of permanent Fall Arrest Systems (FAS) on towers and racks. In 2010, after comparing different FAS options and conducting trials, a cable FAS manufactured by [ C.I.C ] was selected.

Following two fall arrest installation programs, permanent FAS has been installed on 82% of the tower fleet. Stage 3 aims to address an additional 5.5% of towers between 2027 and 2032, focusing on those with increased climbing needs due to the Lines insulator replacement program. Towers in the Southwest region already have FAS installed as part of maintenance and asset replacement projects.

AusNet has completed permanent FAS installation on 62% of terminal and power station line rack structures and ground wire masts. Full completion of installations on racks and ground wire masts is planned for 2027 to 2032.

## 6.5. Tower Footings Submerged in Water

Assessments have noted an increase in tower footings being affected by water, especially during wetter periods. Saturated ground can impact the structural stability, as soil strength decreases at saturation and footing steelwork may corrode, potentially reducing overall integrity.

The underlying causes are natural or anthropogenic. Natural factors include seasonal changes in water table levels, shifts in waterways impacting channel banks near towers, or heavy rainfall that fills natural reservoirs. Examples of human influences are urban development leading to runoff in easements, modifications in property land use that redirect rainfall, and installations affecting water protection.

In such cases, AusNet assesses tower security by conducting geotechnical studies to evaluate soil properties and analyse footing performance. If necessary, measures such as strengthening footings or altering the site like restoring channel banks with gabions or retaining walls may be implemented.

This ongoing operational monitoring programme addresses evolving site conditions. When land use changes are identified as a cause, AusNet communicates with the landowner.

## 6.6. Corrosion Mitigation Below Ground, Cathodic Protection

AusNet employs cathodic protection to shield steel legs and piles buried in soil from corrosion due to harsh soils or stray currents from nearby infrastructure, such as trains or pipelines, which cause galvanic deterioration.

There are two types of cathodic protection: passive systems using galvanised anodes (GA); and active systems called impressed current cathodic protection systems (ICCP). AusNet currently has 23 ICCP units and 15 GA units installed in the transmission network, mostly in urban areas close to train/tram stations, and the terminal station boundaries.

These systems undergo regular inspections and condition monitoring, with current levels measured to confirm that the required protection is provided to tower legs and/or piles.

If anode depletion occurs or if there is insufficient current from the ICCP system, components are replaced or repaired as part of corrective maintenance.

## 6.7. Corrosion Mitigation at Ground Level, SOXS

AusNet uses SOXS, which coats tower legs with epoxy barrier paint from 200mm above ground to 300mm below. As detailed in Asset Health and Performance sections, some of the coatings have begun to crack and fail, which reduces the corrosion protection on the critical load bearing steel legs. SOXS restoration is now a routine corrective maintenance activity.

AusNet is reviewing the program to understand the issue better and identify the root cause of the barrier system failures. The scope of the review involves the application methodology (currently uses hand held brush), the dry film thickness of the coating being applied on the leg, and the appropriateness of the coating system for the intended purpose.

## 6.8. Corrosion Mitigation for Low/Medium Corrosivity Zones

Structure corrosion mitigation is primarily conducted within corrective maintenance programmes, with the objective of maintaining asset performance and ensuring structures reach their intended service life. Standard activities include tower leg painting, replacement of corroded bolts, and where necessary touch up painting steelwork above the waist to arrest corrosion. Additionally, specialised tasks involve comprehensive condition assessments and engineering modelling to evaluate extent of corrosion.

Routine condition assessment surveys determine the severity of corrosion on legs, steel members, and bolts; each component is assigned a condition rating as detailed in the Asset Health section.

Tower leg painting serves as a critical corrective maintenance measure to prevent deterioration by applying protective coatings that shield steel from moisture and airborne salts. Timely initial painting, complemented by patch or touch-up painting every 10 to 15 years, assists in maintaining or extending the design life of the legs.

Member painting is selectively applied in low to medium Corrosivity Zones 1 and 2 to control minor corrosion. Full structure painting is performed only when required, taking cost effectiveness and future maintenance into account. Condition assessments are used to determine the need and timing for repainting.

Corrosion in these areas is currently most effectively managed through member replacement and corrective maintenance.

## 6.9. Corrosion Mitigation for High-Corrosivity Zone

AusNet manages corrosion in Corrosivity Zone 3 (High) by replacing corroded bolts and members instead of repainting, based on both experience and recent cost benefit analysis showing this is the most cost-effective method.

In the early 2000s, painting was trialled on HYTS-APD 500kV towers but widespread coating deterioration occurred (on average 50% coating breakdown) within seven years, demonstrating ineffectiveness and high maintenance costs. Consequently, the painting approach was discontinued, in favour of member and bolt replacement as required driven by inspection assessment.

A recent reassessment confirmed this strategy as the most economic and prudent approach. Under AS/NZS 2312, painted towers in Corrosivity Zone 3 (which aligns with AS 4312 Corrosivity Zone C4) require touch-up painting every 2–3 years and topcoat applications every 5–10 years. The ongoing painting requirements for Zone 3 are not economical compared to the current approach, as further supported by the analysis detailed in Appendix G.

## 6.10. Tower Refurbishment vs Tower Replacement

AusNet's primary strategy for corrosion management of structures involves refurbishing by replacing corroded members, plates, and bolts. This method has been effectively applied to the towers along the HYTS-APD 500kV line since 2009.

However, after multiple refurbishments, a point is reached when major components such as bottom and top chords of crossarms or earth peaks, or key multi-connection primary members must be replaced. At this stage, it becomes necessary to adopt a new approach driven by the need to offload the conductors and ground wires from the tower.

If the transmission line can be de-energised without significant customer or market impact, supporting the conductors and ground wires using a crane is a practical solution. Conversely, if the line must remain energised, implementing a temporary bypass is required to facilitate safe work while maintaining supply continuity.

The HYTS-APD 500kV double circuit line with thirty towers in Corrosivity Zone 3 (High) supplies a major smelter that cannot risk power outages. Any single line outage must be available to be recalled within two to three hours as negotiated with the smelter. In this context, tower replacement emerges as the preferred and most cost-effective solution, due to the expense of installing a bypass to offload the conductors. Analysis indicates that for assets needing more than 15 years of reliable service life in this severe corrosive environment, replacement is more economical.

Tower refurbishment often necessitates offloading of conductors through bypasses, multiple outages (or live line methods), to facilitate blasting, painting, and replacement of critical members, and then requires touch up painting every 2-3 year and offloading to fully repaint every 5-10 year, as required by AS/NZS 2312 in high corrosivity zones.

In contrast, new hot-dip galvanised towers offer a 30–45-year service life in such environments, requiring minimal short-term maintenance. The installation of new towers thus results in a lower maintenance and minimum outage impact compared to refurbishment. Additional details and analysis regarding the HYTS-APD 500kV tower replacements is provided in Appendix G.



**Figure 33: A 500kV tower with ERS bypasses on either side of the tower**

# 7. Proposed Program of Work

## 7.1. Approach

### 7.1.1. Risk

AusNet's asset management decisions within the transmission network are guided by a risk based approach, ensuring alignment with our organisational risk appetite. For transmission line structures, risk treatment required to achieve this over time involves replacement & maintenance activities. Justification for these projects are developed based on current risk and extrapolated risk.

The risk of each asset is calculated as the product of Probably of Failure (PoF) of the asset and the Consequence of Failure (CoF). This risk is then extrapolated into the future accounting for forecast changes in PoF and CoF.

AusNet's approach to asset risk management is detailed in REF: AMS 01-09 Asset Risk Assessment Overview.

#### 7.1.1.1. Asset Quantification Methods

##### Probability of Failure

The PoF for transmission line structures is qualitatively determined using health score model calculations, incorporating three key factors:

- Corrosion Zone
- Asset physical condition score.
- Type of tower (lattice, pole etc)

Asset managers use the health score models to calculate the conditional PoF for the next one year. The following years of PoF are calculated using Weibull Distribution model. AMS 01-09 provides details to logic and parameters of the Weibull model.

For complex lattice tower assets where replacement is being considered, a more thorough structural engineering assessment has also to be undertaken, as described in Section 6.3 *Output Validation*.

##### Consequence of Failure

AusNet assigns a monetised value to CoF which provides an economic basis of calculating potential consequence.

The cost of failure is assessed through Four key lenses: Safety, Environment, Financial and Customer/Market Impact. These lenses provide a structured view of the potential impacts resulting insulator failure, resulting in outages and/or line drops. Table 5 summarises the focus of each lens:

CONSEQUENCE LENSES	DESCRIPTION
Safety	Threat to health and safety of the public and employees
Environment	Bushfire damage
Customer / Market	Loss of supply to customers Impact to energy market
Financial	Emergency response and repairs Asset replacement costs Collateral damage

**Table 5: Consequence Lens Description**

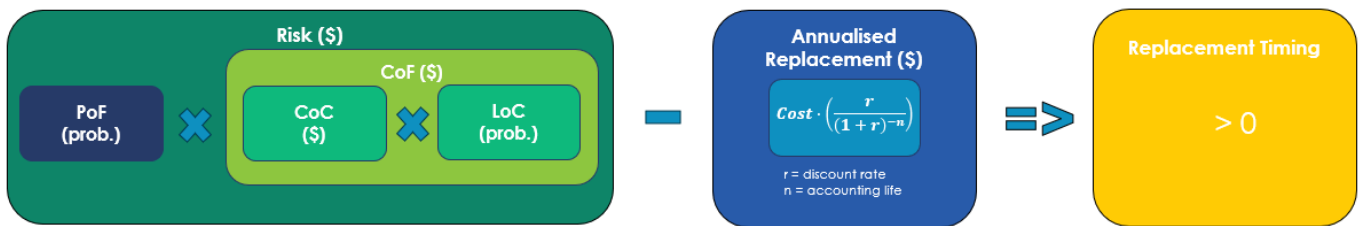
# 7.2. Economic Viability

## 7.2.1. Economic Model

Asset Managers use the calculated risk based on PoF and CoF outputs to identify optimal intervention years, balancing technical feasibility with economic efficiency. These outputs are incorporated into an economic model. The economic model demonstrates the year when the calculated annualised risk is higher than the annualised replacement cost, and as such when the asset becomes economically viable to replace. The concept is illustrated below

The economic model provides a structured approach for each asset in the fleet. The economic model for the justified replacement program is available in the asset class economic model REF:

- ANT TRR 2028-32 Asset Replacement Economic Model – Transmission Line Structures – Tower Replacement -Final
- ANT TRR 2028-32 Asset Replacement Economic Model – Transmission Line Structures – Member Replacement – Final
- ANT TRR 2027-32 - Tower Resilience Study - Summary Report - Rev 1
- ANT TRR 2028-32 Asset Replacement Economic Model – Transmission Line Structures – FAS Station Rack Program – Final
- ANT TRR 2028-32 Asset Replacement Economic Model – Transmission Line Structures – FAS Tower Program – Final



# 7.3. Output Validation

When tower replacement is being considered a structured engineering assessment process must be undertaken to inform the risk assessment. This step confirms that model outputs are interpreted within the broader context of engineering judgement, operational experience, and current asset condition data.

Assessments as to whether the model's recommendations such as, asset replacement, refurbishment or no action are reasonably practicable. This involves verifying condition data, evaluating operational priorities, and considering strategic timing of interventions.

