PWC Asset Class Management Plan

Protection

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 protection relay asset fleet separated into their respective technology level; digital, static, and electromechanical.

The AMP excludes:

- Non-regulated assets that are managed by Power and Water, noting the performance and emerging challenges are similar with non-regulated populations and improvement plans are also applicable.
- Other zone substation assets such as SCADA equipment, circuit breakers, or current and potential transformers

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.

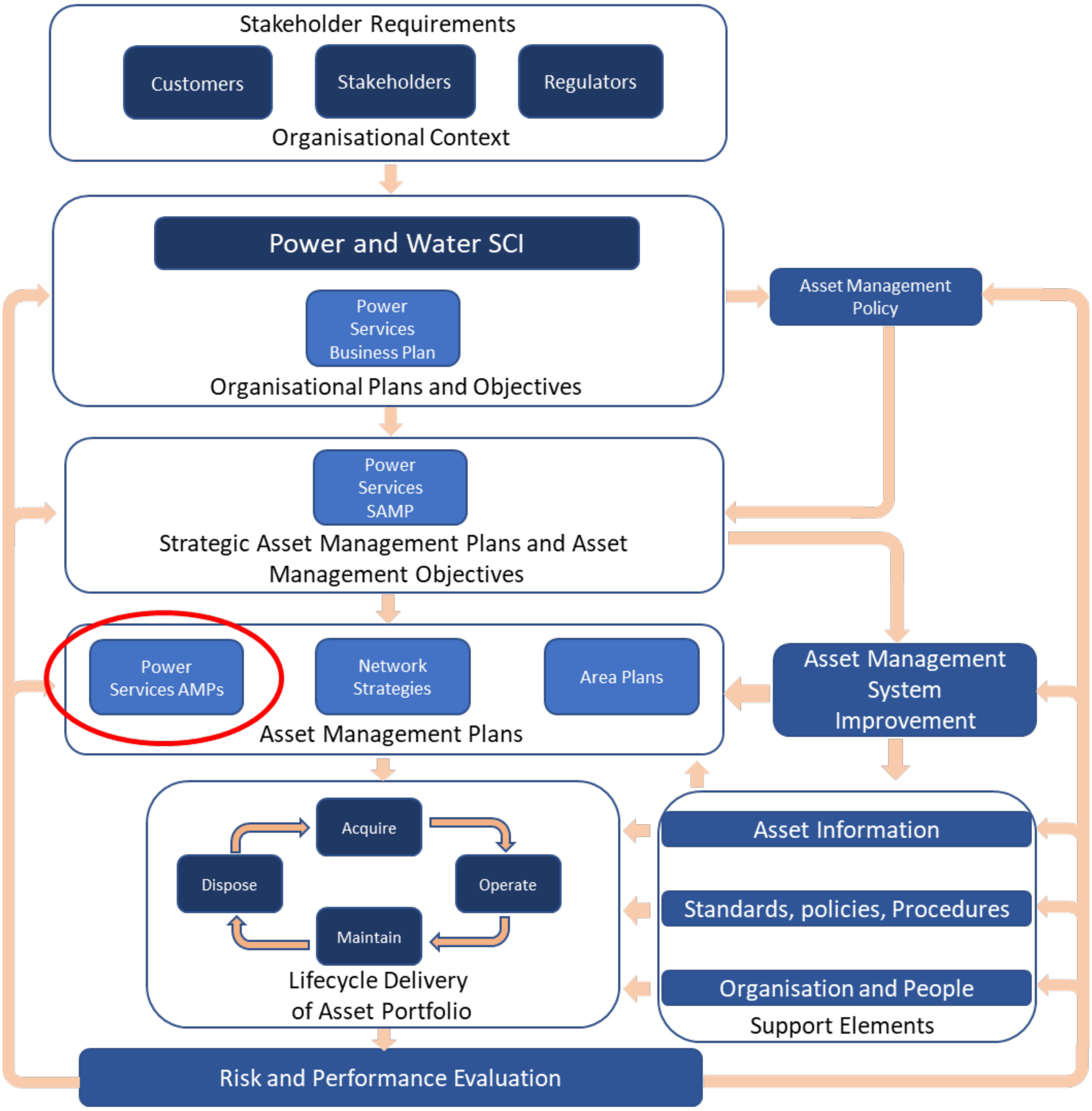

Figure 1: The AMP within the context of the Asset Management System

[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's protection assets are distributed throughout its network footprint, which covers the four regions of Alice Springs, Darwin, Katherine and Tennant Creek, with the largest population in the Darwin Region.

