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Project justifications for pole replacement programs

Ausgrid

Content

1 INTRODUCTION

1.1 Poles and towers in Ausgrid's network

Ausgrid's overhead network is comprised of poles, electrical equipment and electrical conductors. Poles provide structural support for the overhead conductors and accessories so they remain safely clear from the ground, buildings, infrastructure, vegetation, vehicles or watercraft. Poles are also used to support pole mounted substations and other equipment used to operate and control the network.

There are more than 446,000 poles on the Ausgrid network (excluding street light poles and columns). Wood poles account for approximately 96% of the pole population. Steel and concrete poles account for a further 3.4% of the pole population with the remainder comprising of poles made from composite materials (fibreglass composites). Ausgrid also has 736 steel towers which are primarily used for high capacity transmission lines.

1.2 Changes in technology

Wood poles have been used to support overhead conductors since the beginning of the Ausgrid network (over 100 years) and remain as the primary pole type used today. Steel towers and poles were introduced in the 1950s and 1960s respectively, and were primarily used for transmission lines at that time however steel poles have since also been installed on the distribution network in remote or bushfire prone areas. Concrete poles were introduced in the 1980s and have primarily been used on transmission lines due to their strength.

Ausgrid generally replaces poles in a like for like approach, which is typically with wood poles, with the following exceptions:

- Composite poles (known as 'Titan' poles) are being installed in difficult to access locations due to their reduced weight and reduced maintenance requirements. They are now also used to support pole top substations to extend their life.
- Wood poles on transmission lines may be replaced with concrete or steel poles to comply with modern design standards / requirements.

Ausgrid continuously looks for more effective and efficient ways to test and assess pole condition, including partnering with universities to understand current testing methods.

Steel towers were constructed from the 1950s to the 1970s and were used for long high capacity transmission lines as steel or concrete pole technology was not able to provide sufficient support strength at that time. Steel pole technology has improved since these times and Ausgrid now replaces steel towers with steel poles due to their reduced maintenance and refurbishment requirements over their operating life. Steel towers may also be strengthened (as opposed to being replaced) if it is economically feasible.

1.3 Working out what we need to replace / reinforce

Ausgrid undertakes inspections and condition assessments to determine the appropriate treatment options for each pole or steel tower. The different pole and tower construction types have known failure modes, which informs assessment criteria for treatment.

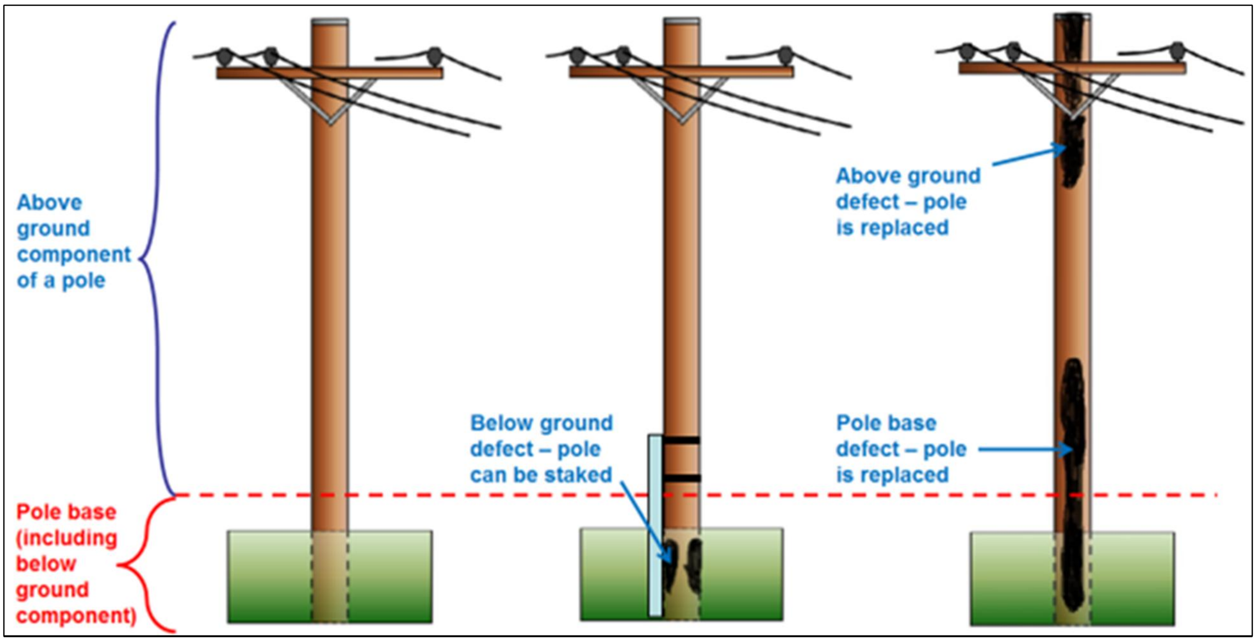
Based on the assessed condition, defect location and cost effectiveness Ausgrid will undertake either a follow up re-inspection task, reinforcement (wood poles only), refurbishment (towers) or replacement of the pole or tower. Reinforcement or refurbishment of poles or towers does not return the asset to an 'as new' condition, however, they provide a life extension of the asset.

Some other poles are identified for replacement in conjunction with the NSW Roads and Maritime Services (RMS) following analysis of vehicle crash data.

1.4 Summary of programs

In total, we expect to spend $169 million on reinforcing approximately 5,500 poles, refurbishing 153 steel towers and replacing approximately 18,200 poles and 16 steel towers. Conditional programs account for 87% of this expenditure.

Figure 1. Indicative wood pole components and failure modes



The following programs are discussed in further detail below:

- Pole replacement and reinforcement ($144 million)
- Blackspot pole replacement ($3.3 million)
- Steel tower replacement and refurbishment ($21.7 million).

2 POLE REPLACMENT AND REINFORCEMENT

2.1 Program description

The conditional pole reinforcement and pole replacement programs address structural integrity issues associated with pole degradation. These programs are outcomes of the pole maintenance (inspection and treatment) program. Pole degradation causes safety risks to the public, customers and workers if:

- The pole fails and falls to the ground, or
- The pole leans too far and the overhead conductors attached to it are no longer at a safe distance from the ground, buildings, infrastructure, vegetation, vehicles or watercraft.

The four main conditional programs related to reinforcing or replacing poles are:

- Replacement of condemned distribution poles (REP_04.02.02)
- Replacement of condemned transmission poles (REP_05.02.06)
- Reinforcement of condemned distribution poles (REP_04.02.34)
- Reinforcement of condemned transmission poles (REP_05.02.34).

These programs commenced in previous regulatory periods and continue to be refined through continual improvement programs. Ausgrid expects to spend $144 million reinforcing approximately 5,500 poles and replacing approximately 18,200 poles in the 2019-24 period.