An important step for complex structures such as towers is a detailed engineering assessment.

The first step in evaluating a lattice tower for potential replacement is to assess the structural integrity of its individual members and bolts. Not all members and bolts contribute equally to the tower's stability—some, such as main legs, primary bracing elements, bolted joints, are critical to load bearing and overall structural performance. A detailed structural analysis using PLS Tower, a finite element modelling (FEM) software, helps identify which members are most critical and what the consequences would be if they failed.

A sensitivity analysis is also conducted to understand how the rate of deterioration or failure of one or more members or bolts could affect the structural performance of the tower. An assessment is made of the wind speed at which the tower may fail within the next five to ten years. This involves comparing the original design wind speed (often based on older standards) with updated design codes requirements such as AS/NZS 7000. By modelling the current condition and projecting deterioration, engineers can estimate the reduced wind speed threshold and assess how long the asset remains fit for service.

When a tower is forecast to fall below its regional design wind speed threshold within the next five years, it triggers a critical review of its continued serviceability. This reduction in structural capacity poses a significant risk, particularly in areas exposed to high wind events and likely occurrence of even more extreme winds based on practical experience. In such cases, the asset's role in supporting network resilience must be carefully considered. If the tower is part of a critical corridor in the transmission network, its failure could have cascading impacts.

The final rectification approach and cost will depend on further feasibility of In-situ replacement by refurbishment or via a full replacement, which must assess and include site specific constraints, outage availability, and safety considerations for live line work, and offloading and Temporary Structural Support Requirements.

## 7.4. Proposed Program

### 7.4.1. Tower replacement program

Twenty-eight towers on the Heywood Terminal Station to [C.I.C] Portland 500 kV Nos. 1 and 2 lines (HYTS-APD), located in Victoria's most corrosive transmission environment, are planned and proposed for replacement due to extensive corrosion. Replacement of six towers is in progress in the current period 2022-27, and a further twenty-two are proposed for replacement in this next period 2027-32.

At 45 years old, these towers show deterioration in key structural elements like cross arms and main members. The protective coatings, last applied nearly 25 years ago, have severely degraded, resulting in section loss and increased vulnerability. These towers are essential for maintaining both the operation of the [ C.I.C ] and overall grid stability, given the smelter's size and load balancing impact on the network.

Over the past ten years, several refurbishment programmes involving member and bolt replacement as well as maintenance works have been undertaken. However, further refurbishment is now considered unviable due to the escalating costs and complexity of replacing severely corroded interconnected members.

Refurbishment work on these towers requires complex and costly procedures such as installation of line bypasses and fully offloading the towers (removing conductors) to keep the [ C.I.C ] supplied. The HYTS-APD 500 kV transmission line is vital to Victoria's electricity network, supplying the [ C.I.C ] and helping maintain grid stability. The smelter required high connection reliability, including a recall time of two to three hours for outages.

Economic modelling indicates that the complete replacement of 28 structures with new towers represents the most cost-effective strategy. This solution mitigates the ongoing expenses and operational challenges associated with refurbishment and continual repainting. According to detailed estimates, within the next decade, the cumulative costs of refurbishing, painting, and recoating 19 out of 28 towers will exceed the cost of complete replacement. By 15 years, replacing all towers is projected to be the most economically viable option to maintain the long-term reliability of this transmission corridor.

The tower program for Portland has been divided into three stages to allow for the practical execution of the work.

**Stage 1** will replace 6-consecutive towers starting from the [ C.I.C ] switchyard to T624 which is a strain tower. This program is scheduled from 2025 to 2027.

**Stage 2** will replace 22-towers, comprising of 21-consecutive towers from T623 to T603, with T597 also included in the program. This stage is scheduled for construction from 2027 to 2029.

**Stage 3** will replace the C4 and C5 condition members and bolts on 36 additional towers along the line towards Heywood Terminal Station. This is included and discussed in the next section, Tower member replacement program.

Figure 34 shows the staging of the program.



**Figure 34: HYTS-APD 500kV line Program Stages 1, 2, and 3**

Refer to Appendix H Tower Condition Assessment, HYTS-APD 550kV line

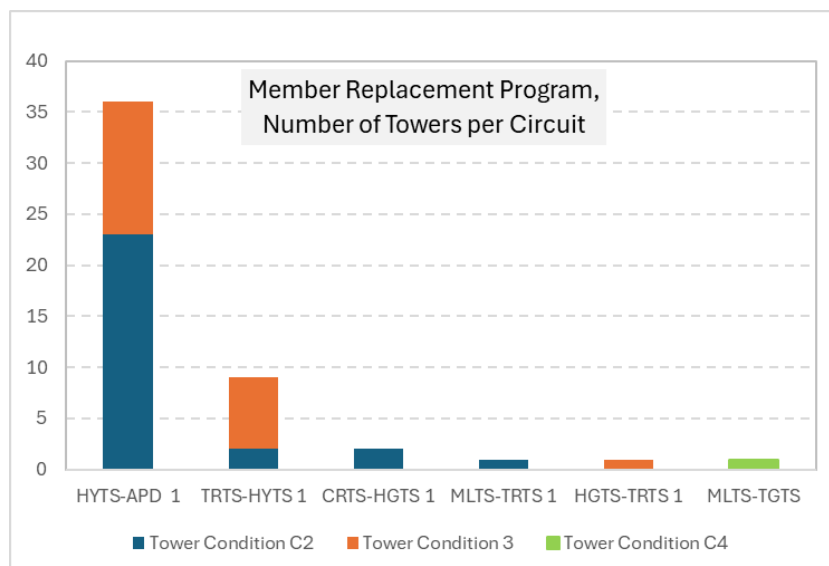
### 7.4.2. Tower Member Replacement (Refurbishment)

The proposed program will include refurbishment activities for fifty 500kV towers located in the southwest of the AusNet's network. The work involves the replacement of C5 corroded members and bolts which do not require offloading of conductors and ground wire from the tower. A more detailed assessment of critical members and bolts will also be undertaken.

The objective of this refurbishment is to maintain the structure to its original design strength and restore the tower's overall condition back to an overall good C1 to C2 condition. By proactively addressing localised corrosion, AusNet will prevent future complications and defer earlier tower replacements on these high market impact lines.

The majority of towers requiring refurbishment works are located on the HYTS-APD 500kV line (36 tower), with 9 towers on the high market impact TRTS-HYTS 500kV line. The remaining 5 towers are more isolated cases but still located in the Southwest of Victoria. Figure 35 below shows the tower count with proposed member replacement by Line name and showing their current overall tower condition score.

Refer to Appendix E for the spatial location of these towers.



**Figure 35: Member Replacement Program**

### 7.4.3. Tower Resilience Program

For the upcoming TRR Period, AusNet is proposing an economic based initiative to commence mitigating climate related risks and improving the reliability of critical infrastructure. This initiative is driven by the occurrence of twelve tower collapses on AusNet's 500 kV network over the past five years, all linked to extreme wind events.

AusNet is proposing to enhance the resilience of eight market critical transmission lines against extreme weather events. This includes seven lines forming part of the 500 kV backbone network and one strategically important 220 kV line. These lines play a critical role in supporting the secure and reliable operation of the National Electricity Market (NEM). Unplanned outages or structural failures on these high-capacity corridors can lead to significant constraints, increased market volatility, and elevated wholesale electricity prices.

The Resilience Program focuses on proactively reinforcing suspension towers which are the most vulnerable towers on these lines, by increasing their minimum windspeed withstand capacity. Specifically, the program proposes structural strengthening of 180 towers (out of 970 assessed) that will exceed wind speed requirements of AS/NZS 7000<sup>18</sup> - the Australian and New Zealand standard for overhead lines.

As tower footings and foundations have shown no signs of damage or structural weakness during these events and in the interest of cost effective and prudent resilience investment, no scope has been included for foundation augmentation or modification, as they are considered sufficiently robust.

For details of the program, please refer to Section 6.1 Tower Resilience.

### 7.4.4. Fall Arrest Systems

A stage 3 tower fall arrest system (FAS) installation program is proposed for the 2027-32 period. So far 82% of the towers on the network have a FAS fitted. AusNet's prudent approach prioritises the next stage of works on towers expected to experience increased climbing activity during the 2027-32 period. A such the FAS program is proposed for installation on 703 towers along the HWTS-SMTS No. 1 and No.2 500kV lines to align with multiple climbing required as part of the insulator replacement program, and for efficiency completing works in one geographical region. The location of structures included in the Tower FAS is attached in Appendix C: Tower Fall Arrest Program.

AusNet has completed the installation of a permanent FAS in 62% of the terminal and power stations line rack structures and ground wire masts population. The completion of the installation on the rack and ground wire mast fleet is proposed to be completed during 2027 to 2032.

<sup>18</sup> Tower resilience will design towers to withstand wind speeds to an ARI of 1 in 1000 years, higher than the required 1 in 400 years for Victoria.

# 7.5. On-going Programs

The proposal for continued work is as follows:

## 7.5.1. Corrosion Mitigation Program

The Structure Corrosion Mitigation Program is an ongoing, OPEX funded activity that includes recurring corrective maintenance and non-recurrent studies and mitigation interventions designed to achieve the service life of targeted structures.

The typical recurring routine activities include tower leg painting and replacement of corroded bolts. The non recurrent program includes more through condition assessment analysis, engineering modelling and a management plan created where structures have members or legs rated C4 or C5 steelwork.

The current program is addressing 17 towers along the Rowville-Springvale 220 kV and Springvale-Heatherton 220 kV lines, a customer critical radial line. A detailed assessment and management plan has also been completed for 66 kV steel poles on the Morwell-Loy Yang Power Station line, which are showing signs of corrosion. A touch up painting program will be implemented to extend their asset life to at least match the power station's remaining life.

Details of the ROTS-SVTS-HTS 220 kV line and MWTS-LY 66 kV poles are provided in Appendix D: Refurbishment and Corrosion Mitigation Works.

# 8. Asset Strategies

High level strategies to be adopted for prudent and efficient management of the transmission structure fleet are:

## 8.1. New Assets

- New structures are designed and constructed in accordance with current industry guidelines and standards.
- For high-risk areas based on the Tower Resilience Study, the design wind speed for new structures will be reviewed and consideration given to use of a higher value than what is normally required by AS/NZS 7000.
- New structures will be constructed with a permanent fall arrest system which is the [ C.I.C ]. This system will be installed for both towers and poles in the transmission network that will require climbing during regular inspections and/or maintenance works.

## 8.2. Inspection

- Continue to assess the condition of transmission line structures during structure detail inspections which are conducted at 3, 6 or 9 yearly intervals.
- Continue to use of Field Mobile Inspection (FMI) technologies for the collation of condition assessment data which facilitate automatic updates of Asset Management databases.
- Explore and introduce new technologies such as Unmanned Aerial Vehicles (UAV or drones) in performing structure inspections to improve the effectiveness, productivity, and safety of workers.
- Explore and introduce the use of LiDAR (Light Detection and Ranging) to create structural models of towers in their in-situ condition, allowing structural analysis to be done on the towers.