The underlying technology of protection devices can be broadly categorised into digital, static and electromechanical devices:

- **Digital relays** are modern microprocessor based devices which provide multiple types of protection. These devices have a significant advantage in self-diagnostic and communication functionality over other relays. They also have event recording capabilities with data capture which aid in fault analysis and investigations.
- **Static relays** are non-microprocessor based electronic devices which have few/no moving parts. These devices have a higher level of sensitivity than electromechanical relays but are representative of an older type of technology compared to digital relays. They generally provide only one particular protection function.
- **Electromechanical relays** are non-microprocessor based mechanical devices which rely on moving parts to function. These devices offer a single type of protection and represent the oldest type of technology.

The asset fleet varies greatly in make, model and type due to differing functions, circuit voltages, and the asset class being protected. Another key factor is protection relays have long expected lifespans (up to 30 years for electromechanical relays) which in conjunction with evolving technology results in a diverse asset fleet.

2.1 Fleet characteristics

Table 1 shows the population characteristics of protection relays. Approximately one third of the population are older-style static and electromechanical relays that have reached or exceeded their expected serviceable life.

Asset type	Quantity	% of total	Average Age (years)	Expected life	% exceeding lifespan
Digital	924	71%	10	20	8%
Static	383	29%	26	20	100%
Electromechanical	3	0%	37	30	67%
Total	**1,364**	**100%**	**8**	**-**	**25%**

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 protection assets is shown in Figure 2.

Approximately 25% of the protection relay population are exceeding their excepted lives, and by the end of the regulatory period this will increase further. The vast majority of those are static and first-generation digital relays, which are operating well beyond their expected design lives. There are also a small population of electromechanical relays remaining in operation and these should be replaced in the short term.

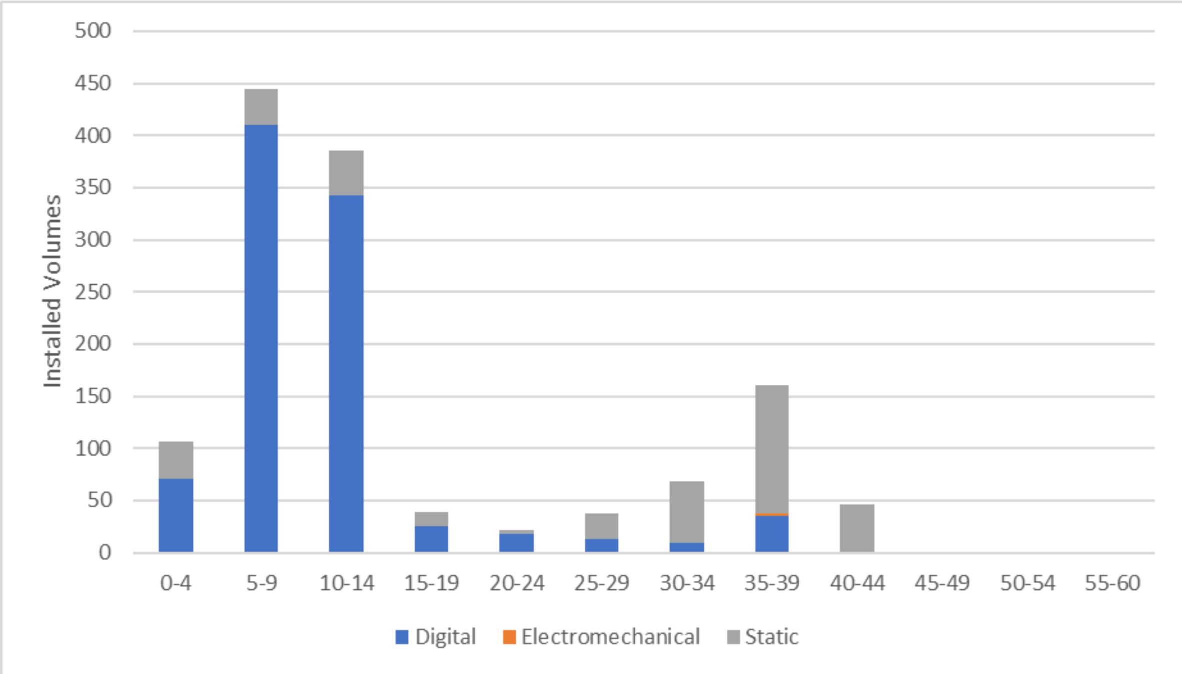

Figure 2 – Age profile by protection relay type

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. Reliability of protection systems the transition to highly renewable grid will require more frequent assessment of schemes, settings and present unique scenarios not previously seen in the Northern Territory.		

