PWC Asset Class Management Plan

Distribution Switchgear

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 following distribution switchgear:

- Pole mounted HV and LV switchgear, including recloser (GCR), Air-Break Switch (ABS), Gas-Break Switch (GBS) and Expulsion Drop-Out fuse (EDO)
- Ground-mounted HV and LV switchgear, including Ring Main Units (RMU) and LV pillars

The AMP excludes:

- Non-regulated or Indigenous Essential Services (IES) assets that are managed by Power and Water

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.

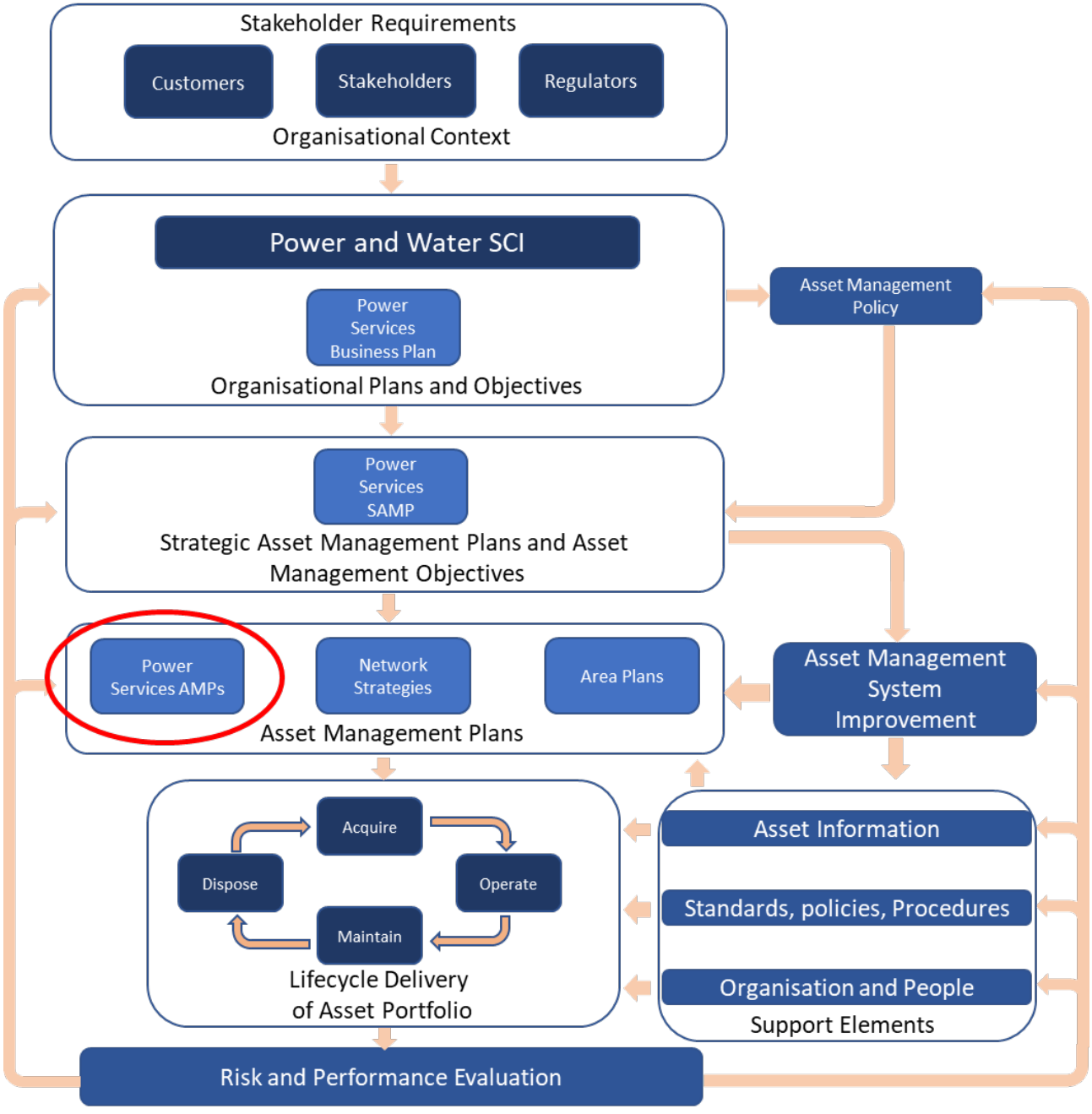

Figure 1: The AMP within the context of the Asset Management System

[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 volumes 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 project 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 14,155 distribution switchgear assets across the four regions of Alice Springs, Darwin, Katherine and Tennant Creek, with the largest population in the Darwin Region.