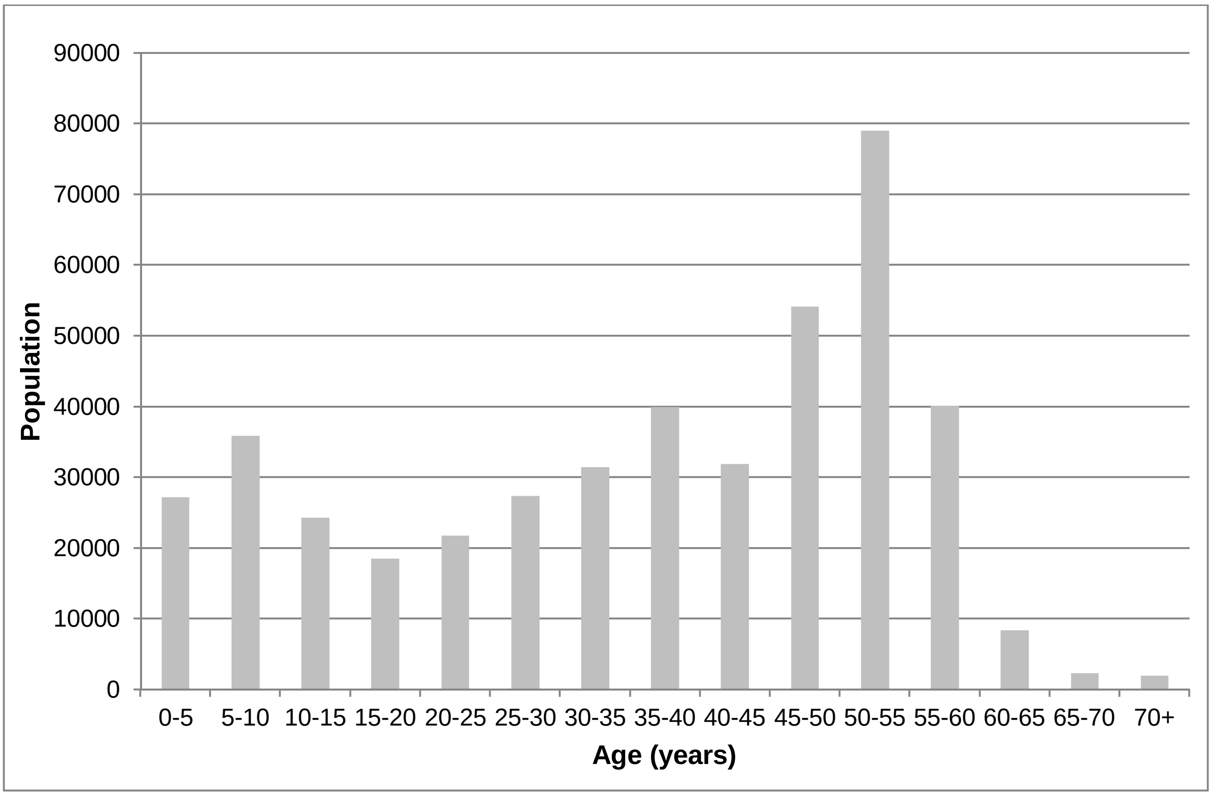
2.2 Background

Ausgrid has approximately 446,000 poles on the distribution and transmission network (excluding those used solely for street lighting purposes). The primary function of a pole is to provide the support necessary to maintain safe electrical clearances from overhead conductors and equipment to:

- The ground, buildings, infrastructure, vegetation or vehicles / watercraft
- Other live overhead conductors and equipment.

The age profile of the poles is shown in Figure 2. The average age of these poles is 35 years with 42% over 45 years of age. Wood poles have a technical life of 45 years, while concrete and steel poles have a technical life of 55 years. Approximately 2% of the pole population reaches 60 years of age each year.

Figure 2. Age profile of poles (as at 30 June 2017)



2.3 Risks – Consequence and likelihood

The key consequences that can result in a loss of this function are shown in Table 1 below.

Table 1. Consequences from loss of function for poles

Consequences	Description
Harm to the public, communities and workers	Falling poles or contact with degraded or fallen live electrical conductors / equipment may cause injury (physical injury, electric shock or burns) or a fatality (electrocution).
	Fires (including bushfires) caused vegetation contact with degraded or fallen live electrical conductors or equipment may cause injury (electric shock or burns) or a fatality.
	Safety issues as a result of loss of supply are detailed below.
Damage to property	Falling poles or contact between fallen live electrical conductors / equipment and buildings, infrastructure or vehicles / watercraft may cause arcing, fires or physical damage.
	Buildings, property, critical infrastructure or natural environments may be damaged by fires caused by vegetation contact with live electrical conductors or equipment.
Damage to the environment.	The natural environment may be damaged by fires caused by failed electrical conductors or equipment.
Loss of supply	Interruptions to electricity supply can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.

The need for pole reinforcement or replacement is driven by the risks which result from a functional failure. A functionally failed pole is one that has degraded to the point where it is no longer able to support the overhead conductors at the required safe electrical clearances. The reduced electrical clearances may be due to the pole failing and falling to the ground, or due to excessive pole leaning.

Ausgrid utilises condition information from inspections and customer feedback to determine when a pole is approaching functional failure and sets criteria to define the point of conditional failure. The criteria generally relates to the 'residual strength' of the pole. Different pole materials have different ways in which they begin to fail (failure modes) leading to reduced structural integrity. The majority of failure modes associated with poles are deteriorating in nature and therefore present an increased likelihood over time. The predominant failure modes for the different pole types are shown in Table 2.