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. Power and Water does not disaggregate the feeder category targets by asset class. Instead, the performance of each asset class is assessed 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 protection asset class. Linear regression shows a decreasing trend over the past 10 years. The forecast performance is based on a rolling average of historical performance.

Since FY12 there have been 62 protection asset failures that have resulted in an outage. Except for FY16, the SAIDI contribution has been very low, averaging less than 1 SAIDI minute per year.

The 8 SAIDI minutes in FY16 were largely the result of a spurious trip on the Sadadeen to Lovegrove express feeders. Due to the small system size in Alice Springs, energisation of the large 66/11kV transformers results in an inrush current which is large in magnitude and duration and can results in spurious sensitive earth fault (SEF) trips. This issue has since been resolved by disabling SEF during transformer switching.

The other major incident in FY16 was the failure of a SPAJ relay at McMinns Zone Substation. Subsequent investigation determined the relay came from a faulty batch of relays, which have now all been replaced.

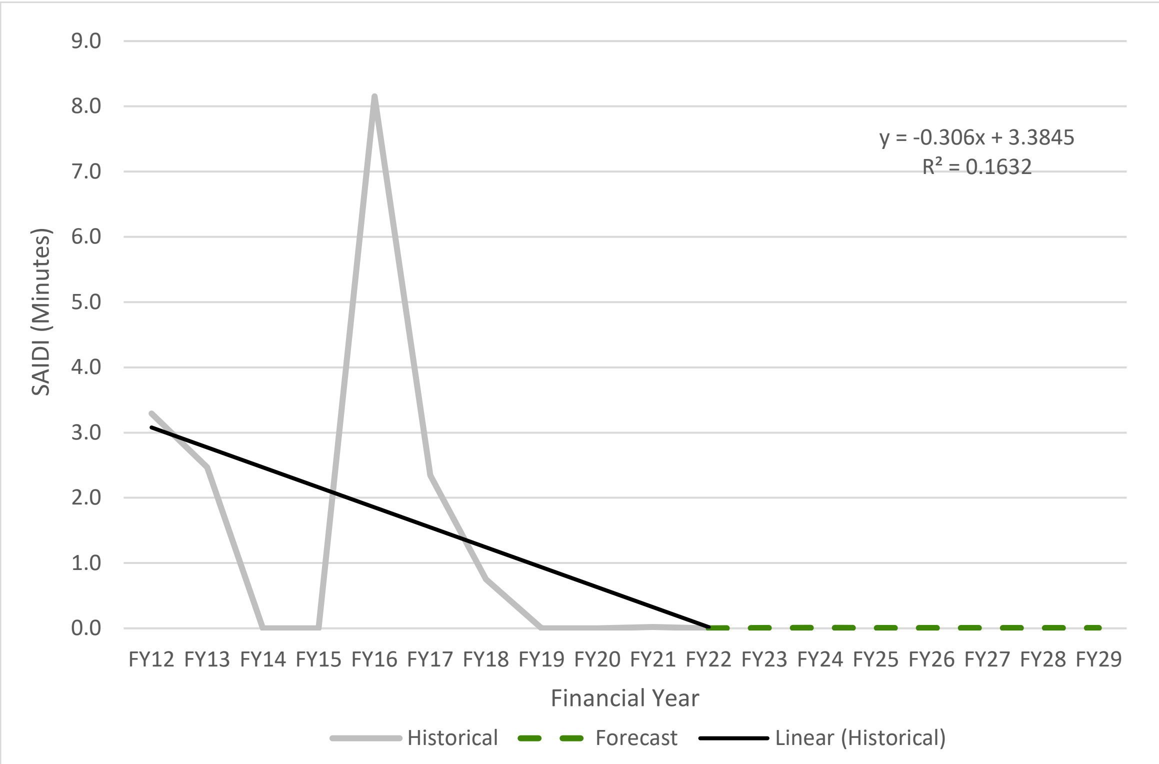

Figure 3 - SAIDI performance of the protection asset class

3.2 Safety performance

There were no safety incidents injuries or fatalities during the period of interest related to failure or maloperation of protection systems.