## 8.3. Maintenance

- Continue to maintain SOX treatment of legs, replace corroded bolts, and damaged steel members as part of corrective maintenance programs.
- Continue to perform corrosion mitigation works, such as touch up painting on corroded structures.
- Continue to perform fleet wide risk assessment to identify corrosion mitigation works based on the structural strength, corrosivity zone and failure effects.
- Use the emergency restoration system (ERS) structures to temporarily reinstate a line impacted by high intensity winds such as synoptic downdraft winds.
- Use splints on degraded members which will require complex and high-risk rigging methods to unload the conductors and ground wires from the structure. This method can also be used on members that have multiple members connected to it making replacement difficult and complex.

## 8.4. Tower resilience

- Strengthen up to 180 structures along high market impact circuits to increase withstand against extreme wind events such as synoptic downdraft winds. The towers will be upgraded to a higher wind speed relative to the requirement of the current overhead line design code, AS/NZS 7000.

## 8.5. Spares

- Continue to maintain sufficient strategic spares for the Emergency Restoration System (ERS) masts and associated hardware.

## 8.6. FAS Installation

- Install FAS on transmission line structures via a dedicated installation program.
- Install FAS on all rack structures and ground wire masts in Terminal stations.

## 8.7. Replacement and Refurbishment

- For towers in Corrosivity Zone 1 (Low) and Corrosivity Zone 2 (Medium), refurbish towers with corrosion by replacing members and bolts.
- For towers in Corrosivity Zone 3 (High) and along circuits with high reliability requirements, undertake detailed scoping and cost estimate to identify the optimal solution – replace vs refurbish.
- Perform structural modelling of existing structures as part of tower upgrades and other lines projects, e.g. conductor and ground wire replacement projects.
- For new towers in Corrosivity Zone 3 (High) use the highest grade of galvanising available – currently heavy hot dipped galvanising (HDG900)

# 9. Resource Reference

NO.	TITLE
1	AS 4312 Atmospheric Corrosivity Zones in Australia
2	LPP 09-06: Condition Assessment of Overhead Lines
3	AS/NZS 7000 Design Structures
4	Occupational Health and Safety Regulations 2007
5	AS ISO 31000 Risk Management Guidelines
6	AS/NZS 1170.2: Structural Design Actions
7	VicGrid Transmission Plan
8	AMS 01-09 Asset Risk Asset Overview
9	AMS 01-05 Strategic Asset Management Plan
10	AMS 10-79 Transmission Line Conductors.
11	AMS10-75 Transmission Line Insulators.
12	ANT TRR 2028-32 Asset Replacement Economic Model – Transmission Line Structures – Final
13	ANT TRR 2028-32 Asset Replacement Economic Model – Transmission Line Structures – Member Replacement Refurbishment – Final
14	ANT TRR 2027-32 - Tower Resilience Study - Summary Report - Rev 1
15	ANT TRR 2028-32 Asset Replacement Economic Model – Transmission Line Structures – FAS Station Rack Program – Final
16	ANT TRR 2028-32 Asset Replacement Economic Model – Transmission Line Structures – FAS Tower Program – Final

# 10. Schedule of Revisions

ISSUE NUMBER	DATE	DESCRIPTION	AUTHOR	APPROVED BY
0	11/11/2011	First publication	[ C.I.C ]	[ C.I.C ]
0.1	18/06/2012	Review and update	[ C.I.C ] [ C.I.C ]	
1	18/01/2013	Review and update	[ C.I.C ] [ C.I.C ]	[ C.I.C ]
2	28/08/2015	Review and update	[ C.I.C ]	[ C.I.C ]
3	16/07/2020	Review and update	[ C.I.C ]	[ C.I.C ]
4	30/09/2025	Review and update	[ C.I.C ] [ C.I.C ]	[ C.I.C ]

## Disclaimer

This template is for generating internal and external document belonging to AusNet and may or may not contain all available information on the subject matter this document purports to address.

The information contained in this document is subject to review and AusNet may amend this document at any time. Amendments will be indicated in the Amendment Table, but AusNet does not undertake to keep this document up to date.

To the maximum extent permitted by law, AusNet makes no representation or warranty (express or implied) as to the accuracy, reliability, or completeness of the information contained in this document, or its suitability for any intended purpose. AusNet (which, for the purposes of this disclaimer, includes all of its related bodies corporate, its officers, employees, contractors, agents and consultants, and those of its related bodies corporate) shall have no liability for any loss or damage (be it direct or indirect, including liability by reason of negligence or negligent misstatement) for any statements, opinions, information or matter (expressed or implied) arising out of, contained in, or derived from, or for any omissions from, the information in this document.

## Contact

This document is the responsibility of Transmission - Network Management Division of AusNet. Please contact the indicated owner of the document with any inquiries.

AusNet

Level 31, 2 Southbank Boulevard

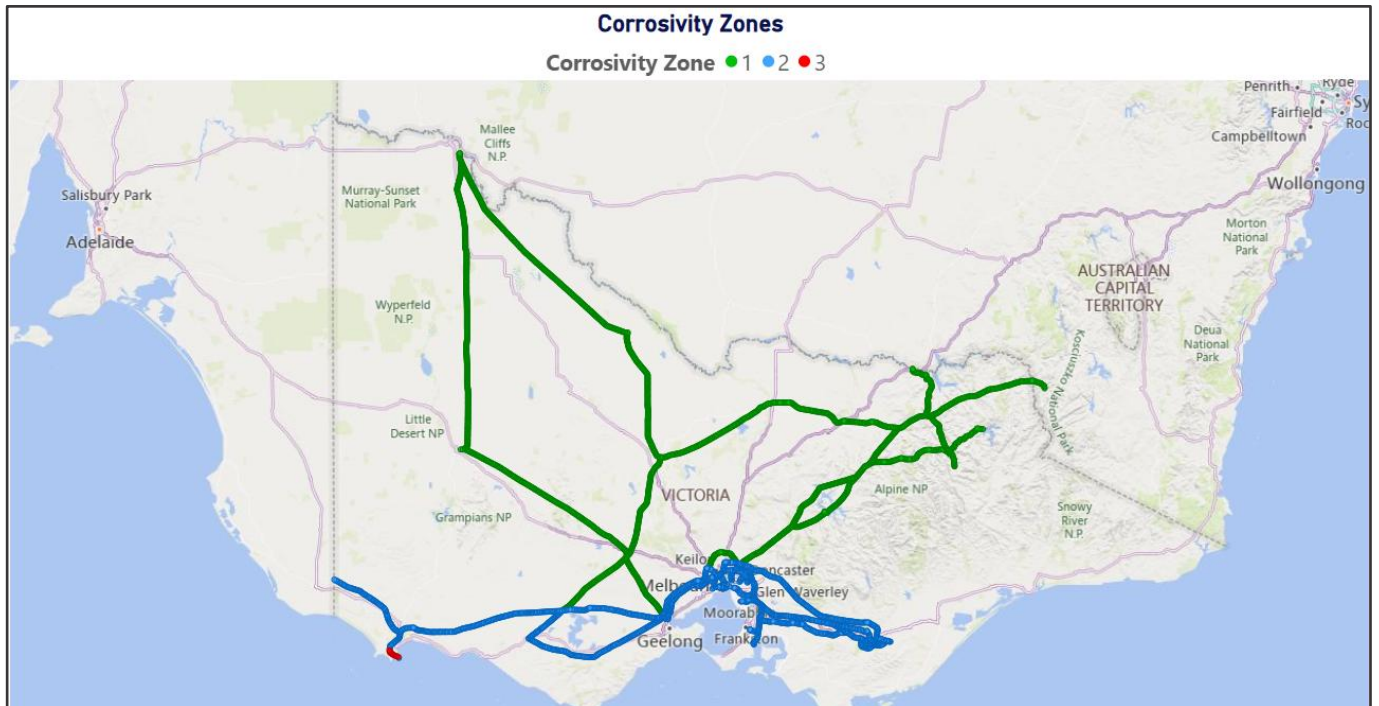
Melbourne Victoria 3006

Ph: (03) 9695 6000

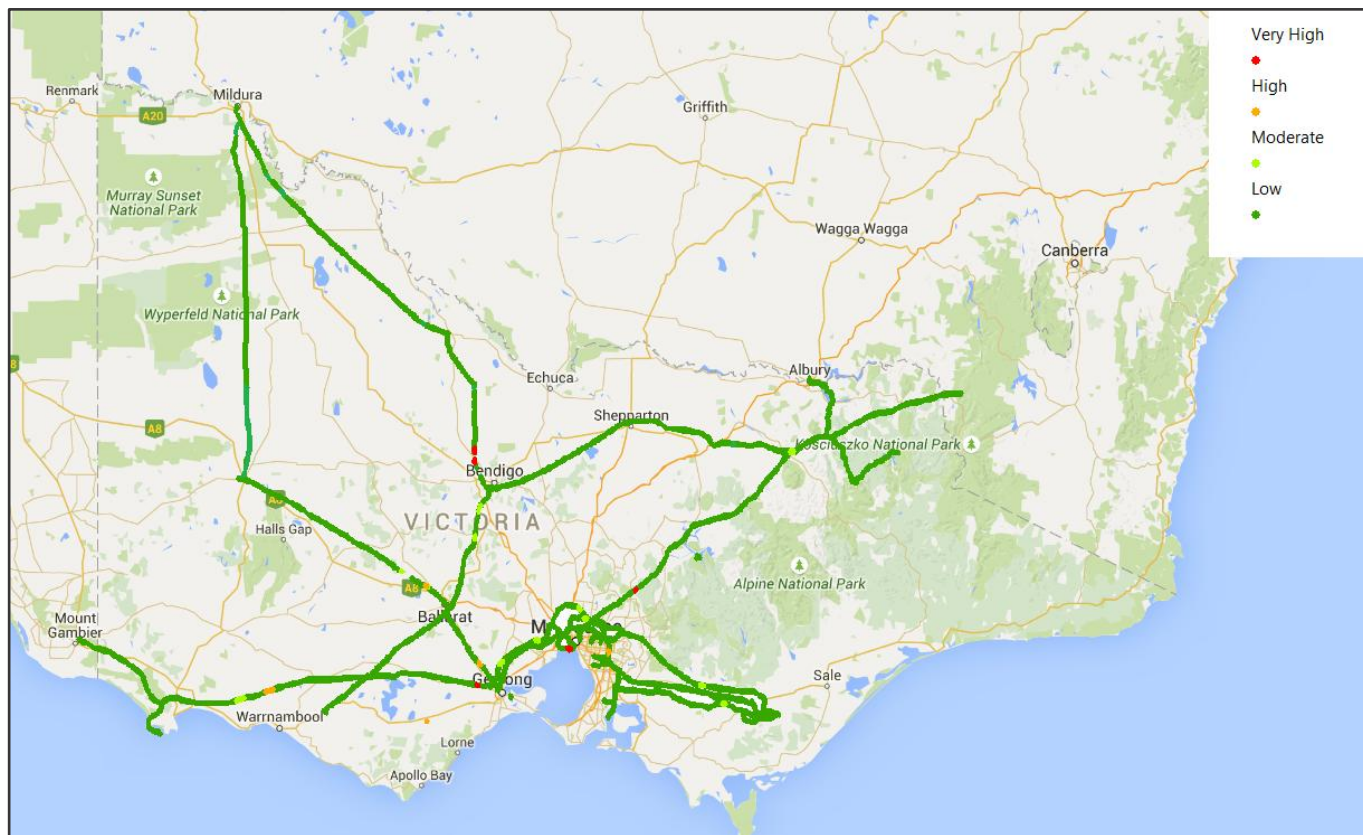


# Appendices

# Appendix A – Corrosivity Zones



# Appendix B – Bushfire Consequences



# Appendix C – Fall Arrest Installation Program

## Tower FAS

Line Name	Insulator Replacement POW	GW Replacement POW	GW Replacement & Ins Replacement POW	Conductor Replacement POW	Cond Replacement & Ins Replacement POW	Grand Total
HWTS-SMTS 1	352					352
HWTS-SMTS 2	351					351
<b>Grand Total</b>	<b>703</b>					<b>703</b>