Table 2. Key failure modes by pole type

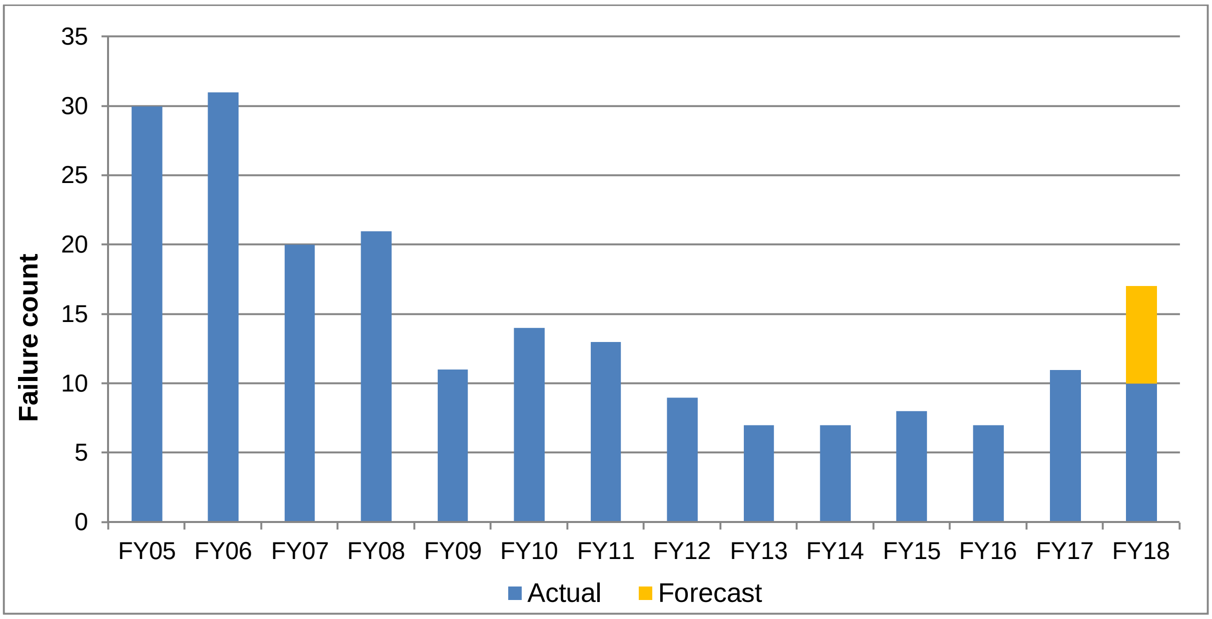
Pole Type	Key Failure Modes
Wood poles	Pole strength degraded due to rot or termite attack (above or below ground).
	Pole strength degraded or pole failure due to third party impact, vandalism, weather (storms / floods), fallen vegetation or failure of ground stays / stay wires.
	Cracking or splitting of the pole due to age degradation / exposure to weather (typically at the top of a pole).
	Pole leaning due to degraded footing, third party impact, vandalism, weather (storms / floods), fallen vegetation, degraded pole base or failure of ground stays / stay wires.
Concrete poles	Concrete cracking due to corrosion of steel reinforcing.
	Pole leaning or pole failure due to degraded footing, third party impact, vandalism, weather (storms / floods), fallen vegetation or failure of ground stays / stay wires.
Metal poles	Pole strength degraded due to corrosion (above or below ground).
	Pole leaning or pole failure due to degraded footing, third party impact, vandalism, weather (storms / floods) or fallen vegetation.
Composite poles	Pole leaning or pole failure due to degraded footing, third party impact, vandalism, weather (storms / floods) or fallen vegetation.

The consequences and likelihood of a pole failure can increase due to a number of factors, including:

- Its material, design or construction
- Being in areas prone to bushfire, storm activity or high winds
- Being in areas with unstable / moist soil
- Being in areas with high pedestrian / vehicle activity or in close proximity to schools
- Supporting circuits which supply critical customers or infrastructure.

In the period from 2012/13 to 2016/17, there was an average of eight pole functional failures per year; however, the trend of unassisted pole failures is starting to increase again after a substantial period of decline. The pole failure trend since 2005 is shown in Figure 3.

Figure 3. Count of unassisted pole failures



The low level of unassisted pole failures reflects the current robust asset management practices for poles providing an understanding of pole condition and therefore the likelihood of pole failure. Detecting failures before they occur and applying treatments maintains poles in a serviceable condition, limiting the likelihood of pole failure and mitigating the potential consequences described above.

The key treatment options that are applied are detailed below.

2.4 Treatment analysis

Assessment of the treatment solutions considered for poles is shown in Table 3 below.

Table 3. Key failure modes by pole type

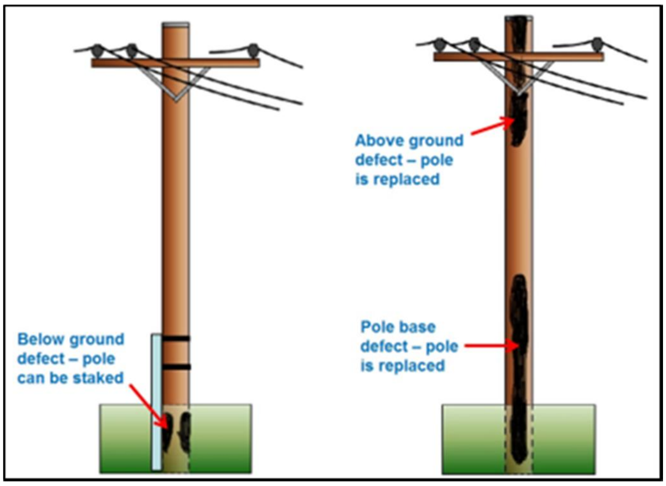
Treatment option	Treatment overview
1 Reinspect the pole	Schedule the pole for a follow up inspection, either in 12 months or at the standard 5 yearly inspection cycle.
2 Repair the pole	Undertake repairs to the pole (for example, termite treatment). The typical cost for termite treatment is $122 per pole. This is an operational expense.
3 Reinforce the pole	Reinforce conditionally failed poles. The average cost to reinforce a pole is approximately $1,100 per pole. Present value cost analysis shows reinforcement is the lowest cost option if it costs less than $6,700 and provides a 15 year life extension[1].
4 Replace the pole	This option is to replace the pole with a new pole of the same or new equivalent technology type. The proposed average cost to replace a pole is approximately $7,200 per pole distribution pole and $24,500 per transmission pole.

[1] The typical life extension of 15 years equates to three inspection cycles - actual life extension varies for each pole and is dependent on its operating context and degradation rate.

Re-inspection (Option 1) and repairs (Option 2) are operational expenses associated with maintaining the assets and may be done where deemed practical and efficient. These options do not extend the life of the pole. Pole repair solutions are limited - the main repair activity undertaken is termite treatment. Termite treatment eradicates the immediate cause of degradation however historical experience has shown an increased rate of internal rot if a wood pole has previously been infested with termites.

Figure 4 shows typical wood pole defects and the other treatment solutions which may be undertaken to address these defects.

Figure 4. Treatment solutions for typical wood pole effects



Wood poles may be reinforced or 'staked' (Option 3) when condition issues are identified in the base of the pole (below ground and up to 1 metre above ground). Reinforcement provides a pole life extension of approximately 15 years. Ausgrid has set criteria for allowing pole reinforcement as all pole base condition issues cannot be mitigated by reinforcement. Historically, reinforcement has been undertaken for approximately 60% of poles which have been assessed as conditionally failed during the pole inspection process. Reinforcement provides life extension to an existing pole at a present value cost which is considerably lower than pole replacement and is our preferred option where it is possible to do so and achieve the intended life extension.