The distribution switchgear functions across the different network voltage levels including LV (400V) and HV (6.35kV, 11kV, 22kV). The asset class for distribution switchgear can be broken down into the following subclasses:

- **Recloser** - pole mounted HV switches which improve network reliability by sectionalising automatically
- **ABS** – pole mounted HV load break switch which is manually operated
- **GBS** – pole mounted HV load break switch which is manually operated and sealed by SF6 in a metal enclosure
- **EDO** – pole mounted HV fuse which isolates upon fault, and can be used to isolate supply
- **Metal-clad RMU** – ground mounted HV switchgear sealed in an earthed metal enclosure
- **Non-metal-clad RMU** – ground mounted HV switchgear encased in a solid insulating material
- **Pillar** – ground mounted enclosure which houses LV cable terminations and switchgear

Distribution switchgear is equipment used to, isolate and protect distribution transformers, transfer load between distribution feeders, relocate distribution feeder open points, to create points of isolation to enable work to be performed safely on the distribution network or isolate faulted equipment from the rest of the network.

2.1 Fleet characteristics

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

Asset type	Quantity	Average age	Nominal lifespan
Recloser	220	6	35 years
ABS	322	40	35 years
GBS	534	13	35 years
EDO	3,415	31	35 years
RMU (metal clad)	1,151	16	35 years
RMU (non-metal clad)	731	22	35 years
Pillars	7,782	22	35 years
Total	**14,155**	**23**	-

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 overhead HV switchgear, underground HV switchgear, and LV pillars are shown in Figure 2, Figure 3 and Figure 4 respectively.

