APPENDIX 5.12: ASSET SPECIFIC PLAN

Secondary Systems - Distribution Substation

Version Control

Date	Version	Description	Author	Reviewed
6/06/17	0.1	Initial Draft	RA	JC
21/09/17	0.2	Update asset charts, reference document details	PW	RA
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Approval

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Reference Documents

Document	Version	Date
National Electricity Rules	94	18 July 2017
National Electricity Law **– National Electricity (South Australia) Act 1996**	15.12.2016	
ACT Utilities (Technical Regulation) Act 2014		2014
Electricity Distribution Asset Management Policy PO1101	2.0	5/11/2015
Asset Management Strategy SM1192	1.0	14/11/2014
Asset Management Objectives		
Asset Management System Manual SM1193	1.0	14/11/2014
Asset Management Governance Framework SM1190	1.0	14/11/2014
Recovery and Disposal of Reclaimed Network Assets PR5017	1.0	4/11/2014
Environmental PCB Management Plan SM4606	3.0	23/02/2016

Table of Contents

Glossary

Term	Definition
EVOENERGY	Evoenergy Distribution
AEMC	Australia Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ASP	Asset Specific Plan
CAPEX	Capital Expenditure
CB	Circuit Breaker
CT	Current Transformer
FMEA	Failure Mode and Effects Analysis
HV	High Voltage
IED	Intelligent Electronic Device
kV	Kilovolt
LV	Low Voltage
MTBF	Mean Time Between Failures
NER	National Electricity Rules
NSP	Network Service Providers
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
OPGW	Optical Ground Wire
PoF	Probability of Failure
PoW	Program of Work
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
STPIS	Service Target Performance Incentive Scheme
UFLS	Underfrequency Load Shedding
VT	Voltage Transformer

NOTE

All analysis has been undertaken using 2017/18 real dollars unless otherwise stated.
Budgeted expenditure for CAPEX & OPEX excludes indirect costs.

Document Purpose

This document is an Asset Specific Plan (ASP). It specifies the activities and resources, responsibilities and timescales for implementing the Asset Management Strategy and delivering the Asset Management Objectives for a specific asset class. In conjunction with the other ASPs, it forms Evoenergy's Asset Management Plan, which describes the management of operational assets of the electricity distribution system.

Detailed in this document are the systematic and coordinated activities and practices whereby Evoenergy manages the asset class in an optimal and sustainable manner. Associated asset condition data, performance data, risks, and expenditure are presented and assessed over the asset life cycle for the purpose of achieving the organisational strategic plan.

As part of the assessment of asset management options, a recommended asset strategy is presented with associated Capital expenditure and Operational expenditure forecasts, including a 10 year budget forecast, for consideration by Evoenergy management.

This document has been developed based on good practice guidance from internationally recognised sources, including the Global Forum on Maintenance and Asset Management (GFMAM) and the Institute of Asset Management (IAM). It has been specifically developed to comply with relevant clauses of ISO55001.

Audience

This document is intended for internal review by Evoenergy management and staff. As part of legislative, regulatory and statutory compliance requirements, the audience of this document is extended to relevant staff of the ACT Technical Regulator and the Australian Energy Regulator.

1 Executive Summary

This Asset Specific Plan provides details of the Asset Management Plan specific to a particular asset class, and is an important part of the line-of-sight management of assets from the corporate objectives and strategy level down to the work execution level. For details of the asset management strategy, refer to the Asset Management Strategy document. For details of how the policies, principles and strategies from the asset management policy and strategy align with the ASPs that form the overall Asset Management Plan, refer to the Asset Management Objectives document.

Distribution substation protection assets are located in Evoenergy distribution substations and are used to isolate faulty electrical equipment within the substations and isolate faults which occur on any connected transmission lines or distribution feeders. The protection systems ensure reliable operation of the network by isolating faulty sections of the network, and ensure the safety of our staff and the community. The correct operation of the protection systems limits the impact of faults on system stability and any potential damage to network infrastructure.

Distribution substation protection must meet the requirements of regulatory authorities such as the Australian Energy Regulator (AER) as outlined in the National Electricity Rules (NER), and the requirements in the ACT Utilities (Technical Regulations) Act 2014.

This ASP adopts a risk-condition based approach in accordance with Evoenergy strategic direction to determine the optimal strategy to maintain and replace distribution substation protection assets over their lifetime. This approach considers alignment of secondary protection asset maintenance with the frequency of the primary equipment being maintained, and replacing assets based on their condition rather than age alone.

Accordingly, the condition of various types of distribution protection assets has been determined as the key criterion that underpins risk-condition based scenario planning analysis for the 2019-2024 regulatory period to choose the most viable option from:

- Option 0: Do Nothing. This option does not entail any maintenance or replacement and basically is a run to fail strategy that increases risk exposure from $23M in the current 2017 year to $77M at the end of the regulatory period, year 2024.
- Option 1: Existing Strategy at Current Expenditure Level. This option focuses on maintenance alone at the current interval of five years at the rate of $350k per annum. This strategy increases risk exposure from current levels of $23M to $50M by year 2024.
- Option 2: Reduce Cost. This option focuses on OPEX cost reduction. The asset maintenance is aligned with the primary equipment maintenance interval of five years for static and electromechanical protection assets and eight years for numerical protection assets. This strategy increases risk exposure from $23M in 2017 to $55.6M by year 2024.The annual OPEX budget reduces to $250k per annum.
- Option 3: Maintain Risk. This option provides cost optimisation in terms of maintenance based on Option 2 and replaces distribution protection assets based on condition monitoring to manage risk. This strategy maintains the current (2017) risk exposure of $23M at end of the regulatory period, year 2024. The annual OPEX and CAPEX budgets are each set to $250k.
- Option 4: Reduce Risk. This option provides cost optimisation by using the maintenance strategy of Option 2 and replacing distribution protection assets based on risk reduction and condition monitoring. This option reduces the risk exposure to $18M by the year 2024. This option retains annual OPEX levels to $250k as proposed in Option 3 and increases annual CAPEX investment to $500k. This option is viable from a corporate strategic perspective and would require prioritisation of distribution substation protection replacement projects such as

old switching stations and translay protections. The commercial benefits and viability of prioritising the CAPEX replacement projects will be provided in individual Project Justification Reports.

Based on the risk-condition approach, cost optimisation benefit, and the health of the assets, this plan recommends Option 3 as the strategy that provides the best cost/benefit while controlling the risk. The optimised program of work budget for CAPEX and OPEX is presented in Table 1.

Total Budget	2019/20	2020/21	2021/22	2022/23	2023/24
CAPEX	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**
OPEX	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**
Planned Maintenance (OPEX)	100,000	100,000	100,000	100,000	100,000
Unplanned Maintenance (OPEX)	50,000	50,000	50,000	50,000	50,000
Condition Monitoring (OPEX)	100,000	100,000	100,000	100,000	100,000

Table 1: OPEX and CAPEX Optimised Program of Work Budget

The annual CAPEX spend for protection replacement is $250k with a reduction of the average annual OPEX costs to $250k from the present spend of $350k.

The condition monitoring and asset replacement approach to maintain risk at current levels will deliver a viable secondary distribution protection asset management plan. The selected option provides the following benefits:

- Cost optimisation of OPEX and CAPEX based on asset condition needs,
- Maintaining overall asset class risk and addressing poor asset health and specific risks in some protection relay makes and models,
- Leveraging opportunities to deploy multifunction protection relays as part of the asset replacement program with additional benefits of condition monitoring of primary and secondary assets, and
- Compliance with AER's strategic objectives.

This ASP presents a broad-based program of work in terms of CAPEX replacements for Distribution protection assets and an optimised program of work approach for maintenance. Each CAPEX replacement project is justified based on various option considerations in a separate Project Justification Report.

2 Asset Class Overview

This section provides an overview of the strategy and objectives specific to the asset class covered by this ASP, provides details of the assets included and their function, and explores the needs and opportunities specific to this asset class.

This ASP covers the Distribution Substation Protection asset class, which lies within the secondary systems asset portfolio. The protection assets within this class are responsible for protecting distribution substation primary systems and associated distribution network infrastructure. For details of the asset groups contained within the Distribution Substation Protection asset class, refer to section 2.2.

2.1 Asset Class Objectives

The asset class strategy presented in this ASP follows the overall Evoenergy asset management strategy and asset management objectives. The asset class strategy is an integral part of the asset management strategy, with the overall objective to provide safe, reliable and cost effective supply of electricity to customers and compliance with regulatory requirements.

This ASP has been developed in alignment with the asset management strategy and seeks to meet objectives in the following categories:

Responsible

- Achieve zero deaths or injuries to employees or the public
- Maintain a good reputation within the community
- Minimise environmental impacts, for example bushfire mitigation
- Meet all requirements of regulatory authorities, such as the AER as outlined in the NER, and the ACT Utilities (Technical Regulations) Act 2014.

Reliable

- Tailor maintenance and renewal programs for each asset class based on real time modelling of asset health and risk
- Meet network SAIDI and SAIFI KPIs
- Record failure modes of the most common asset failures in the network
- Successfully deliver the asset class Program of Work (PoW) to ensure that the protection operates correctly to disconnect faulty sections in accordance with the NER.

Sustainable

- Enhance asset condition and risk modelling to optimise and implement maintenance and renewal programs tailored to the assets' needs
- Make prudent commercial investment decisions to manage assets at the lowest lifecycle cost
- Integrate primary assets with protection and automation systems in accordance with current and future best practice industry standards
- Deliver the asset class PoW within budget.

People

- Proactively seek continual improvement in asset management capability and competencies of maintenance personnel.

That is, the strategy and ASP must be practical in the sense that it can be implemented, must also be flexible enough to satisfy the future requirements of the Evoenergy network, and must be cost effective and efficient with consideration of both technical and human resources.

2.2 Asset Groups

Distribution protection assets are classified in terms of the element they protect, such as busbars, lines, transformers and feeders. Table 2 provides a broad-based classification of asset groups within the asset class.

Asset Class	Secondary Systems Distribution Substation Protection
Asset Groups	Distribution HV Protection Distribution LV Protection

Table 2: Asset Classification – Distribution Protection Assets

2.3 Asset Functions

The primary function of protection systems is to limit damage to power system apparatus and to protect the community. Whether the fault or abnormal condition exposes the equipment to excessive voltages or excessive currents, shorter fault times will limit the amount of stress or damage that occurs. Protection devices monitor critical system parameters, detect abnormality and initiate isolation of electrical network elements under pre-defined fault conditions. The successful operation of protection schemes is a crucial element in ensuring community safety, the safety of Evoenergy personnel, and the integrity of equipment.

2.3.1 Asset Function Definitions

Evoenergy's distribution protection assets have traditionally incorporated electromechanical feeder protection and early generation static relays for distribution transformers, busbars, lines and other 11kV feeder protection.

Newer generation numerical protection devices have started to be introduced over the last five years. These devices are classified as multifunction Intelligent Electronic Devices (IEDs). In addition to incorporating the required protection functions, IEDs also provide control, interlocks (safety), metering, alarm and monitoring functions.

The functions of assets in this asset class are described in the following sub-sections.

2.3.1.1 Distribution 11kV Switching Station Protections

The following protection functions are considered necessary to protect EVOENERGY's 11kV switching station assets:

A) 11 kV Busbar Protection

These devices provide 11kV distribution busbar protection. The low impedance busbar protection operates as a unit protection for faults involving the 11kV bus. For faults external to the protected section, a high impedance circuit in the differential circuit prevents any maloperation.