If a pole is not able to be reinforced based on its assessed condition, or other above ground condition issues are identified, Ausgrid will replace the pole (Option 4). Replacement is typically undertaken in a like for like manner.

2.5 Options

The program options available when considering pole management strategies are summarised in Table 4. These options are based on the need to undertake work on Ausgrid's pole assets when their condition is assessed to be unsafe when left as-is.

Table 4. Program options for managing poles

Program need options	Option overview
1 Reactive Treatment	Implement treatment such as reinspection, repair, reinforcement or replacement when the pole fails.
2 Conditional Treatment	Implement treatment to reinforce or replace poles when individual inspections and condition assessments identify degraded poles.

Program need options	Option overview
3 Planned Treatment	Implement treatment such as reinforcement or replacement of the pole prior to the pole conditionally failing, for example, based on pole age.

The consequence of a pole falling poses serious safety and electricity supply risks to the public, customers and workers and, as such, a reactive approach (Option 1) is unacceptable.

The planned treatment option (Option 3) does not take into consideration the current condition of the pole and would result in many assets being replaced prematurely. At present, over 182,000 poles are older than their technical life, which is an unsustainable volume to replace in a short period. This option would also increase the number of functional failures as many poles will fail prior to 45 years of age due to the likelihood factors described above. As this approach will increase expenditure and failures, and is unsustainable, it was not considered an appropriate option.

Ausgrid's preferred approach is to manage the risks associated with the poles by undertaking an assessment of each pole to determine its condition against the developed criteria (Option 2) and then to prioritise its treatment. The condition assessment is undertaken in the form of a pole maintenance program (inspection and treatment).

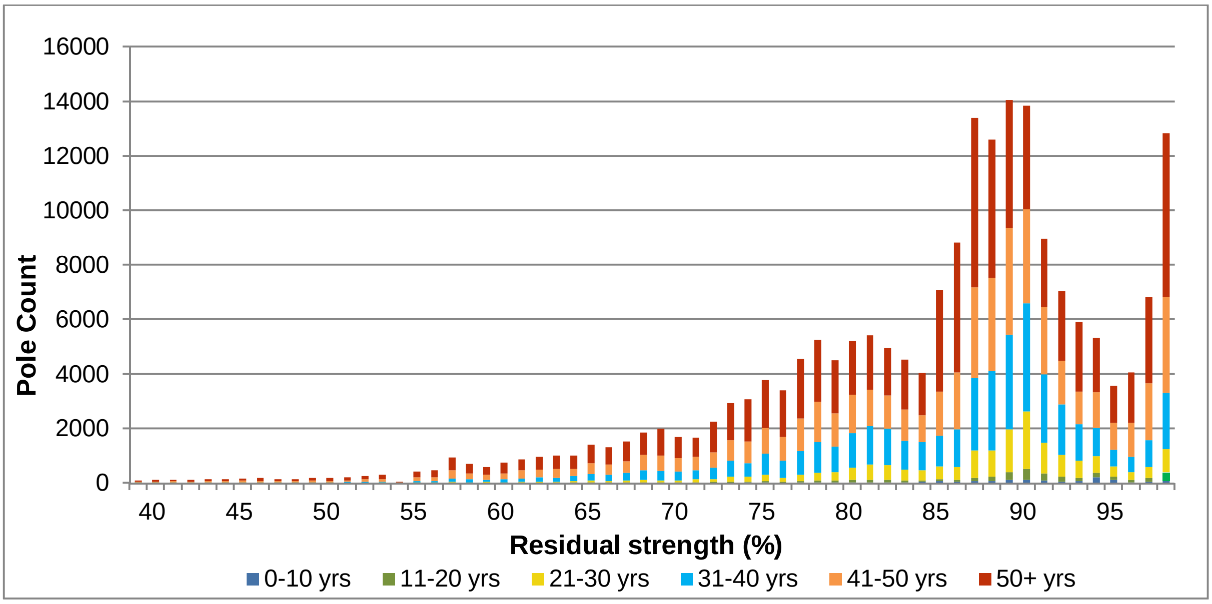
This approach maximises the life of a pole and manages failure risk rather than the long term sustainability of the pole population (average age). Ausgrid believes this to be the most appropriate approach as it defers short to medium term investment for customers particularly where new technologies may lead to further efficiencies or changes in the configuration and design of the 'network of the future'.

2.6 Costing and volumes

Individual pole treatment requirements can only be determined by assessment against the minimum condition criteria at the time of inspection of the asset. Ausgrid inspects every pole in detail to determine its condition. For wood poles, the residual strength of the pole is one of the main factors used to determine its serviceability. A wood pole has 100% residual strength when it is first installed and this reduces over its operating life until the pole is eventually replaced. Poles are assessed for treatment when their residual strength is assessed as being below 50% of its original strength.

Approximately 247,000 wood poles currently have 100% residual strength with the remaining poles being distributed between 0-99%. Figure 5 shows the count of poles with residual strength of 40-99% and their age - it can be seen that the vast majority of wood poles have a residual strength greater than the 50% treatment threshold and that residual strength is not directly proportional to the age of the pole.

Figure 5. Count of wood poles with residual strength of 40-99%.



Due to the large number of wood poles on the Ausgrid network and the quality and quantity of historical measurement data for their residual strength and degradation rates, a very detailed predictive model has been developed. This predictive model uses all of the available information to estimate the future condition of the bases of wood poles and, from this estimate, forecasts annual reinforcement and replacement volumes for wood poles.

As the predictive model only includes data on defects at the base of wood poles, Ausgrid has also used trend analysis of the annual quantities for the following additional failure modes to supplement the forecast of pole replacement needs:

- Wood poles assessed as requiring replacement due to above ground defects
- Wood poles assessed as requiring replacement due to residual strength reductions as a result of internal inspections over their operating life
- Steel poles assessed as requiring replacement due to pole base corrosion
- Concrete poles assessed as requiring replacement due to poor condition.

Pole assessment is conducted by internal resources to test / validate inspection results and to determine whether the pole needs to be reinforced or replaced - some assessments determine that a pole is still serviceable and does not need treatment. Pole inspection and reinforcement is delivered by external resources and is market tested by a competitive tender process for period contracts. Pole replacement is undertaken using a ‘blended delivery’ strategy using both internal and external resources – this strategy creates healthy competition to achieve efficient delivery outcomes and also allows for benchmarking between service providers.

Based on analysis of available industry information, Ausgrid’s pole replacement costs have been assessed as a reasonable average cost for the Ausgrid operating context and sits within the middle of the range of industry costs.