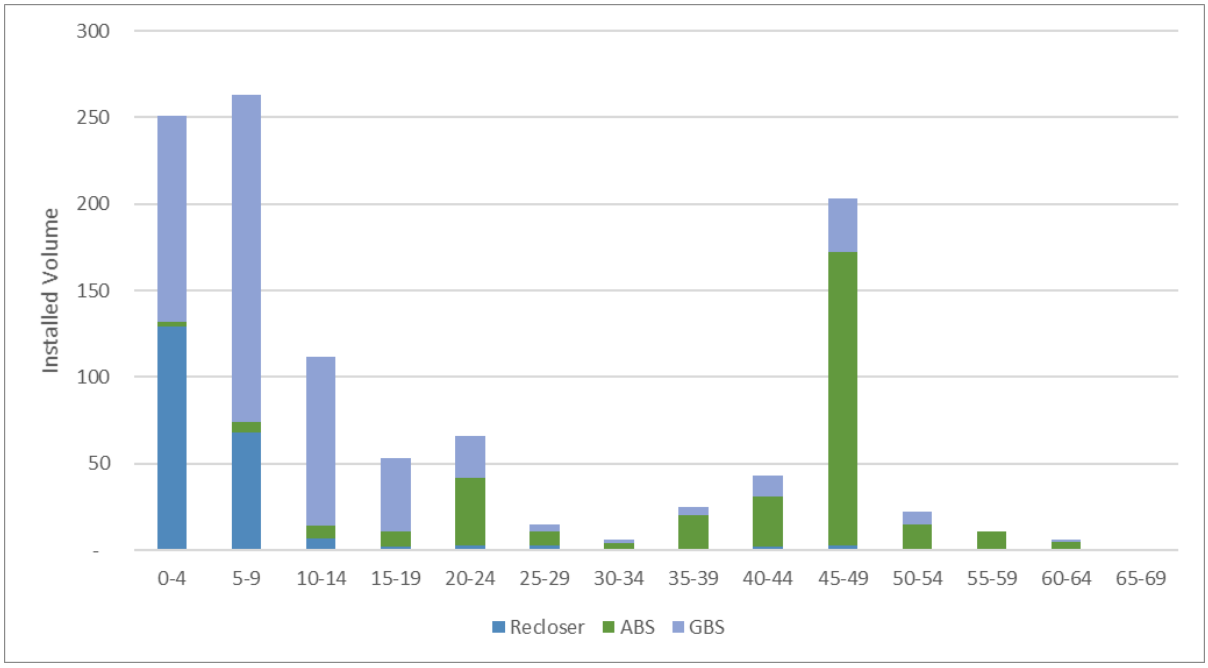

Figure 2 – Age profile for pole-mounted HV switchgear

The age profile for overhead switchgear shows a large cohort of aged ABS units exceeding the nominal life of 45 years, whereas the recloser and GBS populations are much younger with few assets exceeding nominal life.

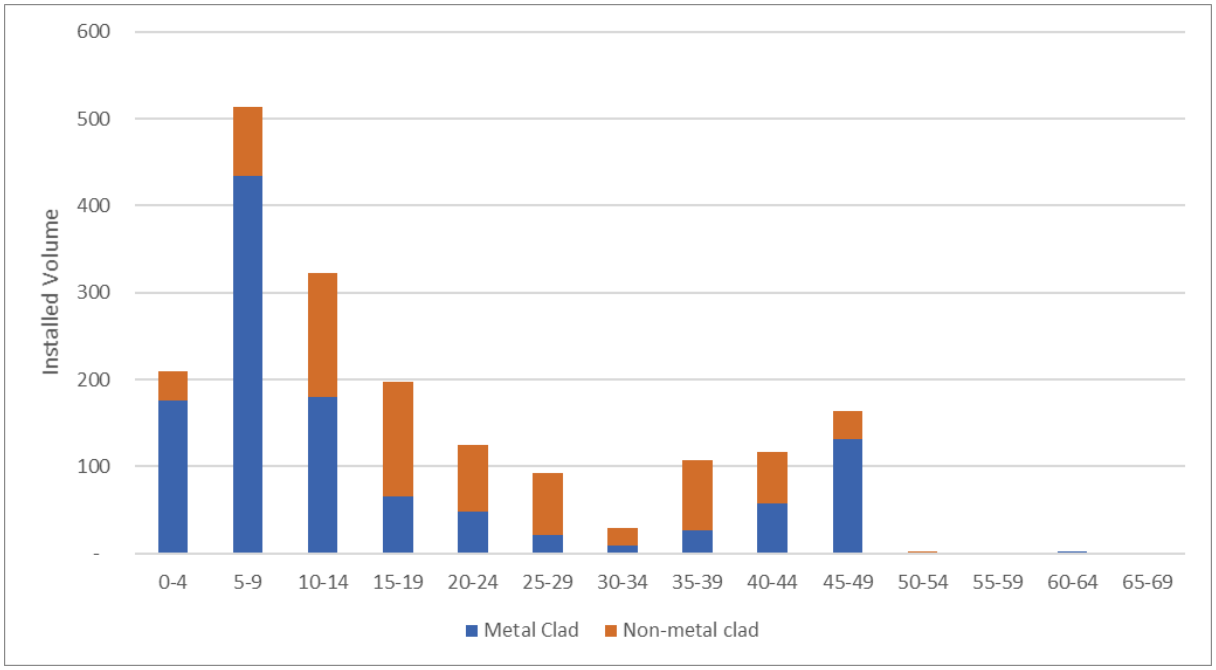

Figure 3 – Age profile for ground-mounted HV switchgear

The age profile for ground-mounted HV switchgear shows a young asset group, with relatively few assets currently exceeding the nominal life of 45 years. The metal-clad switchgear aged more than 40 years are an oil-immersed RTE switchgear which are being phased out and replaced with modern gas-insulated units. The age profile also shows that modern metal-clad RMUs are being increasingly used in favour of the non-metal clad units. This is due to the improved safety and reliability performance and higher capacity ratings of the metal-clad units.