## Terminal Station Racks, FAS

Terminal Station	66kV	220kV	275kV	330kV	500kV	Total
Ballarat		5				5
Bendigo		4				4
Dederang TS				1		1
East Rowville TS	13	9				22
Eildon Power Station		4				4
Frankston TS	4					4
Glenrowan TS	4	7				11
Heywood TS			4		15	19
Horsham TS	5	3				8
Kerang TS	11	3				14
Mortlake PS					2	2
Mount Beauty TS		9				9
Redcliffs TS	12	3				15
Richmond TS		7				7
Rowville TS		46			12	58
Shepparton TS	8					8
Templestowe TS	11	4				15
Terang TS		1				1
Tyabb TS	6	15				21
Wodonga TS	5			10		15
<b>Grand Total</b>	<b>79</b>	<b>120</b>	<b>4</b>	<b>11</b>	<b>29</b>	<b>243</b>

# Appendix D – Refurbishment and Corrosion Mitigation Works

## Proposed Refurbishment program, 2027-2032

Circuit Names	Voltage	C2	C3	C4	Total, per line
MLTS-TGTS	220kV	-	-	1	1
MLTS-CRTS	500kV	1	-	-	1
CRTS-HGTS	500kV	2	-	-	2
HGTS-TRTS	500kV	-	1	-	1
TRTS-HYTS	500kV	2	7	-	9
HYTS-APD 1	500 kV	23	13	-	36
<b>Grand Total</b>		<b>28</b>	<b>21</b>	<b>1</b>	<b>50</b>

## On-going Corrosion Mitigation Works

Circuit Names	Voltage	C2	C3	C4	Total, per line
MWTS-LY 1	66 kV	-	-	13	13
MWTS-LY 2	66 kV	-	-	4	4
ROTS-SVTS 1	220 kV	-	6	-	6
SVTS-HTS 1	220 kV	-	11	-	11
<b>Grand Total</b>			<b>17</b>	<b>17</b>	<b>34</b>

# Appendix E – Tower Member Replacement Program



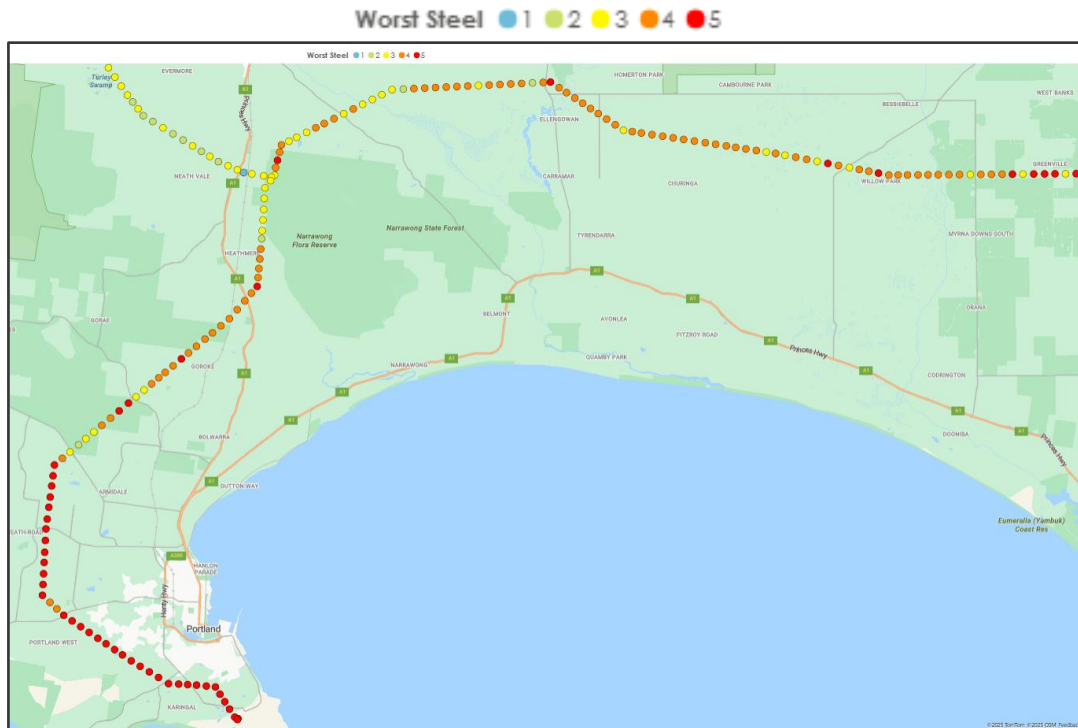
Spatial Map, Towers included in the Member Replacement Program

CIRCUIT NAME	C2 TOWERS	C3 TOWERS	C4 TOWERS	GRAND TOTAL
HYTS-APD 1	23	13		36
TRTS-HYTS 1	2	7		9
CRTS-HGTS 1	2			2
MLTS-TRTS 1	1			1
HGTS-TRTS 1		1		1
MLTS-TGTS			1	1
<b>Grand Total</b>	<b>28</b>	<b>21</b>	<b>1</b>	<b>50</b>

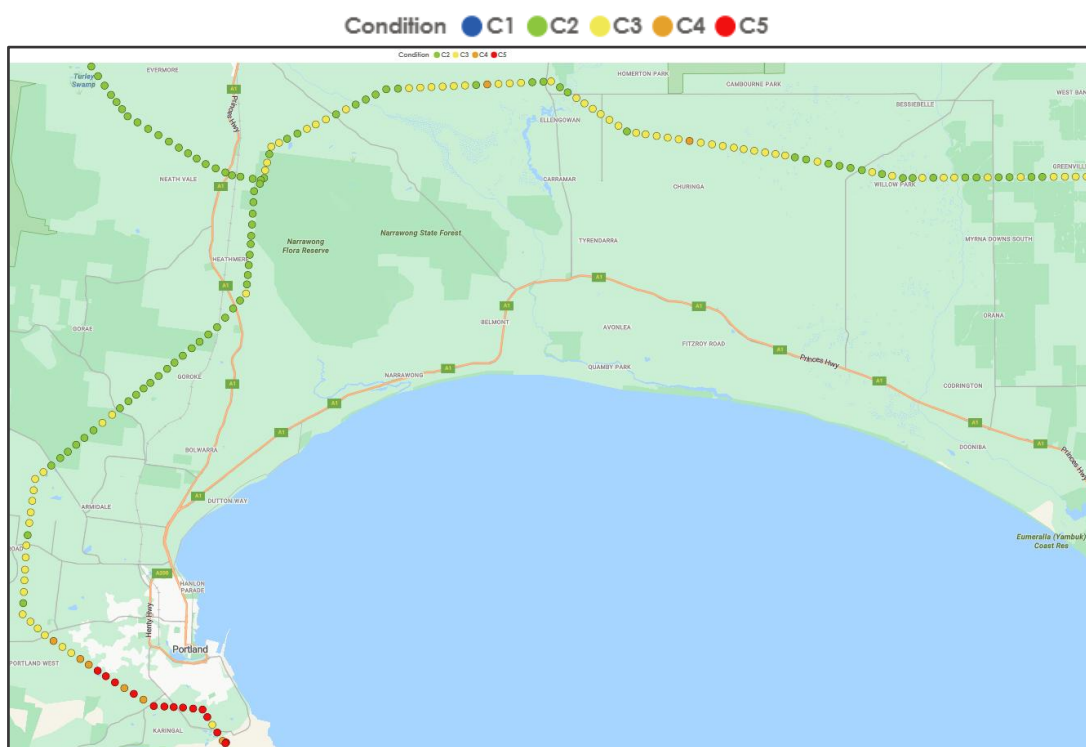
Member Replacement Program – Quantity of towers per circuit & Over-all Condition Score

# Appendix F - C5 Steelwork Condition Score,

Tower Worst Steel Condition, "Above Waist"



Tower Condition, Over-all



# Appendix G – Replace vs Refurbish Strategy (HYTS-APD stage 1 and 2)

## 1 Summary

A lifecycle cost analysis has been conducted for 28 towers in very poor condition on the HYTS-APD 500kV transmission line. The analysis concludes that replacement is the most cost-effective option, assuming a required remaining asset life of at least 15 years.

The ongoing need for this line is demonstrated through VicGrid's long term strategic plan, as outlined in the Victorian Transmission Plan (VTP), which confirms a continued need for this transmission corridor well beyond the plan's 15 year.

Replacing these towers not only addresses immediate asset condition risks but also aligns with future network requirements, supporting system reliability, resilience, and capacity.

## 2 Introduction

The Heywood to Portland 500kV (HYTS-APD) transmission line consists of seventy-seven (77) steel lattice towers installed in the early 1980s to serve the [ C.I.C ] (APD). The towers are numbered consecutively starting from the Heywood end, T553 until T627, where the line splits just outside the smelter switch yard. Here there are two towers side by side, T628A and T628B.

Visual inspection of the structural condition of the towers is currently performed triennially by maintenance service provider and reported as a condition from C1-C5, where C5 is the worst condition. The condition of the tower is defined by its worst member and the percentage of the tower in this condition. Individual members and bolts that need to be addressed are listed in a report separately and actioned through the maintenance system. The details of the inspections are described in documents LPP 09-01 and LPP 09-06.

Since 2021, in addition to the triennial inspections, (and more regular defect inspections) various reports have been prepared on the structural condition of the twenty-eight (28) towers between T597 and T628A/B (at APD). These towers are at the smelter end of the line, with the furthest from the smelter being 12.75 km away (T597). These additional inspection reports were prepared by a variety of contractors and delivery partners, vary in content and the level of detail provided.

The purpose of this review is to evaluate the replace proposal from the Construction Delivery Partner versus to refurbish proposal from the Maintenance Contractor and develop the most cost-effective outcome, while providing the lowest practicable risk for operating this transmission line into the future.

After considering the findings, particular attention has been paid to the balance between refurbishment feasibility and replacement practicality, given the unique challenges and costs associated with each approach. This informed assessment means the proposed strategy both supports asset longevity and aligns with operational safety and reliability objectives, thereby facilitating ongoing compliance with industry standards and network requirements.

## 3. Life Extension Cost Considerations

Based on the inspection reports presented to date, from a corrosion perspective, all the towers could be refurbished to a state where they could continue to provide service for the time frame under consideration. However, cost, time and constructability are significant limiting factors to implementing this strategy. To the point where for most towers, if

not all, the refurbishment option is less than optimal and tower replacement is the most viable, or only option available.

There are many components to build the costs associated with developing the maintenance strategy. While some of these are common between the refurbishment and replacement options, some are unique.