The 2019-24 summary replacement and reinforcement forecast for these programs is shown in Table 5. The costs shown are direct costs only. The results from the predictive model for wood pole reinforcement and replacement, the trend analysis for steel and concrete pole replacement and the increasing trend of unassisted pole failures has resulted in increased forecast quantities during the 2020-24 period. The forecast results in an average of only 0.7% of the pole population being replaced and 0.25% of the pole population being reinforced annually. The variance in each year is a result of the predictive modelling output.

These programs form part of the overall investment being proposed for the replacement of poles. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for this asset category during 2019-24.

Table 5. Forecast for poles

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Replacement of condemned distribution poles					
Volumes for replacement	3,754	3,605	3,542	3,449	3,572
Unit cost	$7,284	$7,258	$7,255	$7,262	$7,252
Total costs ($m)	**$27.35**	**$26.17**	**$25.70**	**$25.05**	**$25.91**
Replacement of condemned transmission poles					
Volumes for replacement	64	65	67	59	65
Unit cost	$24,757	$24,663	$24,663	$24,645	$24,654
Total costs ($m)	**$1.58**	**$1.60**	**$1.65**	**$1.45**	**$1.60**
Reinforcement of condemned distribution poles					
Volumes for replacement	1,302	1,113	1,037	920	1,075
Unit cost	$1,075	$1,078	$1,085	$1,094	$1,102
Total costs ($m)	$1.40	$1.20	$1.13	$1.01	$1.18
Reinforcement of condemned transmission poles					
Volumes for replacement	18	18	21	11	18
Unit cost	$1,075	$1,078	$1,085	$1,094	$1,102
Total costs ($m)	**$0.02**	**$0.02**	**$0.02**	**$0.01**	**$0.02**

3 BLACKSPOT POLES

3.1 Program description

Ausgrid relocates poles that pose immediate hazards to the general public and vehicle occupants through vehicular accidents.

As noted above, the RMS undertakes analysis of crash data annually, including analysis of vehicle collisions with utility poles. The RMS analysis identifies utility pole ‘crash clusters’ where there have been multiple occurrences of vehicles colliding with poles. Ausgrid also analyses locations where multiple pole replacements occurred through third party impact and before the normal end of life of the asset.

Ausgrid considers these crash cluster locations as having a ‘high likelihood’ of vehicle impact with one of our poles (when a vehicle leaves the road corridor) and target pole replacement at these locations under our ‘blackspot pole’ programs. Ausgrid has two programs addressing the risk associated with blackspot poles. The two programs are:

- Relocate Poles in Blackspots – Distribution poles (DOC_11.03.40)
- Relocate Poles in Blackspots – Transmission poles (DOC_11.03.41).

The replacement of blackspot poles to alternate locations, or removal of blackspot poles, reduces the likelihood of a vehicle colliding with a pole and the potential public safety consequences that can arise from a collision.

These programs commenced in the 2014-19 regulatory period. Relocations to date have primarily been distribution poles (Low Voltage (LV) and 11kV). Poles replaced during this period have had no subsequent vehicle strikes, confirming Ausgrid’s approach. Ausgrid proposes to spend $3.3 million on replacement of distribution poles at these blackspot locations during the 2019-24 period - we do not expect replacement of transmission poles will be required during 2019-24 based on past experience.

3.2 Background

From 2011 to 2016, there have been over 50 fatalities and over 3,200 incidents where an Ausgrid pole has been struck during a vehicle crash. Approximately 50% of these incidents resulted in an injury.

Ausgrid has a Memorandum of Understanding with the RMS to cooperate on resolving issues and improve processes for the benefit of the community and both organisations. Ausgrid has committed to work with the RMS to reduce the risk of collision with poles in identified blackspot locations. Ausgrid collaborates with RMS to draw on their road safety engineering capability to determine, and agree on, the risk treatments to be undertaken at the identified priority locations. A number of priority locations previously identified by RMS have been addressed during the current regulatory period.

Replacing or removing the poles reduces the likelihood of a vehicle crash impacting Ausgrid assets and reduces the severity of the consequences to the vehicle occupants, the public and the electricity network.

In May 2010, the NSW Minister for Energy wrote to Ausgrid and other NSW network operators concerning the risk of vehicles colliding with road side poles. The Minister asked all network operators to take a “results focused” approach to the safety issue of motor vehicles crashing into road side poles with a view to progressively reducing fatalities. The Secretary of the NSW Department of Planning and Environment has powers under Section 63K of the *NSW Electricity Supply Act 1995* to ‘direct’ Ausgrid to “remove or relocate poles” on a public road “for the purpose of traffic safety”. RMS has similar powers in that they are able to direct removal of “traffic hazards” under Section 104 of the *NSW Roads Act 1993*.

Ausgrid has not received a ‘direction’ on these matters from The Secretary of the NSW Department of Planning and Environment and has chosen to cooperate with the RMS on behalf of vehicle occupants and the general public to efficiently replace, relocate or remove poles with an elevated risk of requiring reactive replacement through vehicular contact.

3.3 Risks – Consequence and likelihood

The cause of vehicles leaving the road corridor prior to the collision with a pole varies but can include speeding, weather / road conditions, vehicle condition, the road design, the time of day, the drivers experience or driver impairment (fatigue / drugs). The likelihood of a vehicle leaving the road corridor and colliding with an Ausgrid pole varies and is dependent on the distance it is placed from the kerb, barriers between it and the road, and the road corridor design (for example, on a bend in a road compared to a straight section of road). The key consequences of vehicle collisions with poles, increased by pole condition degradation, are shown Table 6.

Table 6. Consequences from loss of function for blackspot poles

Consequence	Description
Harm to the public, communities and workers	Physical collision with the pole causes injuries of varied severity and fatalities to people within the vehicle.
	Pole collapse due to the collision may also cause injury or fatality to pedestrians or others within the vicinity of the pole.
	Contact with fallen live electrical conductors or equipment may cause injury (physical injury, electric shock or burns) or a fatality (electrocution).
	Fires (including bushfires) caused by vegetation contact with fallen live electrical conductors or equipment or vehicle component failure may cause injury (electric shock or burns) or a fatality.
	Safety issues as a result of loss of supply are detailed below.
Damage to property	Contact between fallen live electrical conductors or equipment and buildings, infrastructure or vehicles / watercraft may cause arcing, fires or physical damage.
	Fires caused by vegetation contact with fallen live electrical conductors or equipment may cause damage to buildings, property, critical infrastructure or natural environments.
	Pole collapse due to the collision may also cause damage to buildings, property, critical infrastructure or natural environments.
Damage to the environment.	The natural environment may be damaged by fires caused by failed electrical conductors or equipment.
Loss of supply	Interruptions to electricity supply can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support.