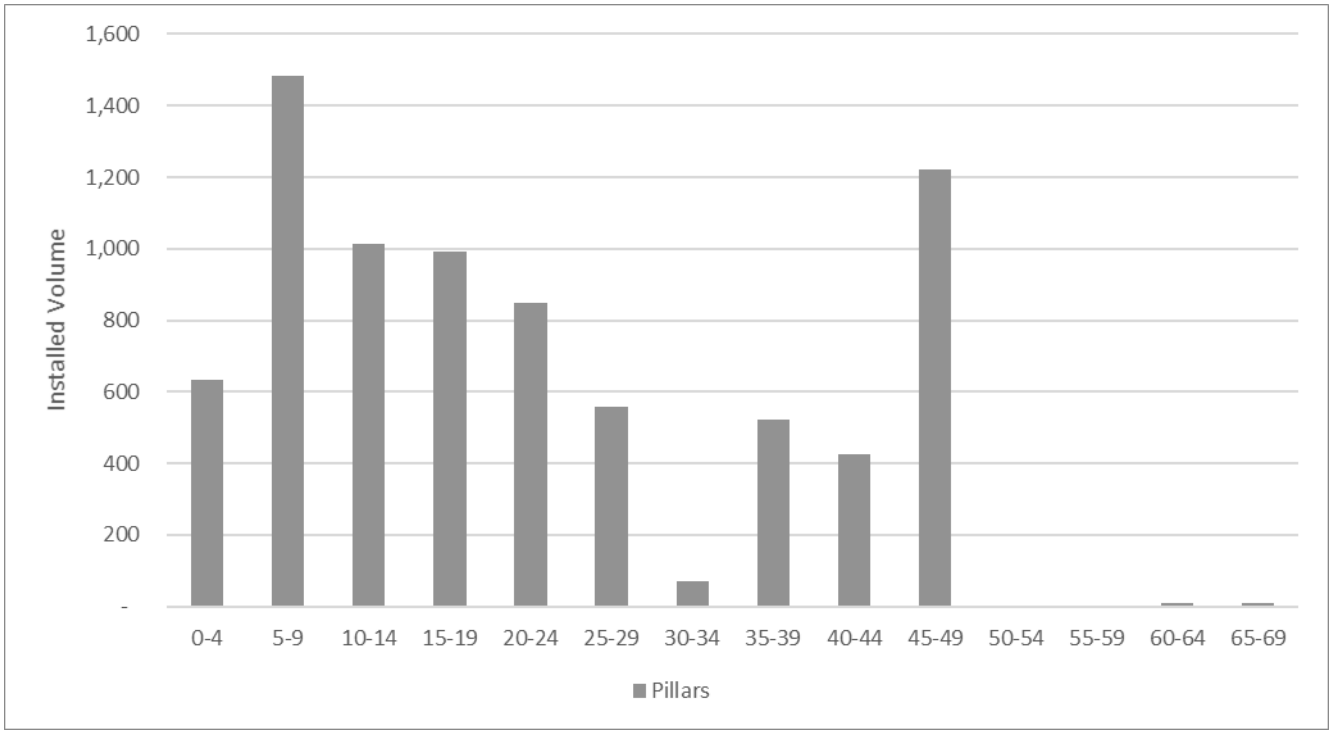

Figure 4 – Age profile for LV pillars

The age profile for LV pillars shows a young asset group, with the exception of a large cohort of older units installed in the wake of cyclone Tracy and the rapid development of new underground suburbs in the 1980s.

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 achieving 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.

Objectives	Measures	Targets	Performance
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.	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.		
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.	Public injuries	0	0
	Worker injuries	0	0
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	SAIDI and SAIFI targets.	Target by feeder type as set by the Utilities Commission.	Targets achieved. Refer to section 3.2

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.		
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 5 shows the historical and forecast performance of the distribution switchgear asset class. The data shows that the average duration of interruptions experienced by customers due to switchgear failures has

decreased over time on average. However, there was a noticeable increase in SAIDI in FY21 due to a single outage caused by mechanical failure of an overhead Air Break Switch during operation.

While there are still a significant volumes of Air Break Switches, they are being phased out in favour of gas break switches upon failure or opportunistically during other network upgrades.