Incidents associated with failures of switchgear that have impacted the reliability of distribution protection have occurred. Lower fault levels on distribution feeders during minimum demand periods have increased the criticality of reclosers in the extremities of long rural feeders. Our response to these types of failures will need to change, and alternative schemes that can be implemented at short notice are required. These schemes prioritise protection outcomes when grading is unable to be maintained, which may increase spurious feeder interruptions because of more sensitive settings, ensuring network faults are detected and cleared.

4. Asset Challenges and emerging issues

4.1 Asset failure

Power and Water sets response timing thresholds that protection assets must meet to remain in operation. Inspection and testing are undertaken in accordance with maintenance policy (refer to Section 6); if a relay is found to fail testing, a defect report is raised to Power and Water Protection Engineers who then determine the most appropriate action to be taken on a case-by-case basis.

- Electromechanical and static relays demonstrate slower operating times as they age
- Power and Water does not have the required skills to recalibrate electromechanical relays. These relays need to be replaced once they exceed their tolerances

The operating time of digital relays can deteriorate with age. This is due to loss of electrolytic fluid from capacitors. Digital relays have other failure modes including; screen faults, faulty contacts, A/D converter fault, faulty module, and communications failures. When any of these failures occur, if the relays are still within warranty, they are returned to the manufacturer for replacement/repair and otherwise they are replaced.

The assessment of the required operating speed is undertaken on a case-by-case basis to ensure the maximum expected life of the relay is achieved within a tolerated level of risk. The acceptable operating speed will depend on the fault levels on the feeder, feeder location and type of load supplied.

4.2 Obsolescence

Relay obsolescence occurs through either the loss of ability to service specific relay types, or the end of production and support of models by vendors. The inability to provide adequate service to older relays is an industry wide problem which manifests for several reasons:

- Electromechanical relay assets have a 30-year asset expected lifespan
- The skillset required to monitor, maintain and repair electromechanical relays differs greatly from digital relays
- Older digital and static relays have a poor interface which makes repair and maintenance difficult
- Power and Water does not retain the skills to repair relays in-house. If digital or static relays are under warranty, they are returned to the vendor otherwise they must be replaced. Due to the low volume of electromechanical relays on the network, Power and Water does not retain the skills to maintain them in house

The end of support and production by venders has led to issues around part replacement, servicing needs, and manufacturer expertise.

4.3 Compliance

A key compliance driver for protection relays is the Network Technical Code and Network Planning Criteria. It requires that the protection system shall comprise two fully independent protection schemes of differing principle, connected to operate in a “one out of two” arrangement.

Power and Water has identified the lack of duplicate protection schemes on equipment operating at 66kV and above at Hudson Creek and Channel Island, which are both critical locations in the network.

Enhancement of these schemes has been occurring over several years and is often dependant or constrained by network outages and system security constraints. It is expected that all remaining issues will be resolved in the next several years.

4.4 Technology transition

Modern relays are based on microprocessor (digital) control and provide multiple protection functions within each device, diagnostic capabilities that support the required investigations into abnormal operations, and timely reporting to System Control. Modern relays are also able to communicate via the SCADA system and the restricted-access engineering ICT network to provide operational information to System Control.

Additional data logging from modern relays and substation data recorders enables:

- Data historian functionality to support analysis of substation operations during unusual events and to evaluate changes in loading, protection settings and system stability over time. Appropriate data logging to the broader corporate network allows the relay operating history to be accessed via the corporate ICT network, whilst restricting the critical control functionality to the restricted access ICT network
- Remote communication and/or control capabilities to enable the remote monitoring of status and the adjustment of protection settings without physical attendance at the substation

This functionality is not available on electromechanical and older static relays. It is now required for compliance with regulations and technical code reporting requirements and will become essential managing the increasingly complex highly renewables based grid.

4.5 Protection co-ordination challenges

In recent years the volume of new renewable generation connections and customer owned storage, generation, load management schemes and microgrids have meant that system studies for connections and alterations have increased in volume and complexity across the country.

This requires more detailed management of protection settings information and ideally deployment, verification and ongoing audit of setting changes to field devices, via secure and remote configuration systems, rather than physical attendance on site. Enabling remote access to protection devices will also mitigate risks during the wet season when some sites may be inaccessible.