The blackspot poles programs improve road safety outcomes for the public and communities by reducing the likelihood that a vehicle leaving the road corridor will collide with an Ausgrid pole resulting in the key consequences. RMS have stated to Ausgrid that moving the pole by as little as half a metre can reduce the consequence severity as it allows additional time for a driver to regain some control of a vehicle (steering or braking) prior to collision with a pole or other object. These programs do not reduce the likelihood of the vehicle leaving the road corridor however the collaboration with RMS enables Ausgrid or RMS treatment achieving the best balance of cost, risk and performance. RMS may enact risk treatments (at their expense) at the identified crash clusters where pole replacement is not possible.

3.4 Treatment analysis

Assessment of the treatment options considered for blackspot poles is shown in Table 7.

Table 7. Treatment options for managing blackspot poles.

Consequence	Description
1 Local site remediation work	Undertaking remediation work to the local area to reduce the likelihood of vehicles leaving the road. This includes the option of installing crash barriers or altering the road design.
2 Pole removal	Remove poles from the location. The need to undertake this treatment is independent of the pole age.
3. Relocate the pole	Relocation of an existing pole to a more suitable location, generally further away from the kerb line.
4 Replace the pole	This option is to replace the pole with a new pole in a different location.
5 Undergrounding the overhead mains	Implement treatment to replace all overhead mains and poles with underground construction.

Local site remediation (Option 1) includes consideration of the vehicular / pedestrian activity, the road design and adjacent infrastructure. Expenditure associated with mitigating assets not owned by Ausgrid is not funded by electricity customers.

Pole removal (Option 2) may be undertaken where possible and practical however poles will still be required if overhead conductors are still required for electricity distribution at a location.

Relocating an existing pole (Option 3) to a more suitable location adjacent to the road is typically not practical. Existing poles cannot be relocated while overhead conductors are attached to it so they would have to be removed prior to pole relocation and reattached when the pole have been re-installed - overhead conductors may need to be extended to reach the pole in its new location. Existing poles will typically be aged and extraction of the pole to relocate it may damage the pole. In addition to this, the existing pole may not be of suitable height or strength to meet current conductor safety clearance or conductor tension requirements. This option is typically only considered for existing poles which are relatively young or have simple overhead conductor arrangements (for example, only have a street light service attached).

Replacing existing poles (Option 4) considers the risks (both likelihood and consequences) associated with the existing pole location and, given local crash data, reviews the optimal location for the new pole or poles. New poles are typically positioned close to property boundaries to maximise their distance away from the kerb and overhead conductors are replaced with bundled conductors to prevent encroachments over private properties. This option is generally not considered if the existing pole is reasonably new (for example, less than five years old).

Replacing overhead conductors and poles with underground mains (Option 5) is a significant expense given its typical complexity. Implementation would impact the community due to road closures and excavation requirements to undertake the work. Poles would still be required for street lighting purposes however types suitable for roadside usage (known as 'frangible' poles) may be installed. This option is typically only considered when it is undertaken in association with integrated road redesign projects planned and funded by RMS or other authorities.

From recent collaboration with RMS, pole replacement or removal has been the two options predominantly selected to mitigate the risk of vehicle collisions with poles at crash cluster locations. At some locations, due to the existing road design and its surrounding environment, it has been agreed that pole replacement is not required and risk mitigation is to be undertaken by RMS or the road owner. Pole replacement:

- Achieves an appropriate balance of risk and cost
- Enables expenditure to be distributed across multiple locations efficiently reducing the risk across the network.

3.5 Options

The program options available when considering blackspot pole risk management strategies are shown in Table 8. These options are based on the need to reduce the likelihood of a vehicle colliding with an Ausgrid pole during a crash. Vehicles colliding with any Ausgrid pole adjacent to a road may be possible following loss of control of a vehicle.

Table 8. Program options for managing blackspot poles.

Program need options	Option overview
1 Reactive Treatment	Implement treatment in a reactive manner following a vehicle strike.
2 Conditional Treatment	Implement treatment to remediate the risks associated with poles that are identified by historical crash data as being in a crash location cluster. Individual sites are reviewed in collaboration with the RMS, for specific site solutions.
3 Planned Treatment	Implement treatment to remediate the risks associated with all roadside poles to remove the risk of vehicle collision in a planned approach.

It is not reasonably practicable for Ausgrid to eliminate all risks associated with roadside poles (Option 3) due to the size of the pole population.

Poles may be replaced in a more suitable location when they are damaged during vehicle collisions (Option 1) however this does not always occur because emergency response crews will not usually be able to determine the location of other utilities below ground in a timely manner when assessing if the replacement pole can be situated in a more suitable location.

Ausgrid's preferred approach to managing the risks associated with vehicles colliding with poles is to target pole replacement based on the crash cluster analysis undertaken by RMS (Option 2). This collaborative approach optimises the management of risk appropriate for the expenditure, rather than totally eliminating the risk.

Further incremental risk reduction is gained when poles are positioned in a more suitable location when they are replaced based on their condition.

3.6 Costing and volumes

Blackspot poles are identified using 'crash cluster' information provided by RMS as well as Ausgrid pole replacement data where the work was initiated by third party damage to Ausgrid poles. During 2015-19, projects have been established for each high priority location identified by RMS (approximately 40 locations) - mitigation at each site involved relocation of numerous poles. These high priority locations are expected to be mitigated by the end of the current regulatory period. Crash cluster locations have not currently been identified for all of the 2019-24 regulatory period, however the forecast volume of individual poles to be relocated are expected to be similar to the current period given historical expenditure and completion of the high priority locations.

Blackspot pole replacement or removal is undertaken using a 'blended delivery' strategy for the program with each pole using either internal or external resources. This strategy creates healthy competition to achieve efficient outcomes and also allows for benchmarking between service providers.

The cost to replace a blackspot pole is typically higher per unit than other pole replacement work because blackspot poles are generally on major roads having more onerous requirements for negotiating road occupancy licences (ROLs) with RMS and increased traffic control requirements. ROLs may also limit the amount of time available to undertake works on the major roads resulting in the requirement for multiple visits to a site to complete the blackspot pole replacement and changeover works.

The 2019-24 summary forecast for this program is shown in Table 9. The costs shown are direct costs only. The forecast (which only includes the program for distribution poles as transmission poles are not expected to be replaced) assumes that each project will include replacement of single poles.

These programs form part of the overall investment being proposed for the replacement of poles. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details on the overall investment proposed for this asset category during the 2019-24 period.

Table 9. Forecast for Blackspot poles

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Relocate Poles in Blackspots - Distribution					
Volumes for replacement	10	10	10	10	10
Unit cost	$66,737	$66,309	$66,095	$65,959	$65,700
Total costs ($m)	**$0.67**	**$0.66**	**$0.66**	**$0.66**	**$0.66**

4 STEEL TOWERS

4.1 Program description

The refurbishment and replacement programs for steel towers address structural integrity issues associated with tower degradation or their inherent design. These programs are developed based on condition issues identified through tower inspections and condition assessments. Tower degradation and inherent design issues cause safety risks to the public, customers and workers if:

- The tower fails and falls to the ground, or
- The tower bends or leans too far and the overhead conductors attached to it are no longer at a safe distance from the ground, buildings, infrastructure, vegetation, vehicles or watercraft.