## 3.1 The Cost Model

### 3.1.1 Common Cost Builders

#### 3.1.1.1 Hardstands and Access Tracks

Hardstand areas and access tracks are required regardless of the maintenance strategy selected. These are used for staging materials and equipment during construction as well as getting the items on site. Although each site will pose different requirements and challenges for hardstands and access, the same cost was assumed for both refurbishment and replacement and across all sites. This is possible as the sample size is of sufficient magnitude that any outliers will be accounted for by the average. The source of this cost was the AusNet estimators who in turn derived their costs from a submission from the Construction Delivery Partner.

#### 3.1.1.2 Bypass Construction

Bypasses are by far the biggest variable and largest contributor to the overall costs and therefore add considerably to the sensitivity in determining the maintenance strategy. Not only the construction method of the bypass but also how the cut over between the bypass is achieved need to be considered.

**Construction methods considered as part of this review include:**

##### 3.1.1.2.1 Monopoles and Emergency Restoration System (ERS) Poles

Both monopoles and ERS poles have the benefit of, with some additional consumables, being able to re-use their main componentry. Where they differ however, is that the monopoles do not require guy wires and their footprint is much smaller than those of an ERS. This smaller footprint changes both the area required under the cultural heritage approvals and the landowner compensation requirements. Alternatively, the ERS pole offers more flexibility when it comes to locations it can be used and reused.

The other major difference between the two system is the cut over process, an ERS can only be transferred to or from using traditional cut over techniques however the monopole offers the additional option of live transfer.

This review looked at the costs of three different approaches:

1. Use monopoles for the first six towers and re-using as many of the monopoles as possible and ordering new ones for cases where the previous purchased monopoles were not suitable. The monopoles for the first nine towers have already been ordered as part of the long lead time provisioning and would be placed into spares once the project was complete.
2. Use monopoles for the stage and use re-usable ERS poles for the remaining bypasses. As noted above monopoles are already on order for the first nine tower and any spares (monopoles or ERS) will be stockpiled once the project is completed.
3. Use ERS for all the bypasses and stockpile the monopoles currently on order as emergency spares or reserve them for future projects. Once this project is complete the ERS can be stored and re-used later. This option has the longest lead time before construction can commence as the ERS towers have not been ordered.

With an estimated \$1.2M cost differential per tower between the most expensive and the cheapest options, this adds significantly to the sensitivity in the costing model.

##### 3.1.1.2.2 Live Transfer and Traditional Cut-over to the Bypass

Live transfer and traditional cut over were investigated for commissioning and decommissioning the bypasses. The traditional cut over method involves outages as the circuit is de-energised when the cut over is made to and from the bypass, it therefore has exposure to the recall window requirements. The live transfer involves moving a live

conductor to the bypass one at a time and therefore there is no or much lower exposure to the recall window. However, live transfer is not without its challenges. The live transfer is

- Estimated to be approximately 10% more expensive than the equivalent traditional cut over method.
- Requires specialist equipment and personnel to perform live transfers safely. These specialist requirements cannot currently be met in Australia and requires support from overseas. To make the process viable for the Delivery Partner, they require a commitment to a minimum volume of work. Small or ad hoc requests are not currently supported as they are cost prohibitive. Therefore, processes that require multiple mobilisations, such as bypassing single towers, are unlikely to be supported using live line transfer at this time.
  - The replacement of the six towers at the APD end of the line will require Alcoa to approve a live line transfer as the termination occurs within their switch yard.
  - ERS is not compatible for a live transfer and therefore the scenario of ERS and live transfer is excluded from further consideration and modelling.

As of Sept 2025, the customer agreed to extend the recall window to 3 hours, making the traditional cut over the most cost-effective approach to transferring to the bypass however, the costs of a live transfer are included in this review for completeness.

### **3.1.1.3 Unique Refurbishment Cost Builders**

#### **3.1.1.3.1 Simultaneous Operations (SIMOPS)**

Simultaneous operations (SIMOPS) is an assumption used to reduce the number of days that are estimated for the project due to the ability to perform multiple tasks on the same tower at the same time. For example, replacing more than one member at a time or painting the upper half of the tower while members in the lower sections are being replaced. However, SIMOPS can only be performed when the tasks do not conflict, an example of conflicting tasks would be painting under a load that is being lifted by a crane. Given the limited size of the work crew (4 climbers) proposed by the Maintenance Contractor per tower there will be limited opportunity for SIMOPS on this project so the model sets this at a modest 20%. Should this be able to be increased it will lead to a reduction in both time and cost of the project and will have a knock-on effect with the other time-based assumptions.

#### **3.1.1.3.2 Craneage**

A crane is required to remove and replace members as well as unloading the tower to accommodate the refurbishment process. Craneage costs are a combination of the crane days estimated by the Maintenance Contractor and the hourly rate for the wet hire of a 250T crane and operator this is then reduced by the SIMOPS factor. The hourly rate for the crane was provided by the AusNet estimators. For the purpose of this model, a 10 hour day is assumed as there will be set-up and travel time for the crane outside the time it is used on the towers.

#### **3.1.1.3.3 Water and Water Cartage**

Water is used in the blast cleaning process for preparing the steel surface for coating. The water supply for Portland and Heywood is drawn from the Daliwyn aquifer and when tested by the Maintenance Contractor, it was found to be too high in soluble salts for the purpose of surface preparation. Therefore, an alternate source of water would be required to be provided to site. It has been assumed for the model that a location such as Warrnambool may be able to meet these requirements. The cost per tower is calculated by the number of blasting days provided by the Maintenance Contractor reduced by the SIMOPS factor and multiplied by the cost per kilolitre of water plus a haulage fee. The cost per kilolitre of water and the haulage was determined from a search on the internet for local providers. However, even though the Maintenance Contractor will require up to 5000 litres per day this is considered only a small addition to the overall cost and therefore doesn't add significantly to the sensitivity compared with some of the other cost builders.

#### **3.1.1.3.4 AusNet Supervision**

AusNet supervision is required by the contractor performing the refurbishment work for task such as issuing permits, safety officers, switching and isolations. The required number of days is derived from the Maintenance Contractor's estimate reduced by the SIMOPS factor. It has been assumed for the purpose of the model that the AusNet supervision will be required to be paid LAFHA for each night of the project, and they will be required to work 10 hour days to facilitate continuous operations.

### **3.1.1.3.5 Downtime**

Weather downtime is the result of weather that is not conducive for working on the towers, too cold or wet for painting, too windy or wet for climbing, etc. The Maintenance Contractor estimated 8% of the total time would be lost due to weather based on the information from [ C.I.C ] for the Portland area.

The Maintenance Contractor proposal only accounts for weather as a downtime event, this is usually not the case, equipment failures and availability and availability of personnel often play a bigger role when determining downtime than the weather and it is far less predictable.

The 8% proposed by the Maintenance Contractor was used in the model, however previous experience in the field would suggest that this number is somewhat low and could be 30% or more depending on the season and reliability of the equipment and personnel. As downtime has a direct impact on any of the time based assumptions AusNet will need to closely monitor this so that factors within the Maintenance Contractor's control do not lead to excessive downtime and extend the project.

Other downtime costs that have not been accounted for is inability to get a permit to perform the required outages. This cannot be known ahead of time.

### **3.1.1.3.6 Procedures**

The Maintenance Contractor will need to develop procedures and safety instruction unique to AusNet and this project. A lump sum for this work was included in the Maintenance Contractor proposal. For the purpose of the model, the cost for developing these procedures and instructions has been equally allocated to each tower. If the scope of the project changes, then the costs for the procedures will need to be redistributed as the development costs do not change.

### **3.1.1.3.7 Engineering**

Engineering input will be required at various stages of a tower's refurbishment. Initially the members will need to be assessed to determine the ability and the procedure to remove them as the current assessment by the Maintenance Contractor is based on a visual inspection and is somewhat subjective.

Further engineering will be needed to determine how many and where the members can be removed under SIMOPS and finally, engineering input will be required to build the "as left" models to be delivered to AusNet at the end of the project.

The Maintenance Contractor provided indicative engineering costs for each of the towers however it can be expected that this will increase if the tower is in poorer condition than first thought and the amount or complexity of the engineering required increases.

### **3.1.1.3.8 Splinting**

The Maintenance Contractor has identified savings by using the splinting process over steel replacement for some of the corroded members. The splinting process involves leaving the corroded member in place and adding additional steel members to take the load in place of the corroded member. There is evidence of this process having been used in the past on these towers in the inspection reports provided by the Maintenance Contractor. The use of splinting requires an engineering report for each member replaced as it needs to be able demonstrate that the load is adequately being transferred to the replacement members. The Maintenance Contractor is proposing to perform this analysis at the time of execution. As the practicality of splinting will not be known until execution the worst-case scenario of replacing all members has been assumed for the model.

### **3.1.1.3.9 Outages**

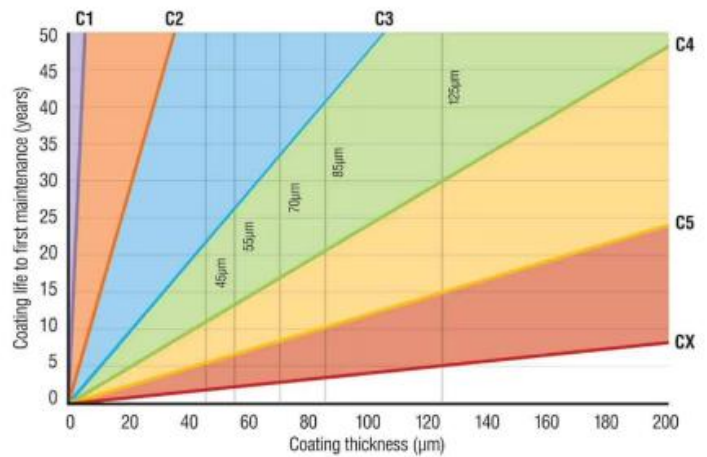
The Maintenance Contractor has highlighted that they require outages to complete the refurbishment work on the towers. It is assumed in the model that if the tower has been identified by the Maintenance Contractor or AusNet as requiring a bypass then no additional outages will be required outside the construction of, and cut over to, the bypass and these have been accounted for in the cost of the bypass. For the towers not being bypassed, the outage costs (switching, permits, etc) have been accounted for by taking the number of outages estimated by the Maintenance Contractor reduced by the SIMOP factor and using the cost provided by the AusNet estimator.

## 3.2 Coating

Other considerations in the analysis are the standards applied for coatings.

### 3.2.1 New Towers

It is recommended that the use of heavy hot dipped galvanising (HDG900) be used for the new towers as the zinc layer is around 50% thicker than the one applied to the original towers (HDG600) and will provide a corresponding increase in service life over the previous HDG600. The graphic illustrates the benefit that the galvanising industry (i.e., AS/NZS 4680) believes are the advantages of using the heavier galvanising, HDG900 (125mm) over HDG600 (85mm).



### 3.2.2 Replacement/New Members and Towers

For galvanising to work as a protective coating, the zinc is consumed as the anode to protect the bare steel, the cathode. The larger the cathode the quicker the anode is consumed, which may seem obvious but is often ignored when it comes to on-site modifications and mechanical damage<sup>19</sup>.