B) Incoming Zone Feeder Translay Protection

Translay protections operate as a unit protection, and measure difference of currents between the two ends of the line. This function disconnects the circuit only for faults which occur within the protected section of the 11 kV feeder. This protection is provided for critical short distance incoming feeders from the zone where overcurrent protections do not operate.

C) Overcurrent and Earth Protection

Overcurrent and earth fault protections are the primary protections against short circuits for incoming and outgoing feeders. Where translays are provided, such overcurrent and earth fault protections act as back-up protections.

2.3.1.2 Distribution 11kV 1500 kVA Chamber Substation Protection

The following protection functions are considered necessary to protect EVOENERGY's 1500kVA, 11kV chamber substations:

A) Incoming Feeder Protection

Overcurrent and earth fault protections are the primary protections against short circuits for incoming feeders. Where translays are provided, such overcurrent and earth fault protections act as back-up protections.

B) Transformer Protection

The following types of transformer protections are commonly applied for indoor chamber substations:

- Transformer HV Back-up Overcurrent Protection

  HV back-up protections are three phase overcurrent protections that provide back-up protection to the main transformer differential protection for faults in HV bushings.

- Transformer Neutral Earth Fault Protection

  Neutral earth fault protections are single phase overcurrent protections energised by neutral CTs that provide back-up protection to the main transformer restricted earth fault protection.

- Transformer Voltage Regulation Relay

  Voltage regulation relay devices are used to regulate transformer voltage and prevent either escalation of voltages to harmful levels or reduction of voltage that would cause damage to appliances.

In exceptional circumstances of parallel transformer operation, the following additional protections are provided for selective discrimination:

- Transformer Differential Protection

  Transformer differential protections provide rapid unit protection for faults occurring within the HV and LV windings and terminals, based on differential current.

- Transformer Restricted Earth Fault Protection

  Restricted earth fault protections provide rapid unit protection for sensitive earth faults that occur within the transformer windings, based on differential current.

C) Flop Over Relays

HV and LV AC flop over relays based on undervoltage are provided on critical chamber substations that are configured with a bus section to transfer loads when voltage supply is lost to one side of the bus section breaker.

D) Outgoing LV Feeder Protection

The outgoing LV feeders are protected by the Merlin Gerin circuit breaker. This item is covered off under a separate asset specific plan for LV switchboards.

2.3.1.3 Distribution 11kV 1500 kVA Padmount Substation Protection

The following protection functions are considered necessary to protect EVOENERGY's 1500kVA padmount substations:

A) Incoming Feeder Protection

Overcurrent and earth fault protections are the primary protections against short circuits for incoming feeders.

B) Transformer Protection

The following types of transformer protections are commonly applied for indoor chamber substations:

- Transformer HV Back-up Overcurrent Protection

  HV back-up protections are three phase overcurrent protections that provide back-up protection to the main transformer differential protection for faults in HV bushings.

- Transformer Neutral Earth Fault Protection

  Neutral earth fault protections are single phase overcurrent protections energised by neutral CTs that provide back-up protection to the main transformer restricted earth fault protection.

- Transformer Voltage Regulation Relay

  Voltage regulation relay devices are used to regulate transformer voltage and prevent either escalation of voltages to harmful levels or reduction of voltage that would cause damage to appliances.

C) Outgoing LV Feeder Protection

The outgoing LV feeders are protected by the Merlin Gerin circuit breaker. This item is covered off under a separate ASP for LV switchboards.

2.3.1.4 Distribution 11kV <1000 kVA Substation Protection

The following protection functions are considered necessary to protect EVOENERGY's 1000kVA chamber and padmount substations:

A) Incoming HV Fuse

HV fuse is provided on the incomer to provide short circuit protection. This item is covered off under a separate ASP for Ring Main Units.

B) Outgoing LV Feeder Protection

The outgoing LV feeders are protected by the Merlin Gerin circuit breaker. This item is covered off under a separate ASP for LV switchboards.

2.3.1.5 Distribution 22/3.75 kV Pump Station Protection

Some of the 22/3.75kV pump station distribution substations incorporate the following protection for the transformer:

A) Transformer Neutral Earth Fault Protection

Neutral earth fault protections are single phase overcurrent protections energised by neutral CTs that provide earth fault protection to the main 22/3.75kV transformer.

B) Transformer Multifunction Overcurrent Earth Fault Protection

This protection provides mitigation against phase and earth faults on the HV and LV side windings and bushings.

C) Transformer Buchholz Protection

For incipient faults that eventuate from within the transformer windings as a result of dielectric breakdown or partial discharge of the windings, Buchholz protections are provided for the main transformer, earthing and auxiliary transformers.

D) Transformer Cooling Circuit Protection

Transformer winding temperature detectors are provided, and operate via a temperature regulated cooling control mechanism.

2.3.1.6 Battery Chargers

Battery chargers are provided for energising DC station batteries that feed secondary system devices in a distribution substation.

2.4 Needs and Opportunities

Traditional Evoenergy protection schemes belong to the older generation of electromechanical and static protection. Many of the traditional complex protection schemes are comprised of a combination of discrete protection devices and timing devices to achieve the level of protection required. With the advent of modern numerical multifunction protection devices, there is an opportunity to combine discrete static or electromechanical schemes into single multifunction assets. This provides opportunities to gradually rationalise assets over a period of time. With the ability to reduce the number of assets due to such a rationalisation process, and the increased levels of protection provided by the new devices, one of the conditions for the accelerated replacement of protection assets is triggered.

Protection relay performance has a profound effect on the safety and reliability of the electricity network. In addition to compliance with the NER, the modern trend for protection also imposes stringent requirements on the need to provide information for the analysis of abnormalities that occur in the power system. Modern protection systems meet the NER requirements and will benefit EVOENERGY by also providing additional business efficiencies through automated condition monitoring of the network and primary systems.

The philosophy of combined protection and substation automation, whilst providing a significant opportunity for asset rationalisation, includes asset condition monitoring as the single biggest benefit that will reduce the risk profile for the assets and avoid the cost of asset maintenance over a period of time.

Thus the need to replace assets is based on a risk and condition monitoring philosophy that would provide the organisation with an optimal compromise of asset replacement based on condition deterioration, and maximise returns through the reduced cost of maintenance over the lifetime of the asset.

2.4.1 Needs

The risk associated with distribution substation protection relays in their current condition is $23M per annum as of 2017. The most significant element of risk is the reliability consequence associated with a protection system failing to operate during a genuine fault due to the malfunction of the protection relays. This risk can result in a number of different outcomes, including explosive failure or damage to associated primary assets, cascading outages affecting other parts of the network, extended outages to customers, and offloading generation.

The overarching need of protection asset management is to ensure asset maintenance and asset replacement maintains risk exposure at an acceptable and manageable level. The current risk is projected to increase from $23M to $50M by the year 2024 as a result of worsening overall network reliability.

With our aim to maintain current levels of system performance and risk, we propose a baseline risk exposure of $23M per annum to be maintained for risks associated with distribution substation protection relays.

2.4.2 Opportunities

2.4.2.1 Optimised Maintenance

With asset maintenance there is an opportunity to optimise maintenance programs, both in the way tasks are performed during maintenance and with the frequency of maintenance. This ASP contains options for different maintenance regimes and consideration of the least cost option to maintain risk at the proposed risk baseline level.

Optimising maintenance will be further possible as older static protection relays are replaced with modern numerical protection, as new relays have automated condition monitoring features, require less frequent maintenance, and are therefore easier and less costly to maintain.

2.4.2.2 Combined Protection and Control with Automated Condition Monitoring

Installing modern multifunction numerical relays will provide added value by delivering the following:

- Combined protection and control in a single device
- More comprehensive reporting of alarms and indications for system operations
- Automated condition monitoring of the secondary systems and associated primary equipment.

This added value through enhanced protection and control capabilities and automated condition monitoring can deliver substantial supplemental benefits for operations and reducing maintenance expenditure, and opportunities should be sought for the installation of modern numerical relays where possible.

2.4.2.3 Early Retirement of Small Make/Model Protection Relay Families

Within the Evoenergy asset base there are a number of smaller populations of particular protection relay make/model families. Reducing the range of different equipment through the early retirement and replacement of smaller make/model family populations will reduce maintenance costs and eliminate the cost of maintaining staff competencies for working on these smaller populations. Opportunities should be sought for the early retirement and optimising of the asset base.

While asset condition remains the primary driver supporting protection replacement projects, the advantages posed by installing modern numerical relays and optimising maintenance needs to be considered in the Project Justification Report cost benefit analysis for asset replacements.

2.5 Associated Asset Classes

The operation of protection devices is associated with other asset classes. Specifically, this involves inputs from current transformers, voltage transformers, and other discrete inputs from devices interfacing to electrical equipment.

Typically, current based protections are overcurrent, earth fault, transformer and line differential protections. Line distance protections seek inputs from both current and voltage transformers.

Overvoltage, undervoltage and frequency based protections seek inputs from voltage transformers.

Station batteries provide the auxiliary supply to power up the electronic circuits.

Numerical protections with measuring properties provide interface back to SCADA/ADMS to read the power system parameters inclusive of fault values and circuit breaker condition monitoring information.

3 Asset Base

This section provides details of Evoenergy's current asset base for assets that are a part of this asset class, including the current age and condition profiles of the assets and the projected asset count.

3.1 Asset Base Summary

Table 3 gives details of Evoenergy's in-service or system spare distribution protection assets as at April 2017.

Asset Type	Quantity	Design Life (yrs.)	Average Age (yrs.)	Oldest Age (yrs.)
Distribution HV Protection	419	30	14	49
Distribution LV Protection	973	30	14	49
Grand Total	**1392**	**30**	**14**	**49**

Table 3: In-service or System Spare Assets

3.2 Asset Service Life Expectancy

The design life of assets is 30 years for static distribution protection assets and 20 years for numerical protection assets. The useful life may be less than or greater than the design life, which can depend on quality of manufacturing, installation, maintenance and operational conditions.

Over the last five years, numerical protection with self-supervision features and seamless integration with SCADA and communication systems has been extensively deployed in the network at the Civic, East Lake, Angle Crossing, and Tennant distribution substations, and at the Bruce switching station. These assets, in addition to the protection and data reporting features, provide extensive condition monitoring of primary and secondary assets. These assets were deemed at the end of their useful life both from a condition and obsolescence perspective. The replacement met the key criteria set out in accordance with the NER.

3.3 Asset Age Profile

Figure 1 shows the age profile of the distribution protection assets.

The asset age profile shows there are a large number of assets over 25 years of age and some assets beyond the expected life of 30 years. In the next regulatory period increasing numbers of assets will reach end of life condition and will require replacement. This need for replacement is further demonstrated in the asset condition profile in section 3.4, where asset health is identified as poor for some models of equipment.