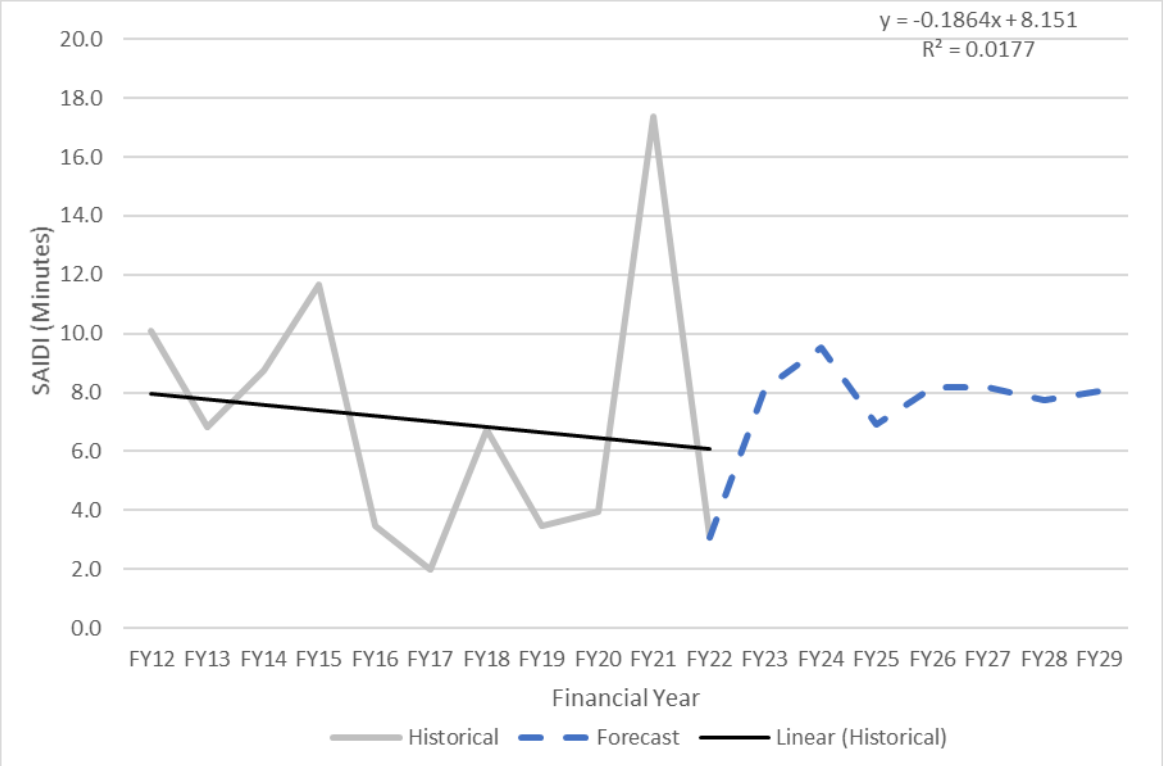

Figure 5 SAIDI performance of the distribution switchgear asset class

3.2 Asset safety

The number of safety related events associated with distribution switchgear for the past 10 years are documented in Table 3. The majority of these incidents relate to distribution pillars, and these are a key public safety concern. The pillar safety issues are discussed further in section 4.2 and a risk-based replacement program is planned to address these issues.

Category	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	Total
Exposed		1	1	-	-	3	1	1			**7**
Vehicle / impact damage	2	8	6	7	25	19	10	6	1	3	**87**

Table 3 - Safety incidents in the last 10 years

An additional public and staff safety concern is the condition of our Magnefix MD4 distribution switchgear. These issues are discussed further in section 4.1.

4. Asset Challenges and emerging issues

4.1 Magnefix MD4 non-metal clad switchgear

Prior to the implementation of a planned replacement program in the current regulatory period, the failure rate associated with Magnefix switchgear had been increasing. The consequences of these failures, while not yet resulting in injury, have raised concerns in relation to the portfolio's condition and changes to maintenance practices have been implemented for units approaching end-of-life. The main failure modes observed are deterioration of the switchgear insulation due to harsh service conditions, and termination failures which can lead to explosive failures. Many of these installations are in public areas which presents an elevated safety risk to members of the public.

