PWC Asset Class Management Plan

Poletop Assets

January 2023

PowerWater

Version control

This document has been approved in accordance with the Delegation of Authority (DoA) as evidenced by signatures and dates contained herein.

Rev	Date	Description	Author	Endorsed	Approved
1	17/01/2023	Revised and moved to new template	M Van Doornik Asset Engineer	B Kaye Manager Asset Strategy and Risk	S Eassie Senior Manager Asset Management

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1. Introduction

ISO 55000 defines an Asset Management Plan (AMP) as documented information that specifies the activities, resources and timescales required for an individual asset, or a grouping of assets, to achieve the organisation’s asset management objectives.

1.1 Purpose and context

The purpose of this Asset Management Plan (AMP) is aligned to the requirements specified in ISO 55000. This AMP:

- Defines what is included and exclude from its scope
- Describes the asset class being managed
- Defines how this asset class will contribute to achieving the Asset Management Objectives that are defined in the Strategic Asset Management Plan (SAMP)
- Identifies the challenges we are expecting to encounter over the AMP planning horizon
- Sets out the projects and programs that we will invest in to ensure we achieve the AM Objectives and address the identified challenges
- Quantifies the risk posed by this asset class with and without the proposed projects and programs of work.

By reviewing this AMP and reassessing asset performance on an annual basis, we will ensure that any emerging issues are identified and can be addressed prior to becoming a significant risk. The outcome of the annual review will support the annual update of the Statement of Corporate Intent (SCI) and provide an input into the annual Transmission and Distribution Annual Planning Report (TDAPR).

1.2 Scope of the AMP

This AMP covers the poletop hardware mounted on poles and towers and used to support and insulate the conductors. Poletop assets typically consist of crossarms, insulators, connectors, clamps and droppers.

The AMP excludes:

- Non-regulated or Indigenous Essential Services (IES) assets, nnoting that the same emerging issues and risks are similar across both populations and improvement plans are applicable.
- Pole and tower structures and conductors
- Other pole mounted assets such as transformers and switchgear

This AMP will avoid, as far as practicable, repeating information that is contained in other documentation. Instead, it will provide a reference to the relevant document or data source.

1.3 Timeframe of the AMP

This AMP is focused on a 10-year planning horizon, with respect to expenditure forecasts, that aligns with the requirements of the SCI and TDAPR. However, when assessing future challenges and emerging trends we may consider longer timeframes and will comment by exception if any longer term issues are expected to arise.

1.4 Asset management framework

Power and Water has a Strategic Asset Management System[1] which sets out the framework for asset management and the hierarchy of documents. This provides line of sight from the corporate objectives through to the asset objectives and how management of this asset class will contribute to achieving those objectives. Figure 1 highlights how the AMP fits in with the overall asset management system.