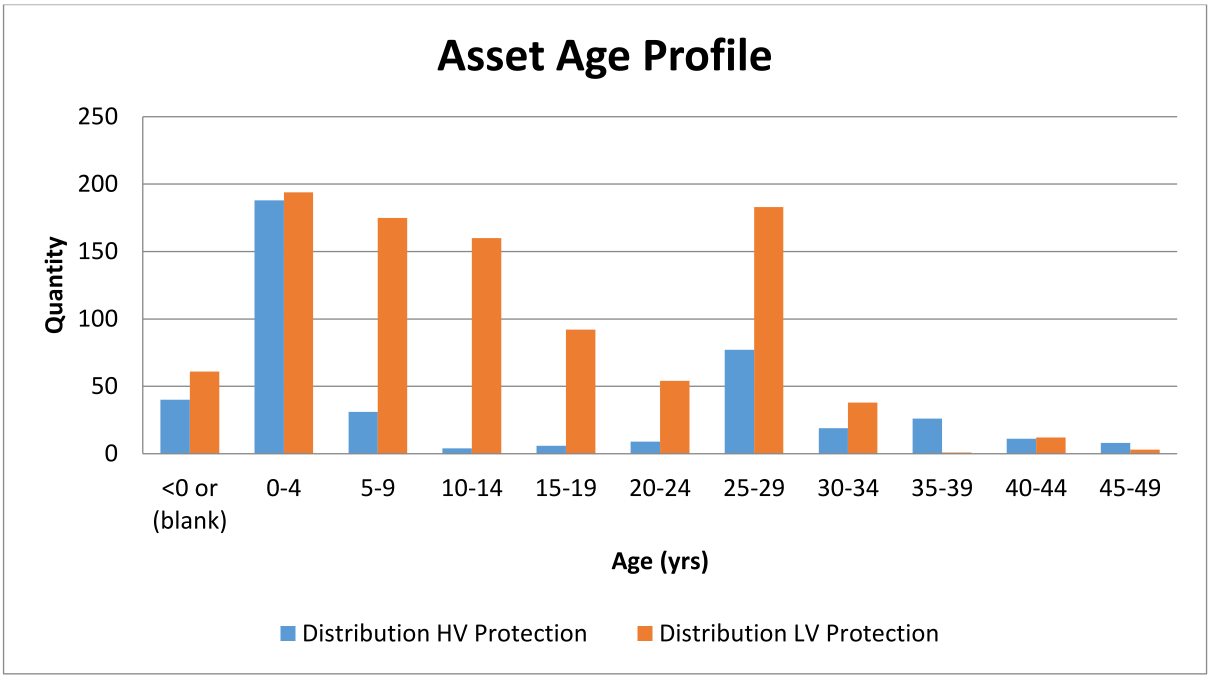

Figure 1: Age Profile of Distribution Protection Assets

3.4 Asset Condition Profile

The current asset health profile is determined by combining the asset condition rating with its criticality rating. Condition is determined by the asset's capacity to meet requirements, the asset reliability and its level of obsolescence. Obsolescence is determined by maintenance requirements and availability of support from manufacturers. Criticality is determined from operational, safety and environmental consequences due to asset failure.

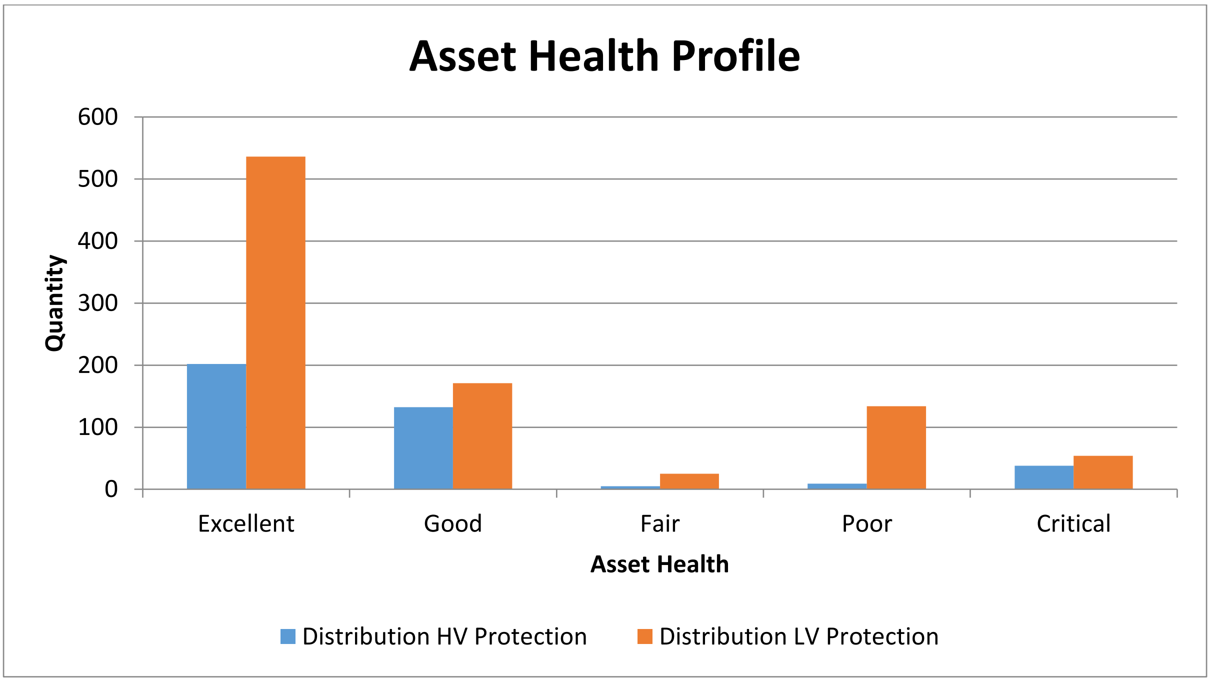

Figure 2: Asset Health Profile of Distribution Protection Assets

Health Score: Excellent (100-90), Good (90-70), Fair (70-50), Poor (50-30), Critical (30-0)

Table 4 gives details of the current condition of the distribution protection assets.

Asset Type	Manufacturer	Quantity	Average Health
Distribution HV Line Differential Protection Relay		**34**	**Fair**
	GEC	9	Fair
	REYROLLE	1	Fair
	SIEMENS	23	Poor
	UNKNOWN/BLANK	1	Fair
Distribution HV Phase Failure Relay		**6**	**Fair**
	EMAILELECTRONIC	6	Fair
Distribution LV AC Flop over Relay		**2**	**Fair**
	RELAYSPTYLTD	2	Fair
Distribution LV Phase Failure Relay		**24**	**Fair**
	EMAILELECTRONIC	24	Fair
Distribution Transformer Differential Protection		**3**	**Fair**
	GEC	1	Fair
	SCHNEIDER	2	Fair
General Purpose Distribution HV Protection Relay		**3**	**Fair**
	GEC	3	Fair
Multi Phase Distribution HV Protection Relay		**263**	**Fair**
	AREVA	38	Good
	EMAILELECTRONIC	1	Fair
	ESP	81	Fair
	GEC	51	Fair
	GEC-ALSTOM	2	Fair
	SCHNEIDER	52	Good
	UNKNOWN/BLANK	38	Fair
Multi Phase Distribution LV Protection Relay		**870**	**Fair**
	EMAILELECTRONIC	29	Fair
	ESP	134	Poor
	GEC-ALSTOM	4	Fair
	NILSEN	37	Poor
	RMSRELAYMONITOR	1	Fair
	SCHNEIDER	458	Fair
	TERASAKI	46	Fair
	UNKNOWN/BLANK	161	Fair
Multipurpose Distribution HV Protection Relay		**38**	**Fair**
	ENGLISHELECTRIC	1	Fair
	GEC	8	Fair
	GEC-ALSTOM	14	Fair
	SCHNEIDER	13	Good
	UNKNOWN/BLANK	2	Fair
Single Phase Distribution HV Protection Relay		**72**	**Fair**
	ASEA	38	Poor
	GEC	33	Fair
	GEC-ALSTOM	1	Fair
Single Phase Distribution LV Protection Relay		**77**	**Fair**
	GEC	77	Fair

Table 4: Current Distribution Protection Asset Condition

Based on Table 4, the following assets are approaching end of life conditions which should be managed by the preferred asset class strategy:

- Old ASEA relays of type RI
- Old legacy Siemens static relays
- Ageing Translay protections
- Ageing distribution protections of old electromechanical type where calibration is steadily being lost or trip contacts are malfunctioning.

3.5 Projected Asset Count

The projected asset count is an estimate of the number of distribution protection assets by year. The estimate includes asset additions and retirements through estimated network augmentation and asset retirements over the period. Refer to Figure 3 for details.

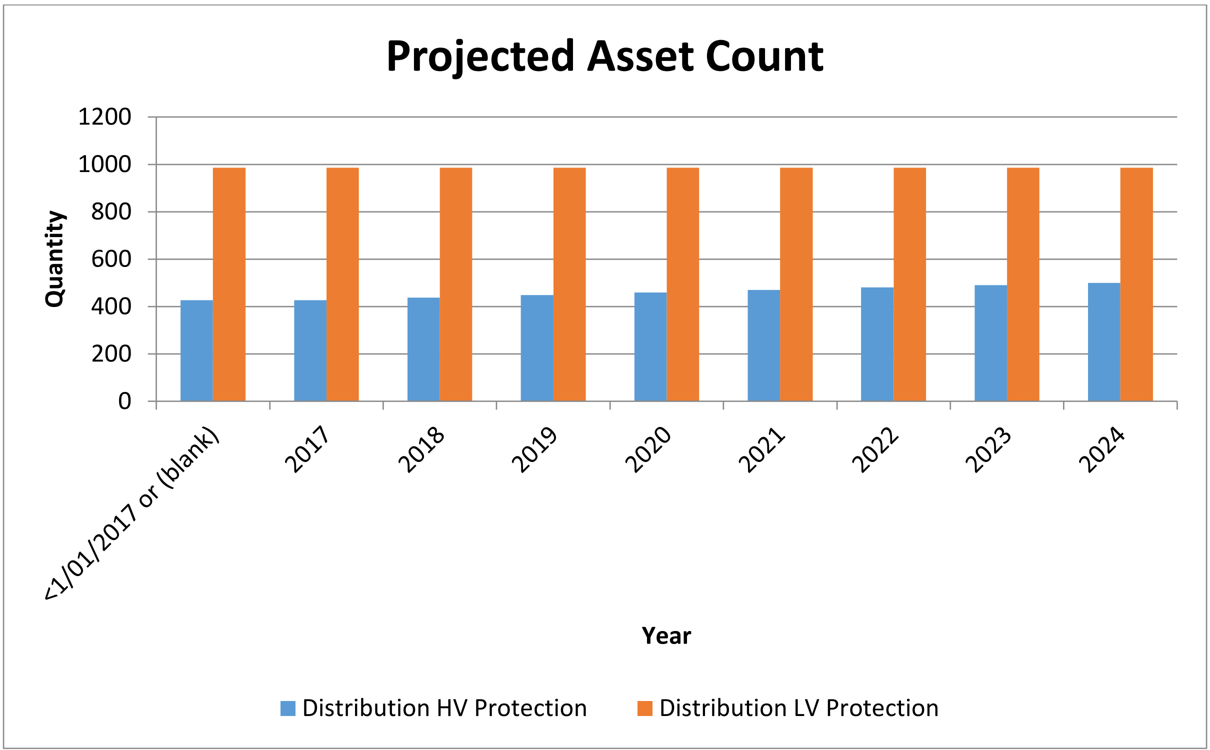

Figure 3: Projected Asset Count of Distribution Protection Assets

4 Asset Performance Requirements

This section details the reliability and performance requirements of the distribution protection asset class.