Ausgrid has two programs for the refurbishment or replacement of steel towers:

- Tower refurbishment (REP_05.02.01–3)
- Tower replacement (REP_05.02.01–5).

Ausgrid expects to spend approximately $16.6 million refurbishing 153 steel towers and approximately $5.1 million replacing 16 towers in the 2019-24 period.

Together, these programs mitigate the risk of towers collapsing due to corrosion, damage to buried footings or other severe defects. They are a continuation of existing refurbishment and replacements activities which commenced in the 2014-19 regulatory period.

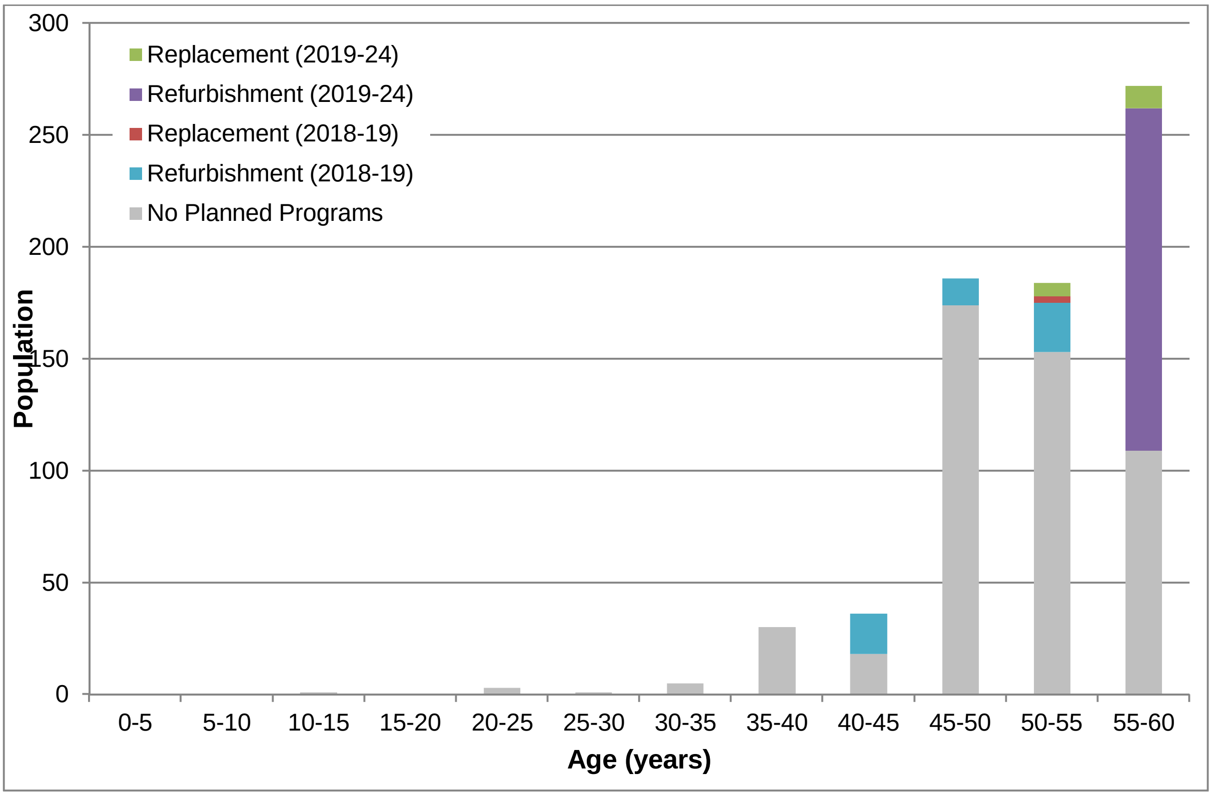
4.2 Background

Ausgrid has 736 towers on the network. The majority (714) support overhead conductors operating at 132kV, with the remainder (22) supporting overhead conductors operating at 33kV. The primary function of a tower is to provide the support necessary to maintain safe electrical clearances from overhead conductors and equipment to:

- The ground, buildings, infrastructure, vegetation or vehicles / watercraft
- Other live overhead conductors and equipment.

Steel towers have a standard technical life of 60 years if they have not been refurbished. It is expected that tower refurbishment will extend the life of a steel tower by 10 – 20 years (depending on their operating environment). The age profile of the towers is shown in Figure 6. The average age of these towers is 51 years - no towers are over their standard technical life of 60 years.

Figure 6. Age profile of steel towers (as at 30 June 2017)



4.3 Risks – Consequence and likelihood

The key consequences that can result following a loss of this function are shown in Table 10 below.

Table 10. Consequences from loss of function for steel towers

Consequence	Description
Harm to the public, communities and workers	Falling towers or contact with degraded or fallen live electrical conductors / equipment may cause injury (physical injury, electric shock or burns) or a fatality (electrocution).
	Fires (including bushfires) caused by vegetation contact with degraded or fallen live electrical conductors or equipment may cause injury (electric shock or burns) or a fatality.
	Safety issues as a result of loss of supply are detailed below.
Damage to property	Falling towers or contact between fallen live electrical conductors or equipment and buildings, infrastructure or vehicles / watercraft may cause arcing, fires or physical damage.
	Buildings, property, critical infrastructure or natural environments may be damaged by fires caused by vegetation contact with live electrical conductors or equipment.
Damage to the environment.	The natural environment may be damaged by fires caused by failed electrical conductors or equipment.
Loss of supply	Interruptions to electricity supply can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.

Consequence	Description
	Failure of steel towers may result in large supply interruptions and penalties or intervention by our regulator.

The need for tower refurbishment or replacement is driven by the risks which result from a functional failure. A functionally failed tower is one that has degraded to the point where it is no longer able to support the overhead conductors at the required safe electrical clearances. The reduced electrical clearances may be due to the tower failing and falling to the ground, or due to excessive tower bending or leaning.

Ausgrid utilises condition information from inspections and engineering condition assessments to determine when a steel tower is approaching functional failure and requires refurbishment or is to be replaced.

Failure modes associated with steel towers are deteriorating in nature and therefore present an increased likelihood over time. The main failure mode associated with towers is corrosion. This is a result of exposure to weather and harsh environmental factors over their operating life. Some types of steel towers (approximately 40 towers in total) have been assessed as being originally designed with insufficient strength to remain standing if a conductor failure was to occur.