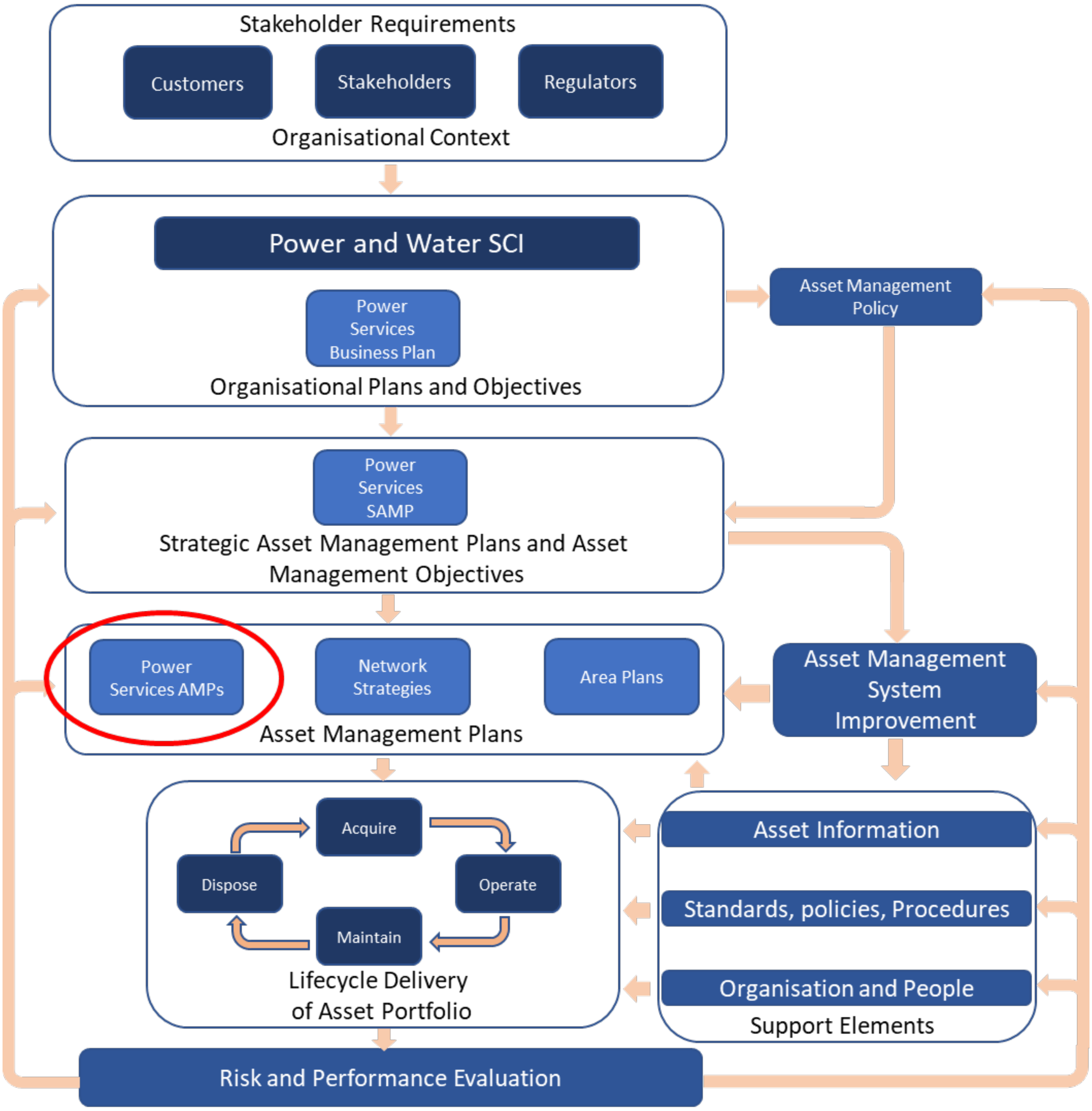

Figure 1 - The AMP within the context of the Asset Management System

[1] CONTROL0548

1.5 Document structure

This document has been structured to align with the Power and Water Asset Management Standard and fits under the SAMP in the hierarchy of documentation. The document has been designed to be concise and provide the outcomes of detailed analysis with references, and not repeat the analysis in this document.

The purpose of each section is described below:

- **Asset profile** provides an overview of what the asset is, to provide context to the reader of the asset's role in the electricity transmission and distribution network. It provides a breakdown by asset characteristics and volume, as well as the age profile which is an important input to asset management.
- **Asset objectives and performance** sets out the asset objectives and how they apply to this asset class. Any gaps or emerging trends are identified and linked to a project or program, if relevant, to address the issue and ensure the asset objectives are achieved.
- **Asset challenges and emerging issues** outlines any existing or emerging challenges that may impact the performance of the asset class or may otherwise impact the management of, or need for, the asset class.
- **Implementation plan** sets out the projects and programs with expenditure per year for the 10 year planning horizon. This is a point in time assessment that is updated periodically so it may not align fully to the SCI and TDAPR if additional analysis has been completed subsequent to the AMP update.
- **Risk quantification and mitigation** describes the approach to risk-based investment decision-making and demonstrates the risk mitigated by the proposed implementation plan.
- **Asset lifecycle management** describes the asset management approach at each stage in the asset lifecycle.
- **Continuous Improvement** outlines the improvement plans related to the asset class.

2. Asset profile

Power and Water owns and maintains a portfolio of 59,942 poletop assets across the four regions of Alice Springs, Darwin, Katherine and Tennant Creek, with the largest population in the Darwin Region.

The poletops function across the different network voltage levels including LV (400V) and HV (11kV, 22kV) and transmission (66kV, 132kV).

2.1 Fleet characteristics

Power and Water owns and maintains a portfolio of 3,296 transmission and 56,646 distribution poletop assets across the four regions, with the largest population in the Darwin Region. The elements that make up the poletop structure include the cross-arm, insulators, and fittings.

Poletop assets are used for maintaining safe conductor-to-conductor and conductor-to-structure clearances. The assets have a key function in the safe and reliable operation of the network.

Power and Water's 132kV and 66kV transmission network consist of mainly steel poles/towers and poletops. Most transmission structures are in the Darwin-Katherine Region with the remaining in the Alice Springs region. There are no transmission assets in the Tennant Creek region.

Distribution poletop assets are present in all regions and can be classified into Low Voltage (415V) and High Voltage (11kV, 22kV). Each distribution pole can carry multiple pole top assets, across both LV and HV, with the most on a single pole being five (2xLV + 3xHV).