4.1 Failure Modes

This section outlines the Failure Mode and Effects Analysis (FMEA) and deterioration drivers for each asset type. Failure modes, Risk Priority Number (RPN) and cost of failure have been nominated by subject matter experts. This analysis is used to evaluate strategy options for this asset class.

4.1.1 Protection Relays

Once protection relay hardware has reached the end of its useful life, degradation of component characteristics will cause the modules to fail. In addition, environmental factors also drive deterioration or deviation in the performance of electronic components. On that basis, protection relays are characterised by an abrupt condition deterioration curve with respect to their maximum potential life. The failure rate during the rated useful life of the product is fairly low. Once the end of life condition is reached, failure rates of modules increase abruptly.

Table 5 summarises the common failure modes for distribution protection assets.

Failure Mode	Failure Cause	Severity	Occurrence	Detection	RPN
Card failure	Relay non-functional. Protection does not operate to clear fault. Fault cleared by either back-up protection or group breaker. Possibility of large scale disconnection of customers.	8	6	5	240
Maloperation due to calibration drift	Relay partially functional. Protection maloperates or fails to operate in one or all phases. Feeder could trip when not necessary or not trip at all, relying on back-up protection to operate. Risk of group transformer protection operation that could cause large scale disconnection of customers. Possible damage to primary systems assets, for example power transformers, switchgear, lines and feeders.	8	5	5	200
Output trip relay contact failure	Inability of output contact to energise trip circuit. Protection operates but does not trip to clear fault; back-up protection clears the fault. More customers are disconnected. Possible damage to primary systems assets.	8	6	5	240
Power supply failure	Relay does not power up. Protection not available to clear fault, back-up protection clears fault. More customers are disconnected.	8	6	5	240

	Possible damage to primary systems assets.				
Failure of CB fail schemes to operate or maloperate	Circuit breaker fail protection faulty. Risk of group transformer protection operation that could cause large scale disconnection of customers. Possible damage to primary systems assets.	8	5	5	200

Table 5: Common Failure Modes of Distribution Protection Assets

4.1.1.1 Deterioration Drivers for Distribution Protection Asset Class

Hardware failures during an asset's life can be attributed to the following causes:

- Design failures

  This class of failures takes place due to inherent design flaws in the system. In a well-designed system this class of failures should make a very small contribution to the total number of failures.

- Infant Mortality

  This class of failures causes newly manufactured hardware to fail. This type of failures can be attributed to manufacturing problems like poor soldering, leaking capacitor, etc. These failures should not be present in systems leaving the factory as these faults will show up in factory quality control and factory acceptance tests.

- Random Failures

  Random failures can occur during the entire life of a hardware module. These failures can lead to system failures. Redundancy is provided to recover from this class of failures.

  The following class of failures are classified in this category:

  - Mean Time between failures of components (MTBF).

    MTBF is the average time between failures of hardware modules. MTBF for hardware modules can be obtained from the vendor for off-the-shelf hardware modules. MTBF for in-house developed hardware modules is normally calculated by the hardware team developing the board. Typically, this is 20-30 years for static/numerical protections and 30-40 years for electromechanical protections.

  - Environmental failures and failure in tropical and humid environment.

    This would account for component failures due to temperature variations, tropicalisation and change in the humidity factors.

  - Software issues and mis-configurations.

    This could be as a result of software or firmware upgrades that would affect the overall functioning of the protection scheme.

  - Inappropriate usage and scheme failures.

    Relays implemented are not appropriate for protection scheme.

  - Calibration and deviation from standard operating curves.

    The departure in the relay operating behaviour would be as a result of ageing and generally related to component failures.

4.2 Asset Utilisation

This section details the utilisation level of the assets. Depending on the asset type, the level of utilisation will have a direct impact on asset condition and performance deterioration rates.

4.2.1 Capacity and Capability

The installation of new numerical devices with recent projects (Angle Crossing, East Lake, Civic, Gilmore distribution substations and Bruce switching station) provides Energy Networks with immediate detection of failed relays without reliance on scheduled maintenance. This greatly reduces the risk of defective units being in-service and potential maloperation. Numerical protections include the following self-diagnostic features that greatly improve the safety and reliability of the network:

- CT Supervision
- VT Supervision
- Relay health
- Trip circuit supervision.

Data logging also provides performance information, allowing more accurate capture, recording and reporting of real-time and historical asset performance, which is not economically possible with static and electromechanical relays.

In addition, numerical protections provide additional information such as distance to fault and fault currents back to the ADMS. The ADMS utilises fault current information to assist in localisation of faults using a fault predicting algorithm. The distance to fault locating feature will improve restoration times. This effectively ensures increased availability and service capacity to consumers.

However, immediate access to event and relay status data comes at a cost. The cost to Energy Networks will require the upgrade of existing SCADA communications to accommodate increased data transfer from the field to the office so that engineers can access event and relay status data.

4.2.2 Utilisation

Asset utilisation is not directly applicable to protection assets as they do not directly contribute to revenue. They contribute indirectly by providing a safe network, preventing damage to major assets, reducing unplanned outage area and duration and the number of customers off supply in an unplanned outage. When a protection relay is in service, it is 100% utilised.

4.3 Risk and Criticality

This section details the criticality of the distribution protection assets and their exposure to risk.

4.3.1 Asset Criticality

Protection systems are critical for reliable operation, asset protection and network safety. Protection devices and systems need to be correctly configured, installed, managed and maintained. Protection devices and schemes limit damage to power system apparatus. Whether the fault or abnormal condition exposes the equipment to excessive voltages or excessive currents, shorter fault times will limit the amount of stress or damage that occurs. Protection devices monitor critical system parameters, detect abnormality and initiate isolation of electrical network elements under pre-defined fault conditions. The successful operation of protection schemes is a crucial element in ensuring community safety, the safety of Evoenergy personnel and equipment.

4.3.2 Geographical Criticality

Primarily protection systems and assets are installed at 11kV distribution substations and switching stations. Distribution protection systems interact with a number of major asset types including transformers, switchgear, circuit breakers, busbars, voltage regulators and SCADA systems.

Whilst geographical criticality affects primary equipment due to climatic conditions as they are mounted outdoors, protection relays located in control rooms are relatively unaffected by geographical locations and climatic conditions.

4.3.3 Asset Reliability

Above all, relays must be reliable, dependable and secure. Relays operate continuously by making correct decisions that discriminate between loads and faults, and discriminate between faults that are in the zone of protection and all other faults. Protection reliability is affected by equipment failures and by appropriate application and installation. Determining device reliability is more important for relays that cannot perform self-diagnostics and alarming.

With a maximum potential life of 30 years, the expected service reliability in terms of failure of protective devices inclusive of maloperations is one in one hundred.

5 Asset Management Strategy Options

This section discusses asset class strategies to manage distribution protection assets throughout their lifecycle and recommends the preferred option. The preferred asset class strategy supports the business asset management policy, strategy and objectives.

5.1 Option Overview

Asset class strategies are evaluated against their cost, risk, benefits and consideration of trade-offs between capital and operational expenditure to achieve the asset management objectives. The options that have been considered include:

- Option 0 – Do Nothing Strategy
- Option 1 – Existing Strategy at Current Expenditure Level
- Option 2 – Reduce Cost Strategy – OPEX optimisation
- Option 3 – Maintain Risk Exposure Strategy
- Option 4 – Reduce Risk Exposure Strategy.

5.1.1 Option 0 – Do Nothing Strategy

This option assesses the inherent risk rating for the distribution protection asset class if no controls or mitigating strategies are in place.

5.1.1.1 Description

This option is the do nothing strategy whereby assets are ‘run-to-failure’ without planned maintenance or planned replacement. Upon failure, assets are assessed and reactively repaired or replaced as necessary. Typical asset management tasks for this strategy include:

- Operation of critical assets until partial or catastrophic failure
- Corrective maintenance to repair faults
- Reactive replacement to restore unrepairable assets.

5.1.1.2 Cost

This option entails nil OPEX/CAPEX costs. However, a provisional budget of $20,000 has been allowed per annum to account for any unplanned maintenance.

5.1.1.3 Risk

As asset condition deteriorates and assets approach the end of their expected life, their reliability will decrease and the risk exposure of this option will rapidly increase.

Risk summary:

- 25% of distribution protection asset class risks with critical rating, with those assets classified as ‘Poor’ condition
- Increasing risk exposure due to aging asset population without planned replacement
- Risk cost of catastrophic failure exceeds $2.5M per failure.

A qualitative risk assessment of this option highlights the inherent risks (no controls) of this asset class and the risk exposure. This is shown in Table 6.

		Inherent Risk				
Likelihood	Almost Certain					
	Likely	Low 17	Medium 2	High 4		
	Possible	Low 1	Medium 1	Medium 6	High 3	
	Unlikely	Low 4	Low 1	Medium 1	Medium 1	High 6
	Rare					
		Negligible	Minor	Moderate	Major	Severe
		Consequence				

Table 6: Qualitative Risk Assessment – Option 0

A quantitative risk assessment for this option has been modelled to estimate the risk exposure and is shown in Figure 4.

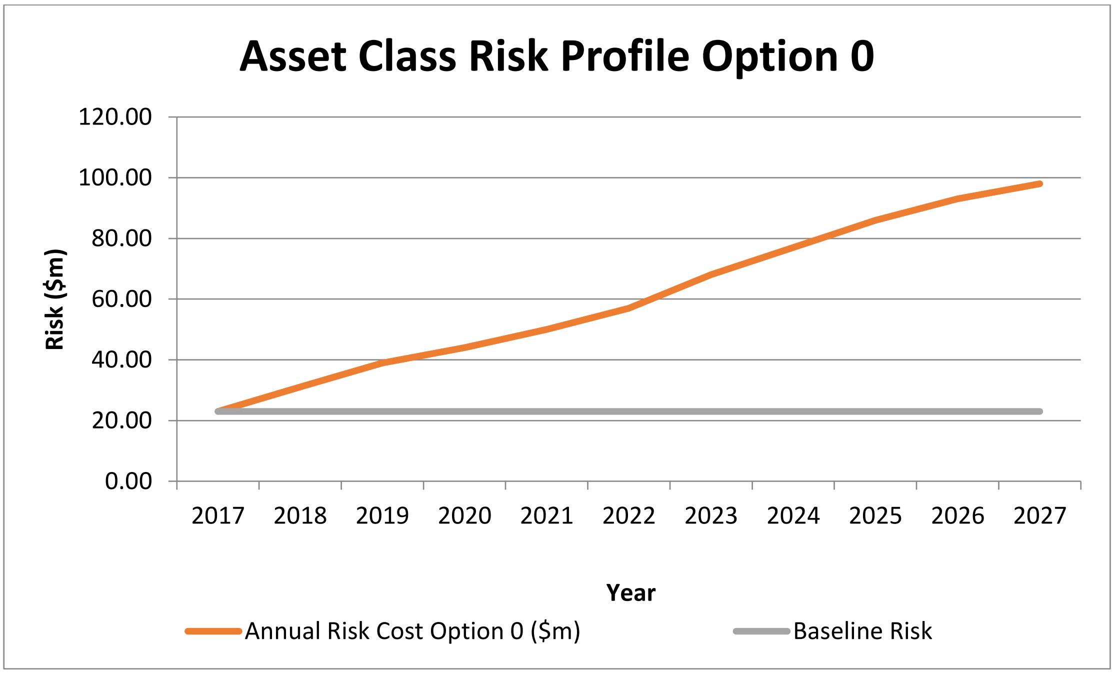

Figure 4: Risk-Cost Analysis – Option 0

5.1.1.4 Option Assessment

Whilst the run to fail option provides economic benefits in terms of avoided OPEX and CAPEX expenditures, the increase in risk exposure from current levels of $23M in 2017 to $77M in 2024 at the end of the regulatory period represents a significant departure from current risk exposure.