Ideally replacement members will be supplied to site in HDG however to achieve the extended life that the new coating offers it will be important that any site implemented modifications, such as cut ends and bolt holes, are correctly treated with a product containing a high level of zinc or micaceous iron oxide (MIO) in the dry film.

The use of these products will reduce the size of the cathode and result in increased longevity of the galvanising.

Ideally this coating should be applied by airless or conventional spray and/or brush, in accordance with the manufacturer's recommendations. Particular attention should be paid to radiusing all the cut edges to reduce the number of sharp edges, as this will aid in preventing early coating failure.

While aerosol packs offer a level of convenience, they are not recommended for the purpose of galvanising repairs as they are difficult to control the dry film thickness due to their low volume solids (high solvent content) and rapid cure which prevents the surface from being wetted out, especially in holes and crevices.

While there is a plethora of coating products that meet the requirements above, the final selection should be a coating that exhibits excellent tolerance to surface imperfections, impact resistance and a demonstratable track record in similar service. It is further recommended that one of the larger suppliers of industrial coatings is chosen, e.g. Dulux, Hempel, Jotun or Akzo Nobel rather than specialist or niche companies as they will not be able to provide the ongoing technical support to the project when required.

The new members should not be replaced as a direct like for like swap as consideration should be given to making them free draining and while mechanically advantageous in some situations, back-to-back members should be avoided as they trap moisture and dirt, are difficult to coat, inspect and maintain.

<sup>19</sup> AS/NZS 4680 & The Galvanisers Association of Australia

# 4. Strategy Comparisons and Considerations

## 4.1 Business as Usual (BAU) approach

The existing BAU maintenance strategy for the affected members has been assessed as insufficient for the 28 towers nearest to APD, as it does not deliver the necessary life extension without significant intervention. To achieve consistent outcomes, a smaller one-off refurbishment program is proposed for a further 36 towers along the HYTS-APD line to address early-stage deterioration before it becomes problematic. This latter scope aligns with more standard practices and techniques. Combined with ongoing maintenance of the other 13 towers, these actions aim to extend the line's lifespan by 30–40 years.

## 4.2 Risk

There were two risk scenarios considered, a tower collapse/unserviceable from a severe wind event and providing an improved/meeting recall time. The probability of either of these events occurring is not changed significantly by either a strategy considered in this review. In each case the probability remains at rare/remote for each of these scenarios with the consequences unchanged. It is therefore reasonable to exclude this as a consideration in the maintenance strategy.

## 4.3 Concurrent work

The tower replacement option becomes more attractive if scheduled maintenance outside the scope of this project can be brought forward to the same period of construction. Not only reducing the cost of mobilisation of equipment and ensuring full utilisation of the equipment and crews onsite, but it will also reduce the number of outages. For example, replacement of conductors, insulators, grounding systems, etc., and tasks that would normally require a circuit to be de-energised to perform, especially if it couldn't be performed within the standard recall window. This assessment may be sufficient to reverse the refurbish/repair business decision to achieve the economy of scales or to improve constructability. Case in point, T625 and T626 are due for conductor replacement within the timeframe under consideration and will be candidates for replacement over refurbishment.

## 4.4 Outages

Customer buy in is required due to the high number of outages (up to 48 for 6 towers as part of stage 1) to complete a refurbishment program. However, this may also be beneficial for them as they may wish to program maintenance within the construction window to take advantage of any extended outages or increased number of single circuit operations. In Sept 2025, [ C.I.C ] agreed in principle, to extending the recall window to 3 hours which will allow greater flexibility in the selection of maintenance strategies and timing.

## 4.5 Workflow

Documenting the considerations that were used to drive the decisions for this project are as important as the decisions themselves, not only as a historical record, but also to provide a decision tree for future submissions. A documented workflow will not only assist in ensuring a consistent and defensible approach but also save time and expense.

The workflow used for this project is shown in Section 8, "A Generic Workflow for Option Selection". This provides the pathway used to define each step by identifying the decisions that need to be made to derive an option that provides the lowest practical risk while managing costs and yet, yielding a design that is transferrable to other transmission lines that may need to consider the replace versus refurbishment option.

As shown in the workflow, overlaying each option are the various methods of construction for a bypass line. Each construction method has its own benefits as well as disadvantages as discussed previously with each bringing the need to be evaluated for both cost and feasibility.

Once brought together the output of the workflow will produce the most effective option overall to implement on a tower-by-tower basis.

## 4.6 Cost Breakdown Spreadsheet

As can be seen from the workflow there is many permutations and conditions stemming from the various choices. Each of these options were modelled using an Excel spreadsheet (Summary Breakdown 20250925.xlsm) to determine which option could provide the most cost-effective approach.

### 4.6.1 Assumptions Used in the Spreadsheet

Apart from the cost builders mentioned previously the model requires additional assumptions and exclusions to reflect the anticipated costs. Examples of some of these are discussed below.

- The annual escalation for pricing used is 4.4% p.a. in line with guidance provided by the AusNet estimators. Higher assumed escalation rates will result in earlier payback from the new tower option and inversely a recoats will be required. First maintenance is defined in the Standard as when 2% of the total surface area has scattered general rust. However, due to the large number of edges on the angle iron and bolts it will likely occur sooner and over a larger area than the Standard predicts, especially on topcoats where there is little to no galvanising remaining e.g. on refurbished members. It is for this reason the lower end of the range is used for predicting coating longevity. lower escalation will delay the crossover between refurbishment and the new towers.
- Coating durability is based on the AS/NZS 2312 for a C4 environments and is indicative of when first maintenance and full

Based on the Australia Standard coating maintenance is likely to be required after

- 2 – 3 years for edges on refurbished members
- 5 - 10 years for the proposed topcoats in the refurbish/member replacement scenario
- 30 - 60 years for new heavy (HDG900) hot dipped galvanising i.e. no maintenance for new towers is required in the period under consideration.

The cost analysis used assumes for the refurbish options that the towers are fully painted at day 0 and that a total recoat will occur every 10 years thereafter. It further assumes that between the full repaints, maintenance painting will occur in areas of corrosion breakthrough in the order of 2% of the total surface area every 2 years. As painting represents a major portion of the overall cost in the refurbishment option the impact to the payback period of a poorly executed coating program cannot be understated. Any actions that will shorten the time between recoats or increases the extent of the repairs required will affect the crossover period between the costs of new towers and the cost of refurbishment e.g. coating durability less than anticipated because of poor application practises, less than optimal coating selection, etc.

- The coating costs for the towers under the refurbishing scenario is taken from the 2025 Maintenance Contractor proposal (\$1000 per metre square by estimated surface area) and extrapolated over time using the standard AusNet escalation.
- The new towers will be supplied with HDG900 and not top coated, with no coating maintenance during the time under consideration.
- In the refurbishment scenario it is assumed that the steel replacement will occur in the first triage, and no further steel replacement is required as the coating is maintained. However, if the coatings are not maintained this assumption will not hold true and the steel/tower replacement may become a future challenge.
- For the refurbishment programs the cost for the construction of a bypass is equally apportioned to each tower where a bypass has been identified as being required by the Maintenance Contractor. However, this does not consider any constructability concerns or inefficiencies that may come from bypassing non-consecutive towers. Constructability and efficiencies will need to be challenged during the detailed design and the final pricing adjusted accordingly.
- It should also be noted at this juncture, the veracity of the Maintenance Contractor assumptions on members to be replaced without a bypass has and cannot be tested, without detailed engineering and onsite assessment therefore, under the refurbishing scenario the final number of bypassed towers may not be known until construction is underway.

- Using the costs from a previously submitted budgetary proposal for constructing these 28 towers, the AusNet estimators assigned a cost for the construction of a single new tower. While adequate for the purpose of choosing a suitable maintenance/replace strategy, the true costs for an individual tower may vary significantly from this estimate. For example, the cost to replace or refurbish a strain tower will not be the same as a suspension tower due to the size and complexity of the former. Similarly, the 2 single circuit strain towers, T628A and T628B are smaller than the other towers on this line and therefore should come at a lower cost than the average.
- The assumed costs for new towers in the model were as follows. These were provided either through the AusNet estimator or AusNet management and were intended to cover all costs associated with the procurement and construction of the new tower and any required bypass.

Bypass Type	Bypass Poles New or Recycled	Cut-over	Cost for New Tower
<b>Monopoles</b>	New	Live	\$ [C.I.C]
		Traditional	\$ [C.I.C]
	Recycled	Live	\$ [C.I.C]
		Traditional	\$ [C.I.C]
<b>ERS</b>	New	Traditional	\$ [C.I.C]

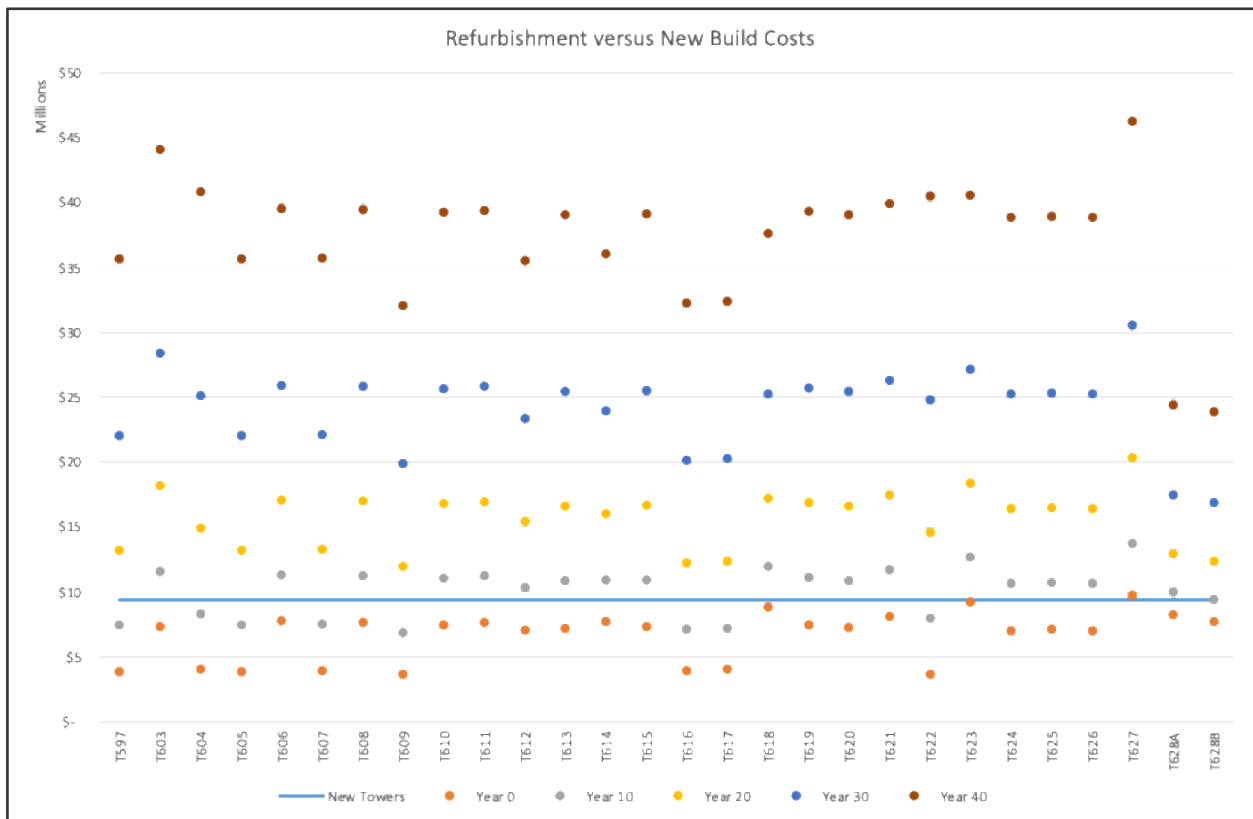
An example from the model of the cost buildup for a single tower is shown in Section 7 Cost Buildup for a Refurbished Tower. It illustrates how the workflow shown in the appendices is translated to determine the cost of refurbishing a tower. Once the refurbishment costs are collated then a direct comparison can be made of the cost to refurbish and the cost of the various tower replacement options.