Reduction in fault levels across the isolated power systems at different rates, or in step-changes, requires more frequent reviews of protection schemes and co-ordination. More robust schemes are required on transmission line between Darwin and Katherine as renewable generation on this line plays a more important role in the power system. Long rural feeders also become more difficult to manage with very low fault levels, also requiring frequent changes and in some cases alternative approaches to protection and sectionalisation to assist in fault finding.

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 protection component:

- Protection relay replacement program ($17.2 million)
- Replace Berrimah zone substation ($28.7 million)
- Tindal zone substation and feeder reconfiguration ($11.3 million)
- DKTL secondary systems replacement ($5.5 million)
- Alice Springs network reconfiguration ($4.2 million)
- Upgrade Humpty Doo Zone Substation ($2.8 million)
- Cosmo Howley Replacement ($0.6 million)
- Centre Yard Replacement ($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.

There are no dedicated augmentation projects, however, new relays will be installed as part of other augmentation projects such as Tindal zone substation and the zone substation reactor program.

5.3 Operational expenditure

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

Maintenance Type	All Assets	Protection
Routine Maintenance	$7.0	$1.2
Non-Routine Maintenance	$7.7	$0.3
Emergency Response	$7.6	$0.4
Total	**$22.3**	**$1.9**

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. Power and Water 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 Power and Water's 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 and enable consistent quantification of risk from their assets into dollar terms. 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.

The procedure is applicable to most assets where there is a direct link between an asset failure and the impact of that failure on the defined consequence categories. Sufficient network data also needs to be available to derive the required inputs.

Power and Water does not have adequate data to undertake a quantitative analysis for protection relays so a qualitative assessment of the risk, based on the key consequence areas set out in the Risk Quantification Procedure, has been undertaken.

The qualitative risk assessment of the inherent risk and targeted risk is shown in Figure 4 using the matrix approach set out in the Enterprise Risk Management Standard. It shows that the unmitigated risk is assessed to be High while the target risk that will be achieved by implementing the proposed programs of work will result is Low.

	Insignficiant	Minor	Moderate	Major	Severe
Almost certain	Medium	High	Very High	Extreme	Extreme
Likely	Low	Medium	High	Very High	Extreme
Possible	Low	Low	Medium	High	Very High
Unlikely	Low	Low	Medium	High	High
Rare	Low	Low	Low	Medium	Medium

Figure 4 Qualitative risk assessment

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.

The requirement for a new asset can be triggered by augmentation drivers, such as the connection of new customers or load growth on existing assets, or replacement drivers such as asset condition or performance issues.

The pace of change in the Territory's power systems requires more sophisticated modelling of power system response to abnormal conditions, directly impacting the criticality of protection design in the planning phases for new developments, particularly in the transmission system.

7.2 Design

Power and Water develops and maintains a Substation Design Manual which defines the functional requirements for zone substation assets, including protection systems, and allows for the standardisation of zone substation designs as far as is practicable, given the broad range of capacities and locations.

Standardisation enables consistent application of best industry practise and continuous improvement in safety, reliability, operability, and maintainability. It establishes technical commonality that allows for an off-the-shelf, best practice, and fit-for-purpose approach to engineering solutions. It also allows for interchangeability and reduced spares holdings that provides operations and asset management benefits.

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 digital relays we perform a regular trip check to confirm that the relay outputs are operating as expected. All relay assets undergo full functional testing periodically. Protection testing is aligned with maintenance on other assets in the same location to minimise the number of outages required. Test failures are reported to our Protection Engineers to determine the most appropriate action to be taken on a case-by-case basis.

- **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 protection assets.

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 data	Asset data maintained in spreadsheets with manual reporting	Create/update assets and transfer data into asset system (Maximo)	Automated quality reporting, aligned with other asset classes
Standardised design	Protection drawing and relay configuration templates for 66kV transmission line protection	Protection drawing and relay configuration templates for 66kV transformer protection	132kV line and transformer protection templates
Engineering access	Limited remote engineering access to relays for fault investigation and diagnostics	Developing an architecture and concept design for remote access to protection relays and achieves cyber security objectives	Remote engineering access to all protection relays, including distribution assets, reclosers
Settings management	Setting stored in files in document management system	Implement settings management system	Settings management system linked to power system analysis software
Substation digitalisation	Leveraging digital relay capability for fault investigation and complex schemes	Improved capability for renewable power system response, islanding and over-frequency.	Investigate implementation and supportability of 61850 in Territory context.

Table 4 - Asset improvement plan

Power and Water Corporation

Senior Manager Asset Management
Power Services
Phone 1800 245 092

powerwater.com.au