The run to fail strategy does not provide any benefits from a reliability perspective. There would be an unavoidable increase in unplanned outages leading to long intervals of power disconnection, safety issues, and inconvenience to customers. Evoenergy would be impacted negatively through reputational loss, loss of reliability and revenue. In addition, this option would worsen SAIFI/SAIDI numbers and result in loss of STPIS revenue incentives.

This option is rejected given the risk it poses in terms of reliability and safety, the two core objectives of Energy Network's strategic vision.

5.1.2 Option 1 – Existing Strategy at Current Expenditure Level

This option assesses the existing asset class strategy for the management of distribution protection assets, maintaining current OPEX levels.

5.1.2.1 Description

In this option, the current five-yearly protection maintenance interval is being considered.

5.1.2.2 Cost

In this option, the current OPEX spending level of $350k per annum is retained based on a five yearly protection asset maintenance interval.

5.1.2.3 Risk

Retaining the current expenditure level for replacing distribution protection assets will expose Evoenergy to an increasing level of risk due to a large number of assets showing poor future health. Current expenditure levels will not meet the need to replace assets and a large number of assets will reach a critical health level at the end of the regulatory period in 2024.

Risk summary:

- A substantial increase in the asset risk profile from $23M in 2017 to $50M in 2024 which could impact the SAIFI/SAIDI and impede the STPIS benefits
- Substantial deterioration of condition of assets failing regularly and replaced like for like.

The exposed asset class risk ratings for this option at the end of the regulatory period (2024) are shown in Table 7.

		Option 1 Risk				
Likelihood	Almost Certain					
	Likely					
	Possible	Low 17	Medium 2	Medium 4		
	Unlikely	Low 5	Low 1	Medium 7	Medium 4	
	Rare		Low 1		Medium 5	Medium 2
		Negligible	Minor	Moderate	Major	Severe
		Consequence				

Table 7: Qualitative Risk Assessment – Option 1

A quantitative risk assessment for this option has been modelled to estimate the risk exposure and is shown in Figure 5.

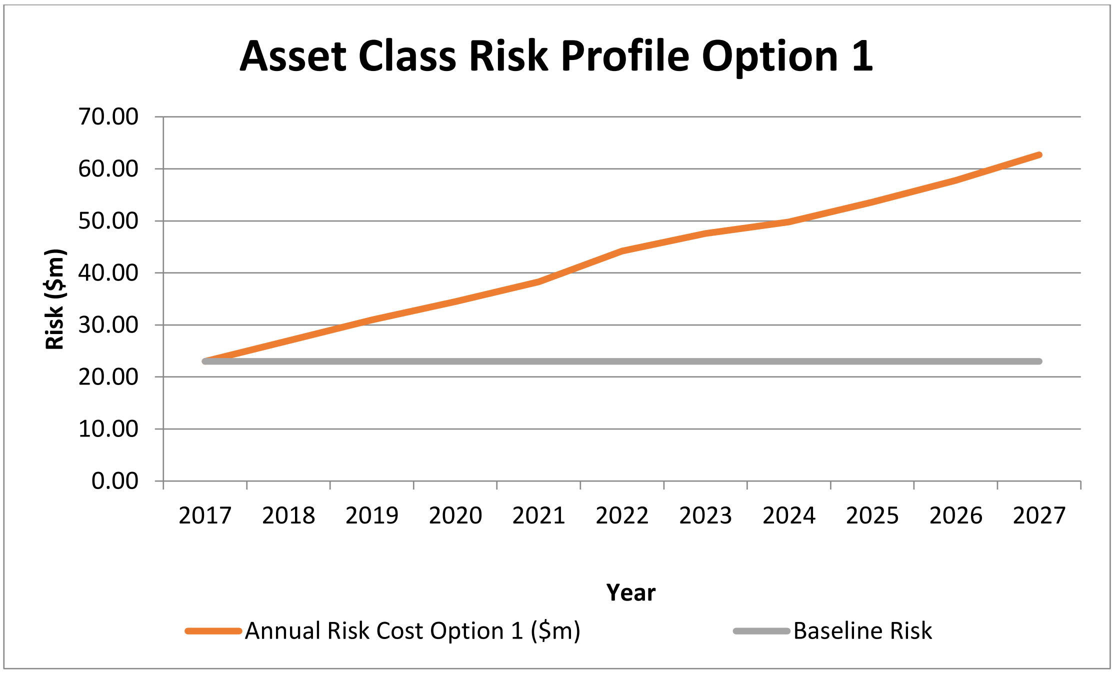

Figure 5: Risk-Cost Analysis – Option 1

5.1.2.4 Option Assessment

The risk exposure of this option increases to $50M by the year 2024. Whilst this option limits the increase of risk compared to the Do Nothing option, it still results in an increased risk exposure of $27M above the baseline risk of $23M, and increases the overall probability of customers experiencing unplanned outages.

This option is rejected given the risk it poses. To alleviate the level of risk exposure, additional CAPEX investment to replace protection assets with average to poor condition would be necessary to reduce unplanned outages to energy customers.

5.1.3 Option 2 – Reduce Cost

This option discusses opportunities to reduce OPEX for this asset class by aligning protection maintenance with maintenance intervals for primary equipment such as circuit breakers. It considers opportunities to reduce costs when compared to the existing strategy (Option 1).

5.1.3.1 Description

This strategy option reduces the OPEX costs compared to the existing asset class strategy by optimising maintenance intervals.

This strategy includes the following tasks:

- Retain current maintenance intervals of 5 years for static and electromechanical protections and align protection maintenance with primary equipment
- Increase maintenance interval for numerical protections to 8 years and 4 years for sanity check of operation while performing primary equipment maintenance.

5.1.3.2 Cost

The annual OPEX level reduces from $350k to $250k.

5.1.3.3 Risk

This approach results in an increase in the asset risk profile from $23M in 2017 to $55.6M in 2024 which would continue to impact the SAIFI/SAIDI and impede the STPIS benefits.

The exposed asset class risk ratings for this option at the end of the regulatory period (2024) are shown in Table 8.

		Option 2 Risk				
Likelihood	Almost Certain					
	Likely					
	Possible	Low 17	Medium 2	Medium 4		
	Unlikely	Low 5	Low 1	Medium 7	Medium 4	
	Rare		Low 1		Medium 5	Medium 3
		Negligible	Minor	Moderate	Major	Severe
		Consequence				

Table 8: Qualitative Risk Assessment – Option 2

A quantitative risk assessment for this option has been modelled to estimate the risk exposure and is shown in Figure 6.

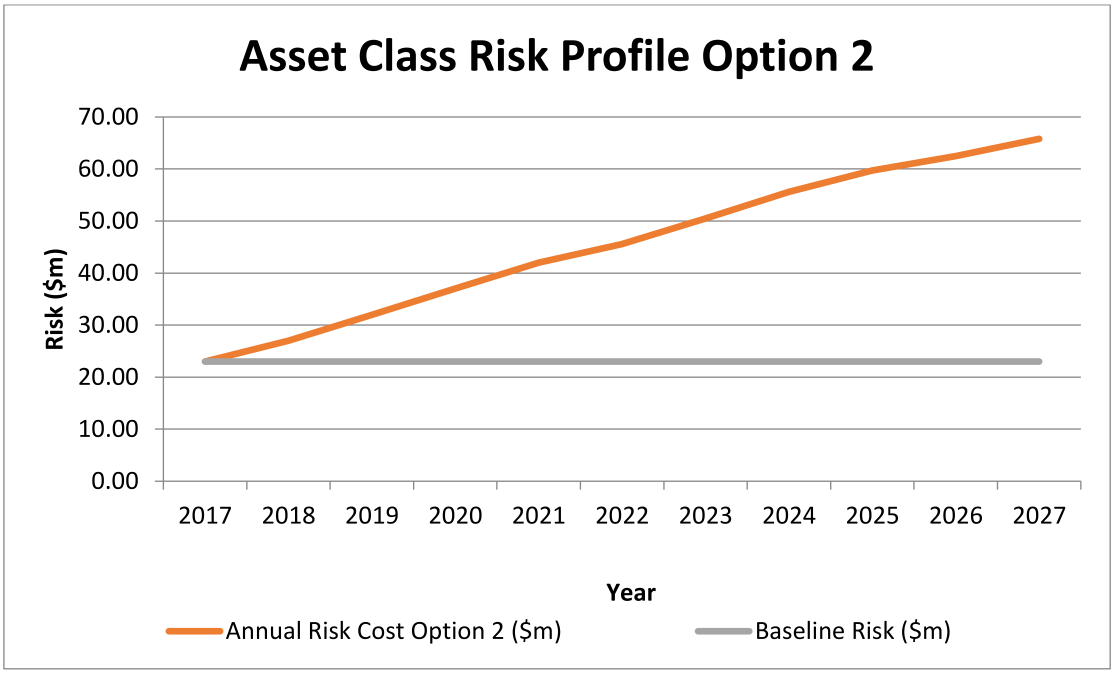

Figure 6: Risk-Cost Analysis – Option 2

5.1.3.4 Option Assessment

The risk exposure of this option increases to $55.6M by the year 2024, similar to the existing strategy. Whilst this option limits the increase of risk compared to the Do Nothing option, and reduces OPEX costs compared to the existing strategy, it still results in increased risk exposure approximately $32M above the baseline risk of $23M, and increases the overall probability of customers experiencing unplanned outages.

This option is rejected given the risk it poses. To alleviate the level of risk exposure, additional CAPEX investment to replace protection assets with average to poor condition would be necessary to reduce risks of maloperation and resulting unplanned outages to customers.

Whilst this option is rejected, the optimised OPEX has demonstrated little increase in risk exposure and the optimised maintenance is included with Option 3.

5.1.4 Option 3 – Maintain Risk Exposure

This option considers a strategy to maintain the asset class risk exposure at the current level, taking 2017 as the baseline year. In terms of developing a viable asset renewal and maintenance plan, the following aspects form the core strategy that would assist in maintaining the risk exposure at $23M at the end of the regulatory period 2024:

- Optimal increase in CAPEX investment to replace assets that are in average to poor condition
- Optimised maintenance strategy as proposed in Option 2.

5.1.4.1 Description

This option maintains the current 2017 levels of risk exposure for the distribution protection asset class. This is achieved by an increased asset renewal program based on asset condition. The condition based replacement option utilises the current health of the assets and identifies ones that are either failing regularly or are experiencing excessive calibration drift. There are a large number of assets showing poor future health and an increase in CAPEX investment is therefore required to maintain risk at the current level.

The OPEX costs are optimised by aligning maintenance of protection relays with the primary equipment cycle of 5 years for most of the protection relays, with numerical relays being maintained every 8 years.

The condition or performance of any two assets of the same make, model, and chronological age, can differ significantly. Because not all assets deteriorate at a standard uniform rate across the asset class, this strategy manages risk along with optimised cost of OPEX and CAPEX across the network by deferring part of the replacement after the regulatory period 2019-2024.