The same process is applied to each of the towers to produce the non-discounted cash flow and discounted cash flow examples that follow. The discounted cash flow model uses the discount of 7%.

The costs are built up year by year basis to allow the application of various scenarios, including delayed maintenance and varying the year that a new tower is built, the type of bypass or the type of cut-over.

## 5 Analysis Output

Regardless of the classification of funds as OPEX or CAPEX, for the 28 towers reviewed, the comparison model predicts that the cost of maintaining a refurbished tower exceeds the cost of building a new tower within the first 10 years for the majority, and the remainder by Year 20.



## 5.1 Non-Discounted Costs

The follow table represents a cost comparison between building a new tower versus the ongoing costs of maintaining the existing tower at the same location using the model developed. This table shows the most expensive bypass option, using new monopoles and a live transfer.

The cost of the bypass affects both the new towers and the towers being refurbished that require a bypass equally, therefore any change is mostly nullified as the differential remains the same. As the cost of the bypass reduces, which in turn lowers the cost of a new tower, in theory it will get to a point where refurbishing is not viable. However currently there is not sufficient of a step change in the cost of a bypass methodology that will achieve this, and refurbishing remains viable for some towers in the short term.

Year 0 in this table refers to the year that the expenditure occurred to refurbish each tower to a “fit for purpose” state. The subsequent years indicate the years post refurbishment and the ongoing cost of maintenance. The model assumes that all refurbishment is completed in the same year, and all towers will be repainted in the same 10 year period. No attempt has been made to model a staggered implementation outside the tower replacement.

As the towers are subject to a total repaint every 10 years this results in a significant cost impact. This cost is of a magnitude that in most cases it gives the impetus to cross over from the refurbish scenario to a replacement scenario. To emphasise this, the table highlights the towers once the refurbishment cost exceeds the cost of the new tower.

C-I-C

## 5.2 Discounted Costs

The example of non-discounted costs represents a cost comparison between building a new tower versus the on-going costs of maintaining the same tower using discounted costs. Like Table 1, Year 0 in this table refers to the year that the expenditure occurred to refurbish each tower to a "fit for purpose" state. The subsequent years indicate the years post refurbishment and the on-going cost of maintenance. The model assumes that all refurbishment is completed in the same year, and all towers will be repainted in the same 10 year period. No attempt has been made to model a staggered implementation outside the tower replacement.

Comparing the discount costs to the non-discounted cost illustrates the robustness of the chosen strategy of replacing the towers as virtually the same towers are identified in both models over the same time period for replacement.

C-I-C

## 6 Recommendations and Outcomes

### 6.1 Refurbish or Replace

The analysis has demonstrated that replacing all 28 towers is the lowest lifecycle cost option, provided a minimum remaining life of 15 years is required.

Beyond cost efficiency, new tower construction offers significant delivery advantages. The process of building new transmission lines is well established within the business and among delivery partners, drawing on proven expertise from previous projects. This familiarity enables the application of standardised design and pricing norms, improving cost certainty and reducing execution risk.

The proposal is to address the risks by a tower replacement program for the HYTS–APD 500kV transmission line in three stages, balancing asset condition priorities, regulatory commitments, and strategic planning.

**Stage 1 (2025–2027): Priority Replacements and Compliance**

- Replace the first 6 towers north of APD, which are in very poor condition and have existing cultural heritage submissions. These towers also require conductor replacement, making them high priority.

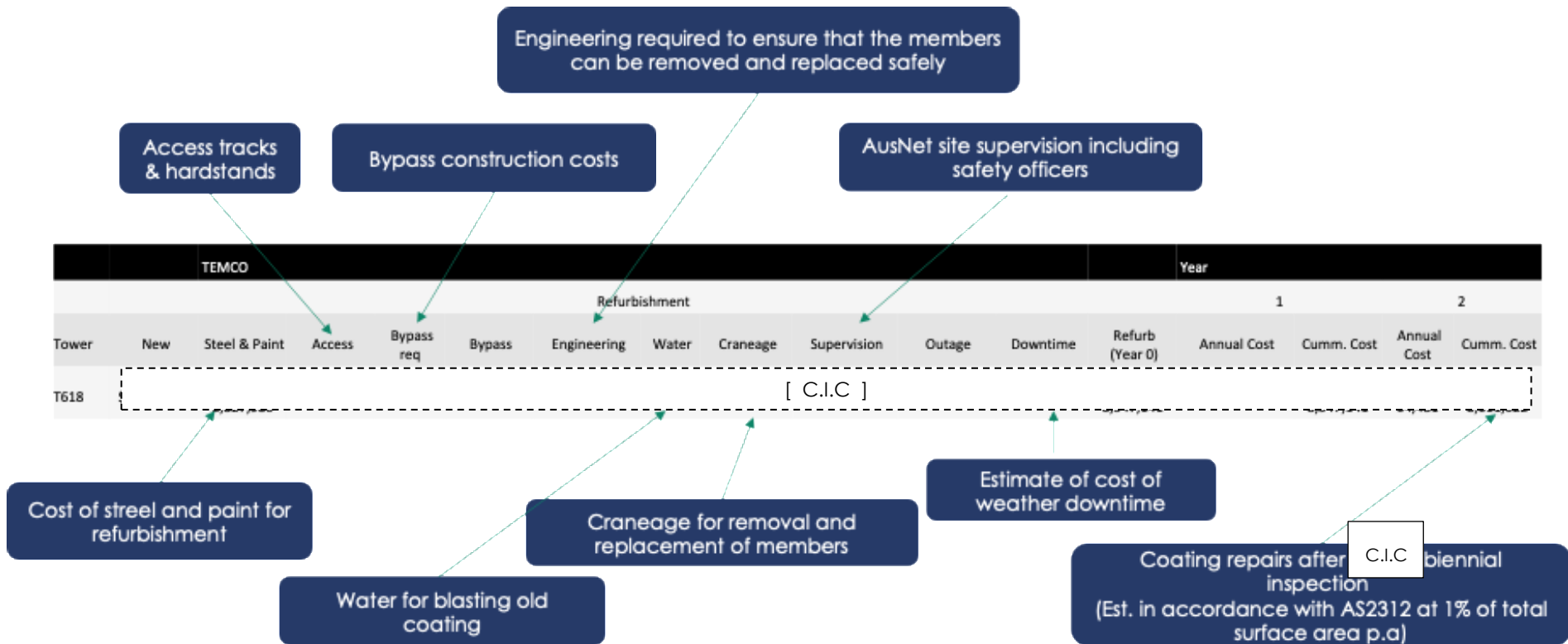
**Stage 2: Remaining Recommended Replacements**

- Replace the remaining 22 towers identified in the lifecycle cost analysis
- The logic and methodology for these replacements mirrors that of Stage 1, ensuring consistency in approach and leveraging established delivery practices.

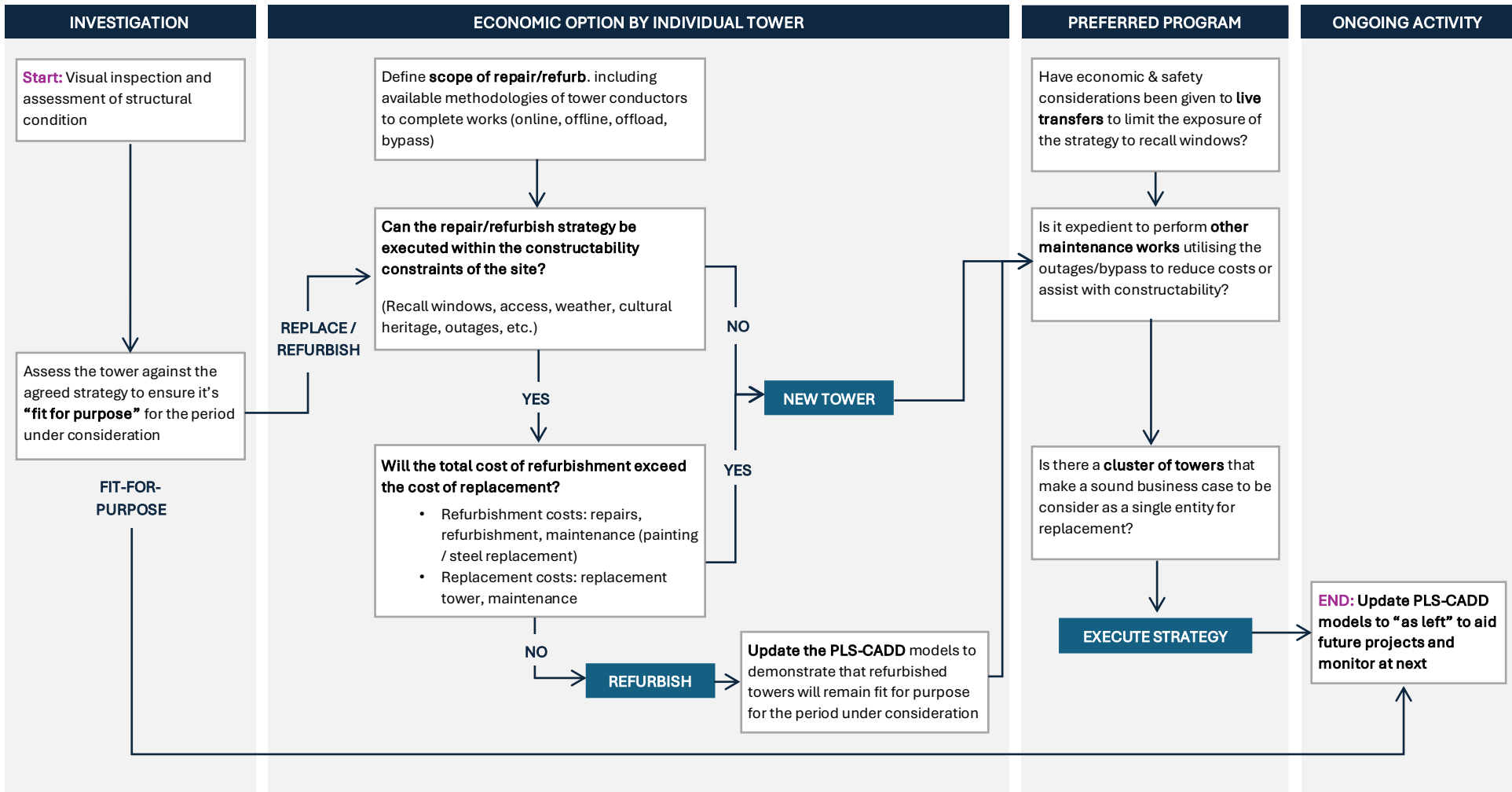
**Stage 3: Strategic Refurbishment Planning**

- Refurbish/maintain the remaining 49 towers not currently included in the replacement scope.
- Develop and present a robust refurbishment strategy so these towers can meet the required life extension targets, aligning with long term network needs and asset management principles.