Older poletops are typically steel crossarms which are welded to the steel pole. Wooden crossarms were historically used in some areas, but composite crossarms are used for all new HV applications due to their insulating properties and longevity. The vast majority of existing poletops are steel with the remainder composite and a very small number of wood.

Table 1 provides an overview of the asset class**.**

Asset type	Voltage	Quantity	Average age	Nominal lifespan
Transmission poletops	132kV	853	37	60 years
	66kV	2,443	47	60 years
HV poletops	22kV	28,742	34	60 years
	11kV	8,735	40	60 years
LV poletops	400V	19,169	39	60 years
Total	**-**	**59,942**	**37 years**	**60 years**

Table 1 - Overview of in-scope assets

2.2 Age profile

The age profiles provide an early indication of expected asset condition and potential life extension or renewal investment requirements. The asset age profile for poletops is shown in Figure 2.

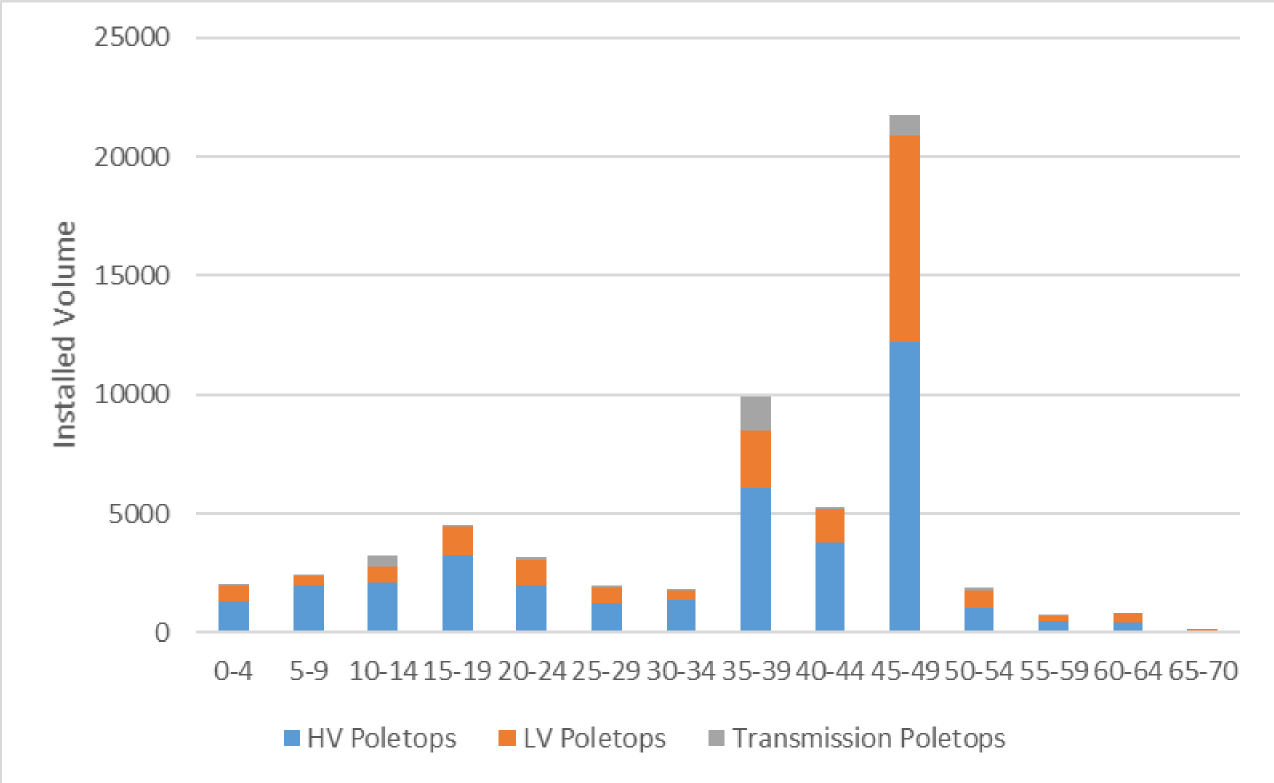

Figure 2 - Age profile for poletops

The age profile shows that most assets are well within their nominal life of 60 years.

Historically, poletops have not been managed as separate assets in our asset systems but as attributes against pole assets. As a result our poletop asset data is challenging to maintain, especially with regard to asset age, and it is likely that the actual age is slightly lower than what is reflected in the age profile. Section 8 discusses our improvement plan for poletop asset data.