5.1.4.2 Cost

The average CAPEX investment is projected to be $250k per annum, with an optimised annual OPEX cost of $250k. The moderate CAPEX investment is expected to provide an optimised risk mitigation level to maintain the current asset risk profile at the end of the regulatory period 2024.

5.1.4.3 Risk

This approach results in maintaining the current levels of risk exposure of $23M through to the year 2024.

The exposed asset class risk ratings for this option at the end of the regulatory period (2024) are shown in Table 9.

		Option 3 Risk				
Likelihood	Almost Certain					
	Likely					
	Possible	Low 17	Medium 1	Medium 1		
	Unlikely	Low 5	Low 1	Medium 1	Medium 3	
	Rare		Low 1		Medium 1	Medium 4
		Negligible	Minor	Moderate	Major	Severe
		Consequence				

Table 9: Qualitative Risk Assessment – Option 3

A quantitative risk assessment for this option has been modelled to estimate the risk exposure and is shown in Figure 7.

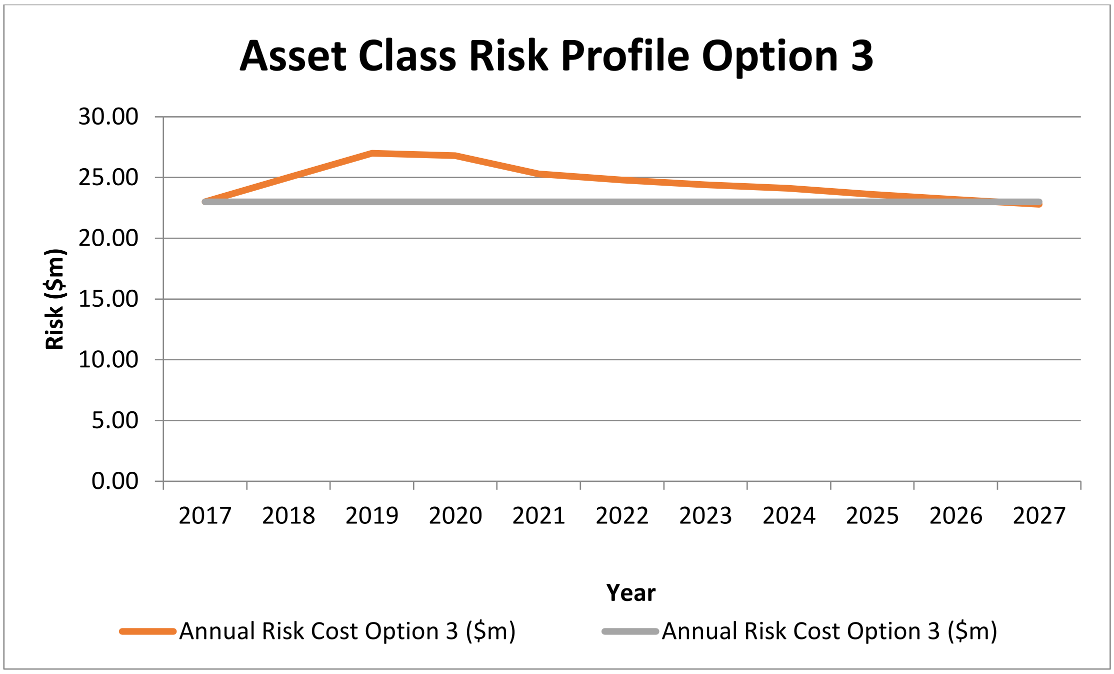

Figure 7: Risk-Cost Analysis – Option 3

5.1.4.4 Option Assessment

This option maintains risk exposure at the current level of $23M for the regulatory period 2019-2024. This strategy implies that the annual CAPEX investment of $250k will result in maintaining the risk that would otherwise increase by $27M to $50M under current expenditure levels (Option 1). This is therefore a prudent investment. An additional benefit of implementing this strategy is maintaining the current levels of SAIFI/SAIDI and STPIS benefits due to avoided cost of unplanned outages and STPIS penalty.

The increased capital investment in maintaining the risk exposure is therefore a viable option as it assists in maintaining power system reliability to EVOENERGY customers at current levels. The commercial benefits and viability of prioritising the CAPEX replacement projects will be provided in individual Project Justification Reports.

5.1.5 Option 4 – Reduce Risk Exposure

This option considers a strategy to reduce the asset class risk exposure from current 2017 levels and assesses the resultant cost. In terms of developing a viable asset renewal and maintenance plan, the following aspects form the core strategy that would assist in reducing the risk exposure to $18M:

- A significant increase in CAPEX investment to replace assets that are in average to poor condition and all distribution substation transformer protection assets
- Optimised maintenance strategy as proposed in Option 2.

5.1.5.1 Description

This option reduces the risk exposure compared to current 2017 levels for the distribution protection asset class. This is achieved by an accelerated asset renewal program based on asset condition. Ageing distribution transformer protection assets that have become obsolete have been considered for pre-emptive replacement.

The condition based replacement option utilises the current health of the assets and identifies assets that are either failing regularly or are experiencing excessive calibration drift.

Furthermore, the OPEX costs are optimised by aligning maintenance of protection relays with the primary equipment cycle of 5 years for most of the protection relays, with numerical relays being maintained every 8 years.

The condition or performance of any two assets of the same make, model, and chronological age, can differ significantly. Because not all assets deteriorate at a standard uniform rate across the asset class, this strategy optimises reduction of risk along with optimised cost of OPEX and CAPEX across the network by deferring part of the replacement after the regulatory period 2019-2024.

5.1.5.2 Cost

The average CAPEX investment is projected to be $500k per annum, with an optimised annual OPEX cost of $250k.

5.1.5.3 Risk

This approach results in reducing the current levels of risk exposure from $23M to $18M.

The exposed asset class risk ratings for this option at the end of the regulatory period (2024) are shown in Table 10.

		Option 4 Risk				
Likelihood	Almost Certain					
Likelihood	Likely					
Likelihood	Possible	Low 17	Medium 1	Medium 1		
Likelihood	Unlikely	Low 5	Low 1	Medium 1	Medium 1	
Likelihood	Rare		Low 1		Medium 1	Medium 1
		Negligible	Minor	Moderate	Major	Severe
		Consequence				

Table 10: Qualitative Risk Assessment – Option 4

A quantitative risk assessment for this option has been modelled to estimate the risk exposure and is shown in Figure 8.

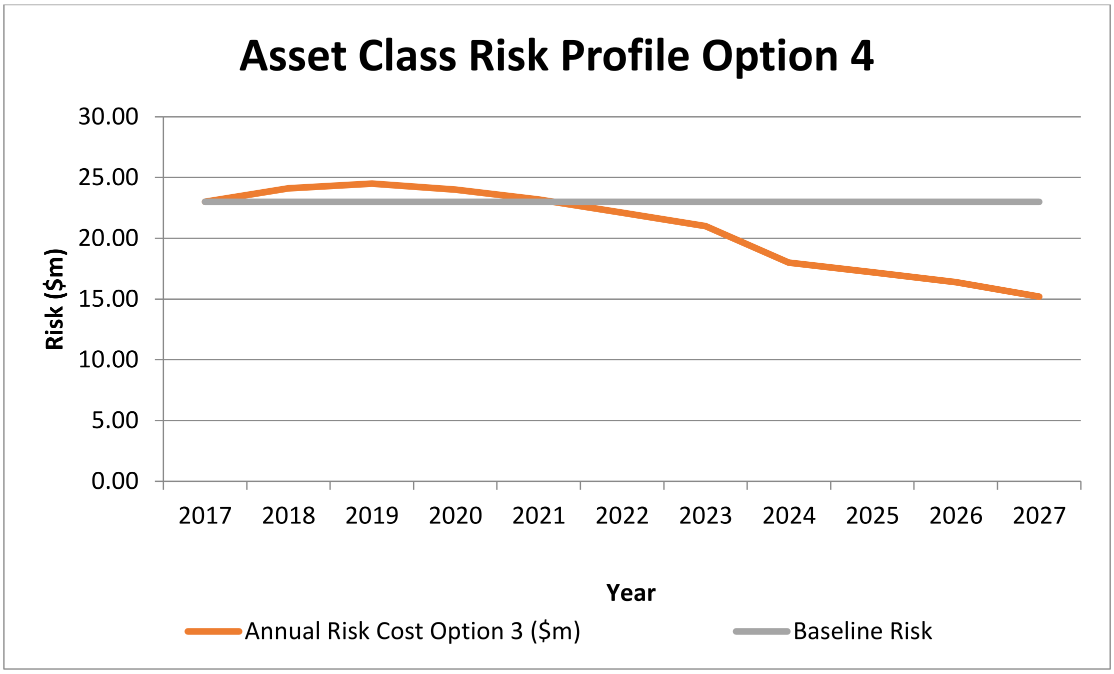

Figure 8: Risk-Cost Analysis – Option 4

5.1.5.4 Option Assessment

This option reduces the risk exposure to $18M for the regulatory period 2019-2024. By the end of the regulatory period, the risk exposure would have otherwise increased by approximately $32M to $50M (Option 1).

The CAPEX investment provides the following tangible benefits:

- Power supply reliability improvement and minimised customer interruptions
- Reduction in SAIFI/SAIDI
- Increase in the STPIS benefits to EVOENERGY's accumulated revenue in the regulatory period.

The additional increase in CAPEX from a commercial perspective is largely offset by the additional income resulting from increased STPIS benefits and increased power reliability to the customers. Therefore this option is viable from a corporate strategic perspective and would require prioritisation of distribution transformer protection replacement projects. The commercial benefits and viability of prioritising the CAPEX replacement projects will be provided in individual Project Justification Reports.

5.2 Option Evaluation

In order to assess the most optimal distribution protection asset replacement strategy, a condition and risk-cost based modelling approach has been conducted using the RIVA Asset Management modelling tool for the various scenarios.

5.2.1 Options Cost and Risk Summary

Option	TOTEX Budget ($) 2019-24	CAPEX Budget ($) 2019-24	OPEX Budget ($) 2019-24	Annual Residual Exposure ($) 2019-24	Annual Risk Change ($) 2019-24
Option 0 – Do Nothing Strategy	$100,000	-----	$100,000	$77M	Increase risks by $55M with respect to 2017 levels of $23M
Option 1 – Existing Strategy	$1,750,000	------	$1,750,000	$50M	Increase risks by $27M with respect to 2017 levels
Option 2 – Reduce Cost Strategy	$1,250,000	-------	$1,250,000	$56M	Increase risks by $33M with respect to 2017 levels
Option 3 – Maintain Risk Strategy	$2,500,000	$1,250,000	$1,250,000	$23M	Maintain risk exposure to 2017 levels of $23M
Option 4 – Reduce Risk Strategy	$3,750,000	$2,500,000	$1,250,000	$18M	Reduce risks by $5M with respect to 2017 levels

Table 11: Cost and Risk Strategy Options Summary

5.2.2 Options Assessment

A scoring matrix approach is used to assess the advantages, disadvantages, risks and benefits of each of the asset management options. Each option is given an overall score, based on the scoring criteria detailed in Table 12.