Compared with metal-clad switchgear, Magnefix switchgear has lower operator safety. There are no barriers present between the operator and the switchgear in the event of a switchgear failure or incorrect operation. In addition, all operations can only be performed manually with the operator standing directly in front of the switchgear. Our plans continue to focus on replacing these units in high-fault current public areas where the consequence of failure is highest.

4.2 Distribution pillar safety issues

Low voltage pillars mark the interface between Power and Water's distribution network and the service connection to a customer. A typical pillar can be used to supply between 4 to 8 residential customers depending on the demand load. They are in high pedestrian traffic areas and in close proximity or immediately adjacent to homes and businesses. Failed or damaged pillars create a health and safety risk for the public and operational crews.

The current fleet of turret pillars is exhibiting end of life issues, predominately caused by the deterioration of the covers, outer enclosures and damage to the base / foundations due to the operating environment. This includes prolonged exposure to heat and UV light, infestation of pests and dirt, subsidence of ground, humid environment created by water sprinklers in garden beds and impact from vehicles. This can lead to a high probability of live internal components/ busbars becoming exposed or easily accessible by the public and result in an elevated risk to public safety.

The risk to public safety is highlighted by the three recent network incidents that have occurred in the past two years. In two instances a cover was removed leaving exposed LV components in residential areas, while the third incident resulted in a member of the public receiving an electric shock from a pillar.

4.3 Automation and reliability of overhead switchgear

Automation, or remote controllability, of field switchgear in overhead areas provides network operators with visibility of faulted line sections and increases the speed of restoration. Targeted installation of this switchgear has contributed to improvements in customer reliability.

The reliability of electronic components has been an ongoing challenge, with the harsh operating environment causing premature failures. The time required to diagnose failures, particularly in remote parts of the network, delays return to service. As products evolve, compatibility issues also impact repair times. Detailed analysis of failure rates is in progress to better understand root causes and more appropriate failure response. To ensure supportability as the fleet of automated switchgear expands, the

impacts on resourcing in specialised areas of SCADA, communications and protection also require ongoing review to ensure the timely repair of defects.

High GBS failure rates including SF6 leaks and semaphore failures, as well as electronics reliability issues in those that have remote control, has meant that the fleet of automated GBS's require reassessment and likely removal. These are typically installed at critical switching points to support timely customer restoration and fault finding on long feeders in rural areas. A new solution for automation of critical switching points is required, including integration with control and communication systems, and physical construction standards for an alternative GBS make/model will need to be developed.

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 distribution substation component:

- All regions condition and failure-based replacement program ($ 55.6 million)
- Distribution switchgear replacement program ($8.5 million)
- Distribution pillars replacement program ($4.2 million)
- Cullen Bay and Bayview LV cable replacement ($6.8 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.

There are no identified augmentation projects or programs for distribution switchgear.

5.3 Operational expenditure

The forecast annual expenditure on maintenance activities is outlined in Table 4 below.

Maintenance Type	All Assets	Distribution Switchgear
Routine Maintenance	$7.0	$0.6
Non-Routine Maintenance	$7.7	$1.2
Emergency Response	$7.6	$1.1
Total	**$22.3**	**$2.9**

Table 4 - 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. Power and Water has 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 6 below shows our forecast of risk on the network that is contributed by the distribution switchgear asset fleet. The unmitigated risk shows increasing risk cost if no actions are taken to address known issues. The mitigated risk shows the risk cost is maintained if the suite of proposed programs is implemented. The current risk level provides a reference to the current level of risk.

The condition of Magnefix switchgear and emerging issues with distribution pillars are the key drivers of increasing risk in the unmitigated case. By addressing the known defects we are able to maintain network risk for this asset class. Our risk based economic analysis demonstrates that implementing the proposed replacement programs and reducing the contribution of risk cost is efficient and has a net benefit to our customers.