2.3 Criticality

Power and Water has established a Risk Quantification Procedure for Investment Decision Making to assess the overall risk posed by the asset fleet. However, when undertaking detailed scheduling and prioritisation of assets within the fleet for specific tasks, such as testing and inspection or replacement, we consider the localised characteristics of individual assets to account for relative criticality within the fleet.

The criticality assessment considers the diversity of the network including impact on public safety, service disruption (reliability) or environmental incidents. The location of an asset has a significant impact on the likelihood and severity of the consequences.

Details of the criticality assessment approach can be found in our Health and Criticality Method (D2018/72550).

3. Asset objectives and performance

The Strategic Asset Management Plan (SAMP) defines the Asset Objectives and how they support Power and Water achieve the corporate objectives. This section shows how the Asset Objectives are supported by this asset class by establishing the measures and targets to assess if the Asset Objectives are being achieved, and any gap in performance that needs to be addressed.

Table 2 states the asset management objectives from the SAMP, identifies whether they are relevant to this asset class, and defines the measures of success, targets and performance gaps. This provides a 'line of sight' between the discrete asset targets and Power and Water corporate Key Result Areas.

The performance shown here represents the historical performance of the asset class to date. It is expected that benefits from investments proposed in the next regulatory period will manifest as benefits in these key objectives.

<table>
<tr><th>Objectives</th><th>Measures</th><th>Targets</th><th>Performance</th></tr>
<tr><td>Ensure appropriately skilled and qualified staff are employed to meet the current and future needs of the network.

Embed a fit for purpose Asset Management System across the business that is consistent across Regulated, Non-Regulated and IES.</td><td colspan="3">A capability development plan will include the requirements to ensure each asset class has defined capability requirements to enable effective management and performance.

The development of our Capital and Operational Works Plan (COWP) will define capacity requirements across different capabilities to achieve asset management objectives.</td></tr>
<tr><td rowspan="2">Maintain the safety of customers, community and staff demonstrated by reducing worker and public safety incidents and implementing public incident reporting metrics into asset plans.</td><td>Public injuries</td><td>0</td><td>0</td></tr>
<tr><td>Worker injuries</td><td>0</td><td>0</td></tr>
<tr><td>Reduce by 50% the number of feeders and communities exceeding performance targets by more than 100% by 2025.

Enable greater visibility of planned and unplanned interruptions to customers through improved online services for all networks and improve accuracy and transparency of</td><td>SAIDI and SAIFI targets.</td><td>Target by feeder type as set by the Utilities Commission.</td><td>Targets achieved. Refer to section 3.2</td></tr>
</table>

reliability performance metrics for isolated remote communities.			
Implement risk quantification for all regulated network (system) capital investment decisions by Jan 2023, and extend for remote generation and networks by 2025.	Implementation of risk quantification for decision making.	Use of Risk Quantification to assess investment needs for all aspects of the asset fleet.	Achieved.
Implement by EOFY 2023 asset criticality process to support granular prioritisation of corrective works based on public safety, reliability, security and other factors, and implement in the AMS and supporting systems by 2025	A quantitative criticality assessment criterion that can be integrated into defect management processes and supported by our ICT systems to be developed for all asset classes. A limiting factor for systemising this approach for poletops is the current asset hierarchy which prevents utilising some functionality in the AMS.		
Preparing our network and systems to be ready for the future, including building in flexibility for future uncertainty, maximising hosting capacity for customer DERs and enabling the energy transition to reviewable energy according to the governments targets.	Development of specific capability requirements for various asset classes is a key focus of our Future Networks Strategy to support increased utilisation of DER while maintaining safety and reliability performance.		

Table 2 - Asset Management Objectives

3.1 Reliability performance

The Utilities Commission requires Power and Water to report performance against targets for SAIDI and SAIFI, by feeder category and network region. We do not disaggregate the feeder category targets by asset class. Instead we assess the performance of each asset class to identify trends that require further analysis, and to determine if a specific program of works is required to support achievement of our targets at the feeder category level.

From a whole of system perspective, Power and Water has continued to improve its performance, although there has been mixed performance in each feeder category and region. These trends are discussed in the SAMP and are the subject of the network reliability performance improvement strategy.

Figure 3 shows the historical and forecast performance of the poletops asset class. The data shows that the average duration of interruptions experienced by customers due to poletop failures has decreased steadily over time. There has been one noticeable increase in SAIDI to 4 minutes in FY22, largely due to a single insulator failure in a key location.

Although there is some year-to-year variation, the SAIDI contribution of poletops appears to have stabilised at around 2 SAIDI minutes since FY16. This is a result of our ongoing feeder improvement programs which aim to target the worst performing feeders with reliability improvements such as insulator replacements, increased network automation, segregation and new HV feeder ties. We forecast a consistent reliability performance going forward.