Criteria	Description and Weighting
Cost	This ranks the relative CAPEX and OPEX costs associated with the options. The weighting reflects the relative importance of this criterion.
Risk – Safety, Environmental, Reliability, Other	The extent to which the option provides mitigation/controls to risks identified. The weighting reflects the relative importance of this criterion.
Strategic Objectives	The extent to which the option meets the requirements of the asset management strategic objectives. The weighting reflects the relative importance of this criterion.
Innovation/Benefits	The extent to which the option provides business benefits including but not limited to information or intelligence to support innovative asset management and network operation. The weighting reflects the relative importance of this criterion.

Table 12: Option Evaluation Scoring Criteria

	Criteria				Option Score
	Cost	Risk	Strategic Objectives	Innovation/ Benefits	
Criteria Weighting	30%	30%	30%	10%	100%
Option 0 – Do Nothing	3	1	1	1	53%
Option-1 – Current Strategy	2	2	2	2	67%
Option 2 – Reduce Cost	3	2	2	2	77%
Option 3 – Maintain Risk	3	2	3	3	90%
Option 4 – Reduce Risk	1	3	3	3	80%

Scoring Key			
0	Fatal flaw	1	Unattractive
2	Acceptable	3	Attractive

Table 13: Scoring Matrix

5.3 Recommended Option

A risk condition based costing approach has been adopted to determine the most optimal recommendation for capital replacement projects and maintenance strategy that will provide the best technical and commercial benefit to EVOENERGY in alignment with the AER's strategic objective of reduction in condition monitoring expenses.

This approach is expected to improve the SAIFI/SAIDI figures and improve the STPIS benefits. Based on the evaluation of different scenarios for CAPEX and OPEX in section 5.2, the option that will provide the greatest benefit is given below.

5.3.1 Asset Strategy Recommendation

This section gives the recommendation for the preferred asset management strategy option.

The graph in Figure 9 provides an overall picture of all five risk options.

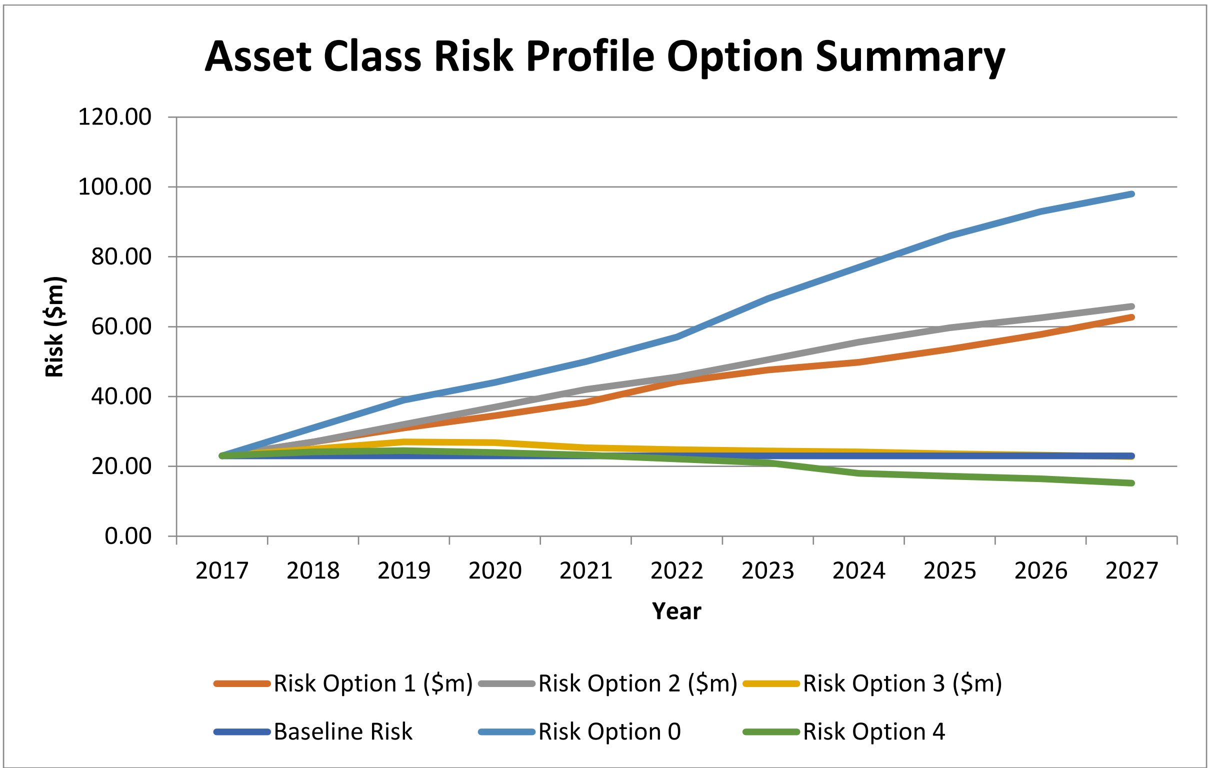

Figure 9: Risk Profile Comparison – Distribution Protection Assets

While Option 4 looks attractive, the very large step change in the asset replacement program would be difficult to deliver from a resourcing and coordination perspective.

Based on the risk management approach adopted to deliver a viable secondary distribution protection asset management plan, Option 3 – Maintain Risk has been chosen as the most viable strategic approach that would provide the following benefits:

- Cost optimisation of OPEX and CAPEX
- Management of asset profile risk and improved future health condition
- Condition monitoring of primary and secondary assets.

5.3.2 Forecast Asset Condition

Health profile is determined by asset condition and performance history. Condition is determined by the asset's capacity to meet requirements, asset reliability and its level of obsolescence. Obsolescence will be determined by maintenance requirements and availability of support from manufacturers.

The future health profile is the asset health profile at the end of the Regulatory Period, year 2024, under the recommended option to maintain risk exposure. This forecast is based on:

- Initial health profile

- Deterioration due to aging
- Deterioration where condition monitoring identifies specific risks for certain models of equipment
- Allowance made for replacement and refurbishments.

A strategic decision is made at the start of the period on the adequacy of the asset class health, and whether the asset class health should be maintained, improved, or allowed to decline during the period. The maintenance program is adjusted to achieve the required asset class health at the end of the period.

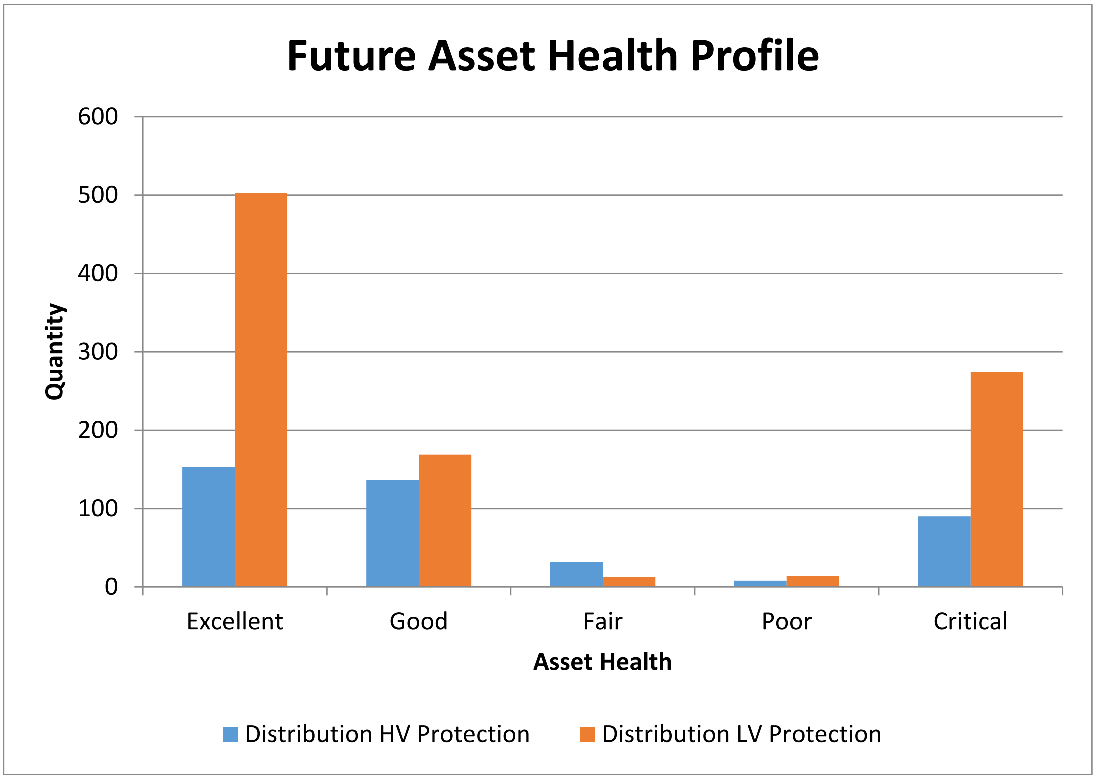

Figure 10: Asset Future Health Profile – Distribution Protection Assets

6 Implementation

This section provides implementation details for the recommended asset management strategy option.

6.1 Asset Creation Plan

Assets are added to the network from asset replacement and network expansion plans. Acquisition plans for asset renewal from a protection perspective aligns with EVOENERGY's protection strategy of combined protection and substation automation in accordance with best industry practice. Accordingly, modern numerical protections are the preferred replacement option.

Over the next few years, a number of customer funded distribution substation and solar generation hubs will form the core of the distribution network augmentation program. The strategy and the approach from a secondary systems perspective will be driven by the requirements of combined protection and substation automation solution.

6.2 Asset Maintenance Plan

The objective of this maintenance plan is to economically achieve the longest possible reliable working life of assets. This is done through condition monitoring, preventative and corrective maintenance and has been adapted to Evoenergy's assets, operating environment and conditions.

6.2.1 Development

The maintenance plan is designed to achieve the objectives of the asset specific strategy. The following engineering techniques were used to develop the maintenance plan:

- Failure Mode and Effects Analysis (FMEA)
- Condition monitoring
- Historic performance
- Equipment manuals
- Continuous review of asset performance and fine-tuning of maintenance triggers.

Asset Type	Maintenance Task	Maintenance Trigger
Distribution 11 kV Protections Static/others	Condition Assessment	5 years
Numerical protections for 11kV distribution substations	Condition Assessment	5 years sanity check and 8 years full in-situ maintenance

Table 14: Distribution Protection Asset Maintenance Interval Summary

6.2.2 Condition Monitoring

6.2.2.1 Testing

The condition of protection relays is determined from comprehensive condition assessments by performing testing of protection pick-ups, characteristics and scheme functionality using Doble test plans. The condition assessment includes evaluating set parameters by simulating various abnormal power system conditions and faults.

Assets are tested to ensure the condition is satisfactory, fault pick-up is within calibration and can remain in service and operate reliably and safely. This test also supports the condition based replacement strategy and is performed at the prescribed distribution substation maintenance intervals.

6.2.3 Maintenance Strategy

The following sub-sections detail the newly proposed maintenance cycle that seeks alignment with the primary equipment maintenance cycle to optimise outages (some will remain the same as before).

6.2.3.1 Distribution Substation 11kV Static and Electromechanical Relays

The criterion for the maintenance cycle is to reset the primary and secondary maintenance cycle to the same date in order to maintain both of these devices with one outage.

The maintenance cycle of 11kV primary equipment is 5 years.

This will prompt us to reset the secondary static protection maintenance cycle to 5 years for all protections relating to distribution substations.