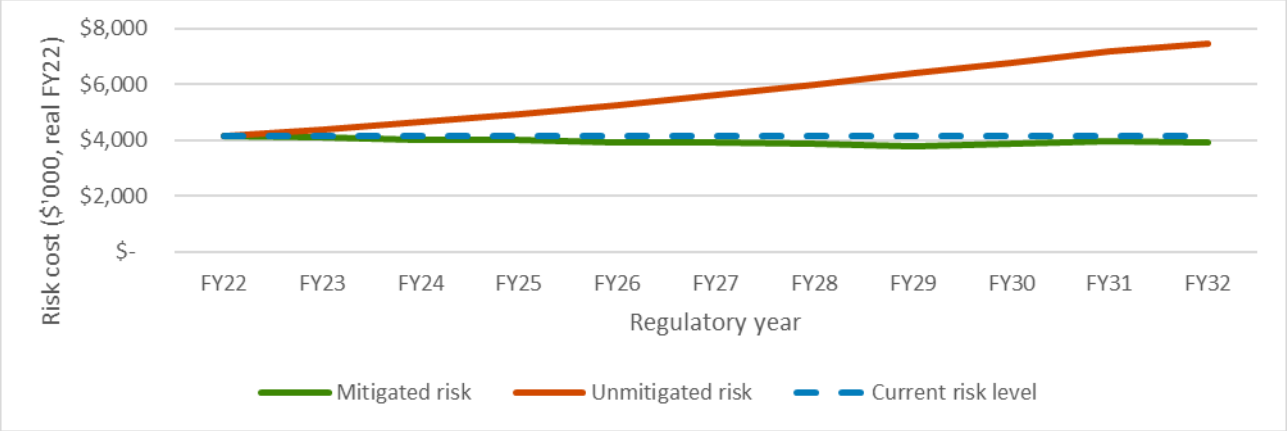

Figure 6 - Forecast total unmitigated and mitigated risk compared to the current risk level

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 distribution switchgear assets, other planning considerations are site selection, capacity requirements and environmental and cultural heritage constraints. Changes to system fault levels require careful consideration. In some parts of the network, fault levels have been increasing due to new generation coming online, which is causing capacity constraints on our older HV switchgear. In other areas the introduction of solar / BESS systems is causing ongoing reduction in fault levels, requiring the installation of additional distribution switchgear to ensure faults are reliably detected and cleared, and there is sufficient back up protection.

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 switchgear, and all new distribution assets installed in Power and Water's 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.

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 all distribution switchgear assets, we perform regular visual inspection,

partial discharge and thermographic scans. Additional maintenance is also performed on specific subclasses as follows:

  - Reclosers: Periodic protection testing is performed. It is critical that reclosers operate in accordance with their defined protection parameters to maintain the safety and reliability of the HV network
  - ABSs: Lubrication of units in critical locations to ensure that switches are operable when called upon
  - Magnefix MD4 switches: Regular overhaul of the units that meet a specific risk profile.
  - Remotely controlled switches: Batteries are replaced, and communication checked every two years

- **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 distribution switchgear.

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. Older distribution switchgear assets have the potential for PCB contamination in the insulating oil, so assets are tested prior to disposal. Newer switchgear assets are often insulated with SF_6 gas, which must be extracted prior to disposal. The recovered gas is provided to a recycling facility for re-use or disposal.

8. Continuous improvement

Table 5 below outlines the improvement plans related to the asset class.

Improvement Area	Today	Tomorrow / In Development	Future
Asset inspection	Visual inspection, partial discharge and thermographic scans	Develop asset inspection manuals, training materials and competencies	Improved defect categorisation and risk-based prioritisation
Defect prioritisation	Prioritisation using qualitative risk assessment and staff experience	Systemisation of asset criticality and improved failure codes	Risk based defect prioritisation supported by asset systems
Automation	Remote control and automation partially implemented. No automation of GBS.	Assessment of automation for options for critical switching points.	Switchgear automation and self-healing networks, support for ADMS or similar.
Supportability and reliability	Assessing performance of key switchgear types. Challenges with maintaining availability of some types, SF6 management.	Development of new standards for switchgear that address reliability and supportability issues	Improved options for switchgear selection and leverage latest technology, and reduce SF6.

Table 5 - Asset improvement plan

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