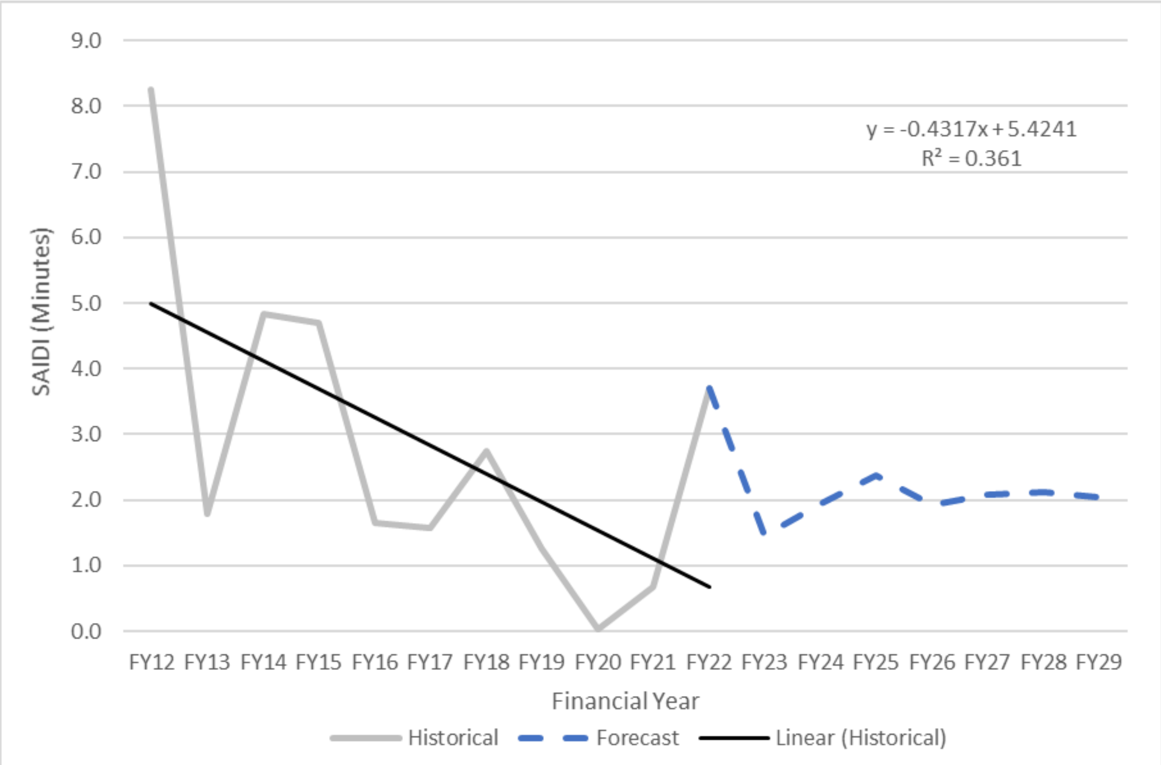

Figure 3 - SAIDI performance of the poletops asset class

3.2 Asset safety performance

Crossarm corrosion is a critical poletop failure mode which impacts public safety. Loss of steel section reduces the crossarm strength, eventually leading to the functional failure of the asset and conductor drops. We have identified an emerging issue with corrosion in transmission and distribution poletops in coastal areas around Darwin and have established capital replacement programs to address this issue.

Corrosion on transmission insulator strings can also lead to complete insulator failure and conductor drops. This is particularly the case on transmission poletops in lightning prone areas. We have established an insulator replacement program for our critical transmission lines to address this issue.

As all distribution poles are steel and conductive, a critical safety measure is effective earthing of poles to ensure reliable protection operation or reduce hazardous voltages under abnormal conditions or insulation failures. Low voltage failures are particularly difficult for protection systems to detect but can create a hazards situation for the public or operational teams interacting with poles. Earthing and bonding, including more detailed assessment in design stages for new developments is and will continue to be a strong focus area, particularly as a considerable proportion of the population of pole tops age, increasing corrosion risks for neutral and earth conductor bonds on crossarms.

4. Asset Challenges and emerging issues

4.1 Transmission line insulator degradation

Line inspections have identified corrosion on the 132kV feeders between Channel Island Power Station and Hudson Creek Terminal Station (CI-HC Line A and B). Particularly affected are sections of line between Channel Island and the Elizabeth River involving approximately 70 towers that traverse inter-tidal mangrove areas. Insulators that are damaged by lightning appear to be the worst affected. The failure mode associated with the corrosion issue is the mechanical failure of the insulator string, either due to the loss of steel section, or the corrosion affecting the grout which bonds the pin to the insulator.