## Section 7 Example of Cost Build-up for Refurbished Tower



## Section 8 Generic Workflow for Work Selection

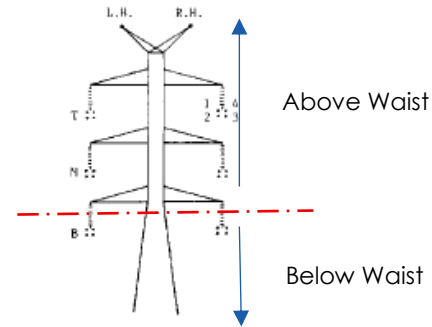


# Appendix H - HYTS-APD Condition Assessment

The table below illustrates the heavy concentration of Very Poor (C5) condition steel members and bolts at the end of the line, ref: spatial map in Appendix E.

In the table below, Percentage, Condition Rating Score the values 1 – 5 illustrates how widespread the “worst condition member” or “worst condition bolt” is along that section of the tower, i.e., Above Waist or Below Waist (ref: tower outline).

Tower Number, Cell Colour	Stage Twr. will be addressed	Percentage, Condition Rating Score	Percentage of members / bolts in Worst Condition Score, AW or BW
Red	Stage 1	1	1 to 5%
Orange	Stage 2	2	6 to 25%
Green	Stage 3	3	26 to 50%
Red Highlight in Orange Cell	Unload Twr. in Stage 1; Replace Twr. in Stage 2	4	51 to 75%
		5	>76%



Tower Number	Line Name	AGE GROUP	TOWER_CA	Corrosivity Zone	Measurement Date	Below Waist Worst Steel Condition	Percentage Below Waist Worst Steel Cond	Above Waist Worst Steel Condition	Percentage Above Waist Worst Steel Cond	Tower Bolt Below Waist Worst	Percentage Tower Bolt Below Waist Worst	Tower Bolt Above Waist Worst	Percentage Tower Bolt Above Waist Worst
						120000	120010	120020	120030	120040	120050	120060	120070
T553	HYTS-APD 1	35-40	C2	2	2025-03-08	3	3	3	3	3	3	3	3
T554	HYTS-APD 1	35-40	C2	2	2025-03-08	3	2	3	2	3	2	3	2
T555	HYTS-APD 1	40-45	C2	2	2025-01-30	2	2	3	2	3	2	3	2
T556	HYTS-APD 1	40-45	C2	2	2025-03-08	3	2	3	2	3	3	3	3
T557	HYTS-APD 1	40-45	C2	2	2025-03-08	3	2	3	2	3	3	3	3
T558	HYTS-APD 1	40-45	C2	2	2025-03-08	3	2	3	2	4	3	4	3
T559	HYTS-APD 1	40-45	C2	2	2025-03-08	3	3	3	3	4	3	4	3
T560	HYTS-APD 1	40-45	C2	2	2025-03-08	2	2	2	2	3	2	2	2
T561	HYTS-APD 1	40-45	C2	2	2025-03-08	3	2	4	2	5	2	5	2
T562	HYTS-APD 1	40-45	C2	2	2025-02-26	3	2	4	2	4	2	4	2
T563	HYTS-APD 1	40-45	C2	2	2025-02-26	3	2	4	2	4	2	4	2
T564	HYTS-APD 1	40-45	C2	2	2025-03-11	2	2	4	2	4	2	4	2




T565	HYTS-APD 1	40-45	C3	2	2025-02-26	5	2	5	2	5	2	5	2
T566	HYTS-APD 1	40-45	C2	2	2025-03-11	2	2	4	2	4	2	4	2
T567	HYTS-APD 1	40-45	C2	2	2025-02-26	4	2	4	2	4	2	4	2
T568	HYTS-APD 1	40-45	C2	2	2025-02-27	3	2	4	2	5	2	5	2
T569	HYTS-APD 1	40-45	C2	2	2025-02-27	4	2	4	2	5	3	5	3
T570	HYTS-APD 1	40-45	C2	2	2025-03-11	3	2	4	2	4	2	4	3
T571	HYTS-APD 1	40-45	C2	2	2025-02-27	3	1	4	2	4	1	4	2
T572	HYTS-APD 1	40-45	C2	2	2025-03-11	3	2	4	2	4	3	4	2
T573	HYTS-APD 1	40-45	C2	2	2025-02-27	3	1	4	2	4	1	4	1
T574	HYTS-APD 1	40-45	C2	2	2025-03-11	3	2	4	2	4	2	4	2
T575	HYTS-APD 1	40-45	C2	2	2025-02-27	3	2	5	3	5	2	5	2
T576	HYTS-APD 1	40-45	C2	2	2025-03-11	2	2	4	3	4	3	4	3
T577	HYTS-APD 1	40-45	C2	2	2025-02-27	3	2	4	2	3	2	4	2
T578	HYTS-APD 1	40-45	C2	2	2025-03-11	3	2	4	2	4	2	4	2
T579	HYTS-APD 1	40-45	C2	2	2025-02-28	3	1	4	2	4	2	4	2
T580	HYTS-APD 1	40-45	C2	2	2025-02-26	3	2	3	2	3	2	3	2
T581	HYTS-APD 1	40-45	C2	2	2025-02-26	3	2	3	2	3	2	3	2
T582	HYTS-APD 1	40-45	C3	2	2025-02-26	3	1	5	1	4	1	4	1
T583	HYTS-APD 1	40-45	C3	2	2025-02-26	3	1	5	1	4	1	5	1
T584	HYTS-APD 1	40-45	C2	2	2025-02-26	3	1	4	1	4	1	5	1
T585	HYTS-APD 1	40-45	C2	2	2025-02-26	3	1	4	1	3	1	5	1
T586	HYTS-APD 1	40-45	C2	2	2025-02-26	3	2	3	2	3	2	3	2
T587	HYTS-APD 1	40-45	C2	2	2025-02-26	3	2	3	2	3	2	3	2
T588	HYTS-APD 1	40-45	C2	2	2025-02-26	2	2	2	2	3	2	3	2
T589	HYTS-APD 1	40-45	C2	2	2025-02-26	3	1	3	1	3	1	5	1
T590	HYTS-APD 1	40-45	C3	2	2025-02-27	4	1	4	1	4	1	4	1
T591	HYTS-APD 1	40-45	C3	2	2025-02-28	4	1	5	1	5	1	5	1
T592	HYTS-APD 1	40-45	C3	2	2025-02-27	5	1	5	1	5	1	5	1
T593	HYTS-APD 1	40-45	C3	2	2025-02-27	4	2	5	2	4	1	4	2
T594	HYTS-APD 1	40-45	C3	2	2025-02-27	4	1	5	1	5	2	5	2
T595	HYTS-APD 1	40-45	C3	2	2025-02-27	4	1	5	1	5	1	5	1
T596	HYTS-APD 1	40-45	C2	2	2025-03-06	3	2	5	3	3	2	5	3
T597	HYTS-APD 1	40-45	C3	2	2025-02-27	5	1	5	1	5	1	5	1
T598	HYTS-APD 1	40-45	C3	2	2025-02-27	5	2	5	3	5	2	5	3

T599	HYTS-APD 1	40-45	C3	2	2025-02-27	5	2	5	3	5	2	5	2
T600	HYTS-APD 1	40-45	C3	3	2025-02-28	5	1	5	2	5	2	5	2
T601	HYTS-APD 1	40-45	C3	3	2025-02-28	5	1	5	2	5	2	5	2
T602	HYTS-APD 1	40-45	C2	3	2025-02-28	4	3	5	3	4	3	5	4
T603	HYTS-APD 1	40-45	C3	3	2025-02-28	5	1	5	2	5	1	5	3
T604	HYTS-APD 1	40-45	C3	3	2025-02-28	4	4	4	4	4	4	5	4
T605	HYTS-APD 1	40-45	C3	3	2025-02-28	4	4	4	4	4	4	4	4
T606	HYTS-APD 1	40-45	C3	3	2025-02-28	4	4	5	4	4	4	5	4
T607	HYTS-APD 1	40-45	C4	3	2025-02-28	5	2	5	3	5	2	5	3
T608	HYTS-APD 1	40-45	C3	3	2025-02-28	5	4	5	4	5	4	5	4
T609	HYTS-APD 1	40-45	C3	3	2025-02-27	5	2	5	3	5	3	5	3
T610	HYTS-APD 1	40-45	C4	3	2025-02-27	5	4	5	5	5	4	5	4
T611	HYTS-APD 1	40-45	C4	3	2025-02-27	5	2	5	5	5	3	5	5
T612	HYTS-APD 1	40-45	C5	3	2025-02-27	5	5	5	5	5	5	5	5
T613	HYTS-APD 1	40-45	C5	3	2025-02-27	5	3	5	5	5	3	5	5
T614	HYTS-APD 1	40-45	C5	3	2025-02-27	5	5	5	5	5	5	5	5
T615	HYTS-APD 1	40-45	C4	3	2025-02-27	5	3	5	3	5	3	5	4
T616	HYTS-APD 1	40-45	C5	3	2025-02-27	5	5	5	5	5	5	5	5
T617	HYTS-APD 1	40-45	C4	3	2025-02-26	5	4	5	5	5	3	5	5
T618	HYTS-APD 1	40-45	C5	3	2025-02-26	5	5	5	5	5	5	5	5
T619	HYTS-APD 1	40-45	C5	3	2025-02-26	5	4	5	5	5	5	5	5
T620	HYTS-APD 1	40-45	C5	3	2025-02-13	5	5	5	5	5	5	5	5
T621	HYTS-APD 1	40-45	C5	3	2025-02-26	5	5	5	5	5	5	5	5
T622	HYTS-APD 1	40-45	C5	3	2025-02-26	5	5	5	5	5	5	5	5
T623	HYTS-APD 1	40-45	C5	3	2025-02-13	5	5	5	5	5	5	5	5
T624	HYTS-APD 1	40-45	C5	3	2025-02-26	5	5	5	5	5	5	5	5
T625	HYTS-APD 1	40-45	C3	3	2025-02-26	5	4	5	4	5	4	5	4
T626	HYTS-APD 1	40-45	C5	3	2025-02-26	5	5	5	5	5	5	5	5
T627	HYTS-APD 1	40-45	C4	3	2025-02-13	5	5	5	5	5	5	5	5
T628A	T628AHYTS-APD 2	40-45	C5	3	2025-02-12	5	5	5	5	5	5	5	5
T628B	T628BHYTS-APD 1	40-45	C5	3	2025-02-12	5	5	5	5	5	5	5	5

## AusNet

Level 31  
2 Southbank Boulevard  
Southbank VIC 3006  
T +613 9695 6000  
F +613 9695 6666  
Locked Bag 14051 Melbourne City Mail Centre Melbourne VIC 8001  
[www.AusNet.com.au](http://www.AusNet.com.au)

## Follow us on

-  @AusNet
-  @AusNe
-  @AusNet.Energy

# AusNet