The consequences and likelihood of a tower failure can increase due to a number of factors including:

- Its inherent design
- Being in areas prone to bushfire, storm activity or high winds
- Being in areas with unstable / moist soil
- Being in areas that are salt affected (coastlines) or highly polluted
- Being in areas with high pedestrian / vehicle activity or in close proximity to schools
- Supporting circuits which supply critical customers or infrastructure.

In the period from 2012/13 to 2016/17, there have been no tower functional failures. This is reflective of the current robust asset management practices for steel towers providing an understanding of their condition and therefore the likelihood of failure. Detecting failures before they occur and applying treatments maintains steel towers in a serviceable condition, limiting the likelihood of failure and mitigating the potential consequences described above.

4.4 Treatment analysis

Assessment of the treatment solutions considered for steel towers is shown in Table 11.

Table 11. Treatment options for managing steel towers

Tower options	Treatment Overview
1 Repair the tower	This option involves undertaking minor repairs to the tower. The typical cost for minor corrective work is approximately $10,000 per tower.
2 Refurbish the tower	This option involves refurbishment of a tower, including member replacement, re-painting and tower strengthening. The average cost to refurbish a tower is approximately $110,000.
3 Replace the tower	This option involves replacing the tower with new pole(s) of the same or new equivalent technology type. The average cost to replace a tower is approximately $320,000.

Repairs (Option 1) are an operational expense associated with maintaining the tower and may be undertaken where deemed practical and efficient. Repairs are typically minor condition issues (for example, corroded bolts or minor steel member replacement). If multiple or major repairs are required on an individual steel tower, it will be assessed for refurbishment.

Refurbishment (Option 2) is undertaken when more extensive condition issues are identified on a tower. Refurbishment involves replacing corroded steel members, removing existing paint coverage and then fully repainting the tower with modern corrosion protection coatings. Refurbishment provides life extension to an existing tower at a present value cost which is considerably lower than tower replacement and is currently the preferred option where it is possible to do so and achieve the intended life extension.

Assessing the sensitivity of the present value cost indicates that the life extension for refurbishment would need to be at or below five years with the current unit rates before replacement was the preferred option. Additionally, at a 15 year life extension, if the cost of refurbishment remains less than 72% of the cost of replacement, the refurbishment remains the most cost effective solution.

Lead paint has recently been identified on some towers and is currently being investigated. This may lead to a change in Ausgrid's tower strategy moving forward due to the cost and risks (safety risks to the public and workers and environmental contamination risks) associated with refurbishment of towers affected by lead paint.

Refurbishment cannot remediate all steel tower conditional failures or inherent design issues and therefore replacement (Option 3) will still be required for some steel towers. Ausgrid's preferred solution for steel tower replacement is to replace them with poles (steel or concrete poles). This solution reduces future maintenance costs.

4.5 Options

The treatment options available when considering steel tower management strategies are summarised in Table 12. These options are based on the need to undertake work on Ausgrid's tower assets when the condition is assessed to be unsafe when left as-is.

Table 12. Program options for managing steel towers

Program need options	Option overview
1 Reactive Treatment	Implement treatment such as repair, refurbishment or replacement when the tower fails.
2 Conditional Treatment	Implement treatment such as repair, refurbish or replace towers when individual inspections and condition assessments (based on a set of criteria) identify that they have deteriorated to the point of conditional failure.
3 Planned Treatment	Implement treatment such as repair, refurbish or replace the towers at the standard technical life of 50 years.

The consequence of a tower falling poses serious safety and loss of supply risks to the public, customers and workers. This option could also lead to major prolonged electricity outages due to long replacement timeframes required to replace a tower. Due to these risks, an approach that only manages these assets in a reactive manner (Option 1) is unacceptable.

The planned treatment option (Option 3) does not take into consideration the condition of the tower and would result in many assets being replaced prematurely (before they conditionally fail). In this case, 64% of the population would require treatment next period. As this approach will increase expenditure and failures, it was not considered an appropriate option.

Ausgrid's preferred approach for managing tower risks is to undertake a condition assessment of each steel tower utilising an inspection program or engineering audit and assessing tower condition to determine the most efficient treatment and timing. The effectiveness of the inspection and condition assessment process is such that this option provides a viable method to address the asset condition or inherent design flaws prior to failure, without treating the tower too early, maximising the life of the tower for minimal risk.

This approach optimises the management of risk rather than the long term sustainability of the steel tower population (average age). Ausgrid believes this to be the most appropriate approach as it defers short to medium term investment for customers particularly where new technologies may lead to further efficiencies or changes in the configuration and design of the 'network of the future'.

4.6 Costing and volumes

Steel tower treatment requirements are determined by conditional assessment at the time of inspection of the asset. The condition assessments also inform the appropriate treatment option that is required, i.e. refurbishment or replacement. The forecasts for the refurbishment and replacement programs have been based off the previous risk assessments undertaken by Ausgrid to maintain a sustainable tower asset base. The refurbishment program is currently being reviewed due to the identification of lead paint on many towers. The outcome of this investigation will determine the appropriate strategy (i.e. whether to refurbish or replace individual towers) however Ausgrid assumes that approximately 20% of the population of steel towers will be identified as requiring full refurbishment during the 2019-24 regulatory period, which is a decrease from the current period refurbishment rate.

Refurbishment of towers is delivered by external resources and is performed under market tested period contracts. Steel tower inspection and replacement is currently delivered by internal resources with a specialised skill set.

The 2019-24 summary forecast for these programs is shown in Table 13. The costs shown are direct costs only. The volume forecast is based on the assumption that 20% of towers inspected annually (30 of the 147 inspected) will require refurbishment and a small number of towers will require replacement based on insufficient structural strength under conductor failure situations due to their inherent design and lower peak wind loads used at the time of design.

A specific category for steel towers is not included in the Reset RIN template '2.2 REPEX'. Refurbish and replacement costs are not comparable against a steel pole however Ausgrid has aligned tower replacement to the 'POLES > 66KV & <= 132KV; STEEL' asset category and tower refurbishment has been aligned to the 'Other' asset category.

These programs form part of the overall investment being proposed for the replacement of poles and the 'Other' asset category. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for these asset categories during 2019-24.

Table 13. Forecast for steel towers

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Refurbishment of towers					
Volumes for replacement	33	30	30	30	30
Unit cost	$107,867	$107,952	$108,471	$109,168	$109,741

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Total costs ($m)	**$3.56**	**$3.24**	**$3.25**	**$3.28**	**$3.29**
Replacement of towers					
Volumes for replacement	3	4	3	3	3
Unit cost	$320,977	$320,253	$320,319	$320,687	$320,717
Total costs ($m)	**$0.96**	**$1.28**	**$0.96**	**$0.96**	**$0.96**