4.2 Transmission line poletop corrosion

Feeder inspections have identified areas of advanced crossarm corrosion particularly on the 66kV Weddell to Strangways Zone Substation (66 WD-SY) transmission line. The aged assets on this line were noted as having particularly advanced levels of corrosion. The crossarm construction is unique in that hollow box section steel was used and not galvanised. This is thought to be creating a “micro-environment” inside the sections due to the humid conditions allowing corrosion to advance at a higher rate than observed on “Angle” or “Channel” section steel used elsewhere on the network. Wildlife nesting, particularly bats, and associated contamination is also a contributing factor to accelerate corrosion.

4.3 Bird damage to polymer insulators

Damage to polymer insulators from birds, particularly cockatoos and corellas, are an industry wide issue. The construction and maintenance advantages associated with polymer insulators is highly desirable, but the bird damage during construction or any extended line outages is common. Bird damage is less likely when the line is energised. When it does occur, it is usually superficial. Extensive testing of polymer insulators in external labs, and our own testing facility has proven their insulating performance after limited damage and flashovers, however bird damage in construction scenarios is often too extensive and completely compromises the insulator.

To mitigate this in new construction, where the exposure to birds is highest, porcelain insulators are assessed in design stages based on risk of bird damage. Maintenance and refit programs (often performed live) utilise polymer insulators, reducing manual handling risks and improving efficiency.

4.4 Distribution poletop corrosion

The vast majority of HV and all LV crossarms in the coastal region of Darwin are steel as a result of reconstruction after Cyclone Tracey. These assets are starting to show signs of advanced corrosion defects. Routine inspections aimed at the early identification of asset condition issues has been found to be ineffective when assessing corrosion degradation and the remaining mechanical strength in poletop structures. In most cases, it is only when severe material decay becomes visible that an assessment is made. This advanced stage of deterioration is preceded by a gradual decay in mechanical strength that is not easily identifiable during routine inspections. Pole top failures can cause poles to become live, particularly in LV scenarios. HV protection will reliably operate for HV failures, however there is still a significant public hazard if conductors fall in residential and high traffic areas until the fault is detected and cleared.

4.5 Earthing and neutral bond condition for LV pole tops

All poles supporting LV have a short bonding conductor installed between the neutral conductor and the crossarm, noting that all LV crossarms are steel. This ensures that even in poor soil conditions that a failure of LV insulators or conductor insulation, any hazardous voltage is as low as practicable and ensure that protection devices operate whenever possible.

Visual inspections have historically been the primary control measure, however this is becoming inadequate as increasing corrosion and its impact on connection effectiveness is not reliably detectable in this way. As age increases, the likelihood of poor connections increases. Improvements using higher definition cameras and drones will improve the identification of severely corroded bonding connections, but a more robust process to measure effectiveness is in development.

5. Implementation plan

The following set of projects and programs have been developed to address the gaps in asset performance compared to the asset objectives and our long-term view to start planning for forthcoming asset challenges.

5.1 Replacement expenditure

Replacement expenditure is defined as work to replace an asset with its modern equivalent where the asset has reached the end of its useful life. Capex has a primary driver of replacement expenditure if the factor determining the expenditure is the existing asset's inability to efficiently maintain its service performance requirement.

The identified projects and programs are listed below. The indicative cost (real FY22) of the project or program for the 10-year horizon is provided and includes the entire project, not only the poletops component:

- All regions condition and failure-based replacement program ($ 55.6 million)
- Alice Springs - replacement of corroded poles ($19.5 million)
- Cockatoo conductor replacement program ($7.9 million)
- Transmission line poletop corrosion replacement program ($4.7 million)
- SY-HD 66kV line conductor clearance ($4.4 million)
- Coastal poletop corrosion replacement program ($0.8 million)

5.2 Augmentation expenditure

Augmentation expenditure is defined as work to enlarge the system or to increase its capacity to transmit or distribute electricity. It also includes work relating to improving the quality of the network, for example, to meet regulatory obligations.

The identified projects and programs are listed below. The indicative cost (real FY22) of the project or program for the 10-year horizon is provided and includes the entire project, not only the poletops component:

- Transmission line uprating ($7.1 million)
- Power quality compliance program ($6.8 million)
- Low clearance or easement compliance ($3.5 million)

5.3 Operational expenditure

The forecast annual expenditure on maintenance activities is outlined in Table 3 below.

Maintenance Type	All Assets	Poletop
Routine Maintenance	$7.0	$0.2
Non-Routine Maintenance	$7.7	$0.15
Emergency Response	$7.6	$2.5
Total	**$22.3**	**$2.85**

Table 3 - Forecast annual maintenance expenditure ($ Million FY22)

5.4 Delivery plan

There have been a number of challenges during the current regulatory period that have resulted in under-delivery of capital plans. We have undertaken a detailed analysis of our internal processes and activities to identify the causes and compiled a detailed plan to address this issue. The analysis and resulting plan to enable delivery of the proposed program of works is described in our Capital Delivery Plan.

6. Risk quantification and mitigation

Power and Water has established a Risk Quantification Procedure for Investment Decision Making to assess the overall risk posed by the asset fleet. Our procedure considers the asset's condition and failure modes, the likely risks of failure on safety, security and reliability of services to customers, and the relative maintenance and capital costs. In some cases, our decision making will be influenced by demand growth or customer upgrade requirements. Essentially, our decision making is based on an economic assessment of risks, costs, and benefits.

Figure 4 below shows our forecast of risk on the network that is contributed by the pole tops asset fleet. The unmitigated risk shows increasing risk cost if no actions are taken to address known issues. The mitigated risk shows the risk will continue to increase but at a lower rate. The current risk level provides a reference to the current level of risk.

The analysis presented in Figure 4 is based on the transmission tower pole top program. While pole tops are replaced as part of other programs, such as the Alice Springs corroded poles replacement and Cockatoo Conductor replacement, the risk benefit attributed to pole tops has not been isolated and has total risk benefit has been allocated to the main asset class for the program.

The risk incurred by the transmission pole top replacement program is found to be increasing. This is considered to be a reasonable outcome as the assets being addressed are part of the two transmission lines that connect Darwin to the Channel Island Power Station. All pole top assets are of similar age so would expect to be in similar condition, while our capacity for replacement is limited. Hence, the risk from asset deterioration is increasing at a faster rate than we are currently able to address it.

During the planned replacement program, we will continue to refine our approach to identifying deteriorated pole tops, improve our approach to replacement and refine our assumption in the risk analysis as our knowledge improves.

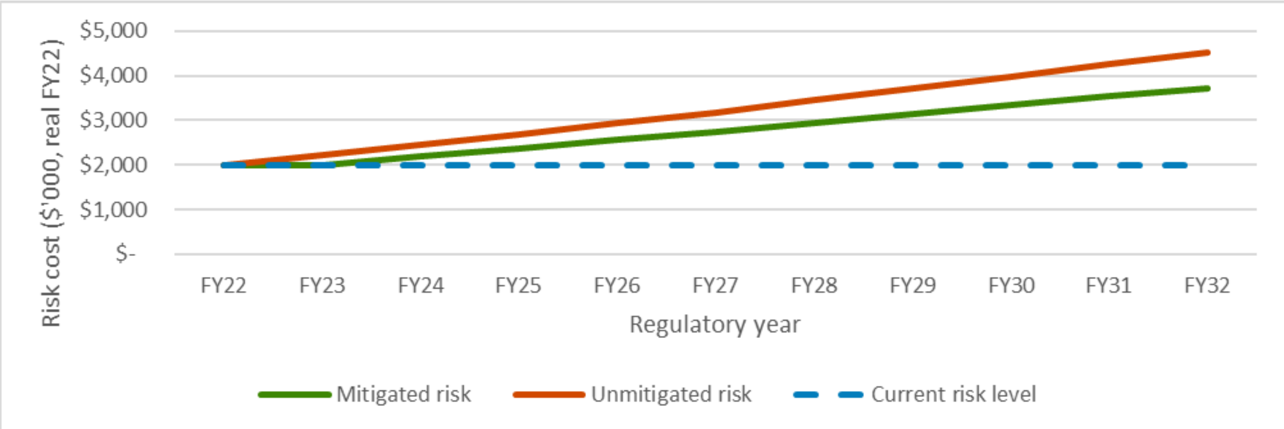

Figure 4 - Forecast total unmitigated and mitigated risk compared to the current risk level

7. Lifecycle asset management

Power and Water's asset management approach considers the entire asset lifecycle. This approach supports prudent asset management decision making to effectively balance risk, cost and performance over the life of the asset. The intended outcomes of a lifecycle approach are to:

- Maximise asset utilisation
- Minimise asset lifecycle costs
- Keep asset risk as low as reasonably practical
- Review and continuously improve asset management practices

The following sections detail Power and Water's lifecycle management activities.

7.1 Planning

Asset planning identifies the need for an asset, outlines its functional requirements, and identifies the lowest cost solution that maintains risk within tolerable levels. Key planning inputs include asset condition, performance, criticality, and forecast demand.

For poletop assets other planning considerations are environmental constraints such as proximity to coastal areas and exposure to lightning.

7.2 Design

The design phase involves the detailed specification of the asset function and physical characteristics.

Power and Water develops and maintains standard designs and technical specifications for most distribution assets, including distribution poletops, all new distribution assets installed in the Power and Water network must comply. Standardisation has many benefits, including staff familiarity, asset and component interchangeability, increased production and productivity, and standardisation of construction equipment and processes. This is especially the case for assets with a high volume of installation and replacement.

Distribution poletop standards have evolved as condition issues emerged and newer technologies have become available. Steel crossarms are being phased out in favour of fibreglass crossarms due to their insulating properties and corrosion resistance. Similarly, porcelain insulators are no longer used, having been replaced by polymer units.

Transmission assets have a relatively low volume and new assets are installed infrequently. As a result, Power and Water does not have standard designs for transmission assets, instead utilising the latest industry standards and detailed design process to optimise cost, performance and operating life for new transmission poletops.

7.3 Maintenance

Asset maintenance involves the upkeep of assets to ensure they will function to their required capability in a safe and reliable manner from their commissioning through to their disposal. Maintenance requirements can evolve as the condition and performance requirements of the assets change throughout its life.

Maintenance activities can be classified into three distinct areas:

- **Preventative maintenance** involves the activities carried out to reduce the probability of failure or degradation of asset performance. It includes routine inspection and monitoring, upkeep and repair, testing and component replacements. Preventative maintenance requirements are documented in our Asset Strategies Procedure. For distribution poletops we do a routine visual inspection. Transmission poletops undergo a similar visual inspection and a subset of lattice towers are climbed to enable closer inspection to detect any emerging issues. Transmission lines are also subject to an annual aerial patrol in which a helicopter is used to rapidly assess all transmission line assets following the storm season
- **Corrective maintenance** involves planned activities to repair defects or restore asset condition. Defects are typically identified during preventative maintenance and are prioritised for rectification based on the risk they pose to the network.
- **Unplanned maintenance** involves activities to immediately restore supply or make a site safe in response to asset functional failure.

7.4 Renewal

Asset renewal is the establishment of a new asset in response to an existing asset's condition, or the extension of life of an existing asset. The need for asset renewal is typically identified during maintenance, and is verified in the asset planning stage. Asset renewal aims to optimise the utilisation of an asset whilst managing the safety and reliability risk associated with the failure of the asset.

Where it is practical to do so, Power and Water has targeted asset replacement programs which aim to proactively replace assets when the risk of asset failure is higher than the cost of the replacement. In some cases proactive replacement is not justified and the asset is replaced upon failure.

Section 5 outlines the implementation plans relevant to poletops.

7.5 Disposal

Assets are assessed for potential reuse prior to disposal. Where it is economical to do so, assets may be retained as essential spares or components of the asset salvaged for spare parts. This is particularly the case for legacy assets since like-for-like replacements may not be available. Assets with remaining value are offered for sale prior to disposal.

Power and Water ensures that all assets identified for disposal are disposed of in an environmentally responsible manner.

8. Continuous improvement

Table 4 below outlines the improvement plans related to the asset class.

Improvement Area	Today	Tomorrow / In Development	Future
Asset inspection (distribution)	Visual inspection of pole and tower assets using check sheets	Develop asset inspection manuals and training materials and competencies. Improve techniques using imagery, drones, particularly for corrosion identification.	Risk based application of specific inspection techniques to improve efficiency in urban vs rural areas. Diagnostic techniques for corrosion measurement.
Asset inspection (transmission)	Ground-based visual inspection and helicopter patrols. Tower climbing.	Review options to improve data quality such as drones / LIDAR and data management.	Improve diagnostics and detection of developing failures.
Asset data	Poletop data held as attributes against a pole asset. Data is inconsistent and difficult to analyse.	Poletop data improvements to support planning and optimisation	Poletop assets created and maintained in our asset system.
Defect prioritisation	Prioritisation using high level risk assessment and staff experience	Systemisation of asset criticality and improved failure codes	Risk based defect prioritisation supported by asset systems
Earthing and bonding	Visual inspection of service wire connections and general pole top design	Review testing and condition assessment requirements for neutral bonds and implement neutral bonding strategy	Advanced smart meter diagnostics to detect neutral integrity issues.
Design and construction standards	Embedded robust standards and performance	Investigate improved wildlife protection options and review of LV crossarm standards	Maximise reliability and safety of pole top design.

Table 4 - Asset improvement plan

Power and Water Corporation

Senior Manager Asset Management
Power Services
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