6.2.3.2 Distribution Substation 11kV Numerical Protections

Since numerical protection relays are equipped with built-in self-supervision features, they require less maintenance effort compared to static protection relays.

Therefore for the 11kV distribution network in the first 5 years, we are proposing a minor maintenance on their parameters and operations, followed by a comprehensive protection function check after 8 years.

Furthermore, if we are able to keep a record of successful protection operations, the maintenance for such protections could be deferred to the next cycle.

Alternative scenarios have been considered for optimising OPEX and CAPEX costs, reliability improvements and safety.

6.3 Asset Renewal Plan

This asset renewal strategy minimises risk through planned replacement or refurbishment of assets at end of life before catastrophic failure. The condition based replacement strategy uses asset condition to trigger asset replacement or refurbishment and considers the following factors;

- Poor condition from condition assessments and consequently high risk
- Economic obsolescence (economical to replace with alternative product)
- Technological obsolescence (availability of spare parts and support)
- Safety risk (inherent fault in a type of equipment)
- Suitability of ratings.

The decision to replace or refurbish distribution protection assets is assessed on a case by case basis to the whole of life costs, technical feasibility, safety improvements from modern technology and network planning and alignment with the philosophy of combined protection and substation automation in accordance with the best industry practice. We take a strategic approach to asset replacements informed by the condition of the assets and with consideration of opportunities offered through enhanced functionality provided by modern numerical relays.

Evoenergy Distribution has identified the need to replace a significant number of problematic relays due to defects and performance, obsolescence and functional deficiencies in a number of critical protection applications on both transmission and distribution networks. These relays are integral to the safe and secure performance of the network. It is a requirement that Evoenergy be in a state of preparedness for either scheduled replacement or replacement arising from premature failure. Whilst the older distribution substations utilise old static and electromechanical protections, the newer distribution substations deploy numerical multifunction protections.

6.3.1 Key Drivers

The following factors drive the CAPEX programs pertaining to protection assets:

- Replacing faulty assets with poor condition – Generally, faulty units amount to protection relays whose components have either failed or operate with deviation in their parameters. Notably, these assets have a poor condition score, and thereby are candidates for replacements.
- Replacing aged assets – This would amount to replacing relays which are close to reaching the end of life in terms of the stipulated MTBF or its performance including technological obsolescence such as inability to communicate with SCADA.
- Replacing asset with support issues – Either no OEM support or no/limited spares. This problem is typical of either the product having reached the end of its life-cycle or the manufacturer is no longer in business.
- Replacing assets with small populations – Optimise maintenance and assets that are hard to maintain. Rationalisation of the asset base to fewer asset types reduces maintenance requirements, test plans and learning curve of personnel managing the assets.
- Replacing assets that do not meet regulatory requirements – Assets that do not meet regulatory compliance in terms of unit protection scheme or with expedited operating times such as the old static distance protections are increasingly being replaced by modern multifunction protections that can provide unit protections and offer redundancy of protections.
- Replacing assets to meet emerging network requirement – Evoenergy Network is facing major challenges with the ingress of medium and small solar generations and battery storage devices. This requires a rethink of protection philosophy and application due to the alteration of the network behaviour due to low fault currents and voltage regulation.
- Providing total solution of monitoring and protection – There is an opportunity to replace old protections and SCADA with newer concepts of integrated protection and substation automation. The application of this concept results in a comprehensive secondary systems solution that provides protection, control and condition monitoring of primary and secondary systems. The strategy for protection is a subset of the larger network management strategy, of which monitoring, communication and data acquisition form the cornerstones of a comprehensive network solution. This implies a combined protection and SCADA solution.
- Improve safety and reliability – The protection philosophy is based on the provision of duplicate redundant protection systems operating simultaneously to mitigate failures and ensure availability under all conditions in accordance with the NER. The NER requirements exclude the grandfathering provisions for new assets or assets that are being augmented or replaced.

The methodology for determining criterion for replacements to occur through RIVA has been adequately explained under the section pertaining to asset maintenance strategy.

6.4 Asset Disposal Plan

The assessment of disposal plans for distribution protection system assets is based on the following key criteria:

- Obsolescence of technology
- Mean time between failure of components typically 20-30 years
- Failures and deviation in performance
- Power system conditions and changes in system configurations.

When determining the time frame for replacement and disposal, it is recommended that the lower of the two figures between MTBF and technology obsolescence be applied.

A planned and phased approach should be adopted towards disposal of protection assets such that:

- All historical and operational data are migrated to the new system
- Operational continuity is ensured.

So far within Evoenergy Distribution, relays removed from service are stored as inventory to replace faulty units. This process will continue until an asset class is no longer in service and therefore spares are not required.

6.5 Associated Asset Management Plans

Distribution protection assets are aligned to the concept of combined protection and substation automation. In terms of maintenance strategies, they are aligned to primary equipment, be it 11kV circuit breaker or 415V switchboard. Whilst most of the replacement of protection assets occurs independently, which in some cases extends the mid-life range of the switchgear, a 415V switchboard replacement almost invariably results in providing the opportunity to replace ageing protection equipment.

6.6 Asset Strategy Optimisation Plan

The aim of the asset optimisation plan is to provide:

- Completion of condition monitoring across all assets
- Online condition analysis from IED protection relays.

By implementing the asset optimisation plan for distribution protection assets, the following additional benefits eventuate:

- Reduction of condition monitoring expenditure of secondary protection assets by increasing maintenance frequency and obviated condition monitoring expenditure
- Reduction of primary equipment condition monitoring expenditure due to monitoring of circuit breaker contact wear, close and opening time and determining maintenance interval based on the aggregate of short circuit current interrupted.

7 Program of Work

This section provides the program of work and the resulting operational and capital expenditure forecasts.

7.1 Maintenance Program

This section outlines the operational expenditure for preventative maintenance, corrective maintenance and condition monitoring.

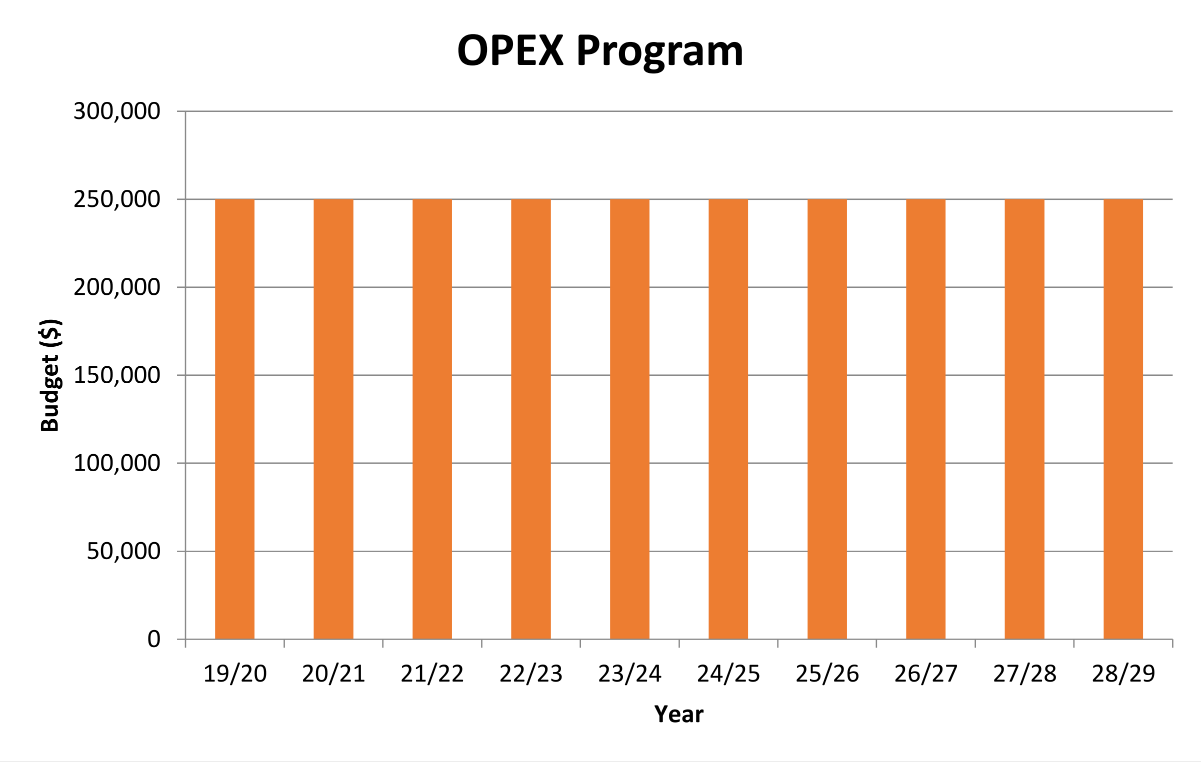

Figure 11: OPEX for Maintenance Program of Distribution Protection Assets

Program	Secondary Systems Protection Maintenance and Condition Monitoring
2019-24 Budget	Annual budget for distribution protection assets: **$250,000**
Scope	This program includes: Protection planned and unplanned maintenance and condition monitoring.
Project(s) Details	**Protection Maintenance and Condition Monitoring** The following maintenance activities are to be undertaken for distribution substation protection asset maintenance on an annual basis: 250 – Distribution substation protections 15 – Distribution substation battery chargers Note: The above figures are average estimates of assets to be maintained. The exact quantity may vary over the 5 year period.

Risks and Opportunities	Protection condition monitoring and maintenance allows the identification and rectification of issues in protection assets before failure occurs and saves the business any potential loss of revenue and reputational risks due to failure to clear the faults. Protection condition monitoring also assesses the condition of protection assets, optimising the on-going protection replacement program. Results of protection testing can be used to formulate the methodology for the protection replacement program on the basis of the condition monitoring scorecard stored in Cityworks. The scorecard will be formulated on the basis of maintenance works and calibration performed on those assets.
	The strategy for optimised maintenance is based on the revised maintenance strategy of alignment with primary systems assets.

Table 15: Secondary OPEX Distribution Protection Maintenance Program

7.2 Capital Program

This section outlines the capital expenditure for asset replacement and refurbishment.

The strategic approach to CAPEX spend in relation to protection replacements is based upon the following rationale that underpins maintaining asset class risk profile at current values:

1. Program Prioritisation

The prioritisation of protection replacement is based on the following approach:

- The failure history of the protection relay assets.
- The results of maintenance and condition monitoring undertaken on individual assets at each zone substation.
- The condition assessment of each make/model family of protection relay.
- The criticality of each protection relay in terms of connected load and customers, the likelihood and consequence of faults on the network segment and network reliability (STPIS).

2. **Bottom up consideration of asset condition**

Failures, obsolescence and the risk of assets no longer supported result in age and condition based risk to the network. Asset replacements are therefore necessary to mitigate failures and reduce risk profile of the network. Therefore selectively, critical protections such as unit Translay feeder protections back to zone that are reaching obsolescence shall be prioritised for replacements.

3. Prediction of asset failure

Due to the random nature of failure of ageing electronic protections, it would be difficult to predict the exact location for prioritisation. Based on ageing curve and obsolescence of old electromechanical and Translay protections, these protections shall be targeted for selective replacement with the highest priority accorded to the most critical loads. Ageing pilot cables shall be replaced by fibre. This will result in old legacy Translay protections being replaced by modern numerical line differential protections.

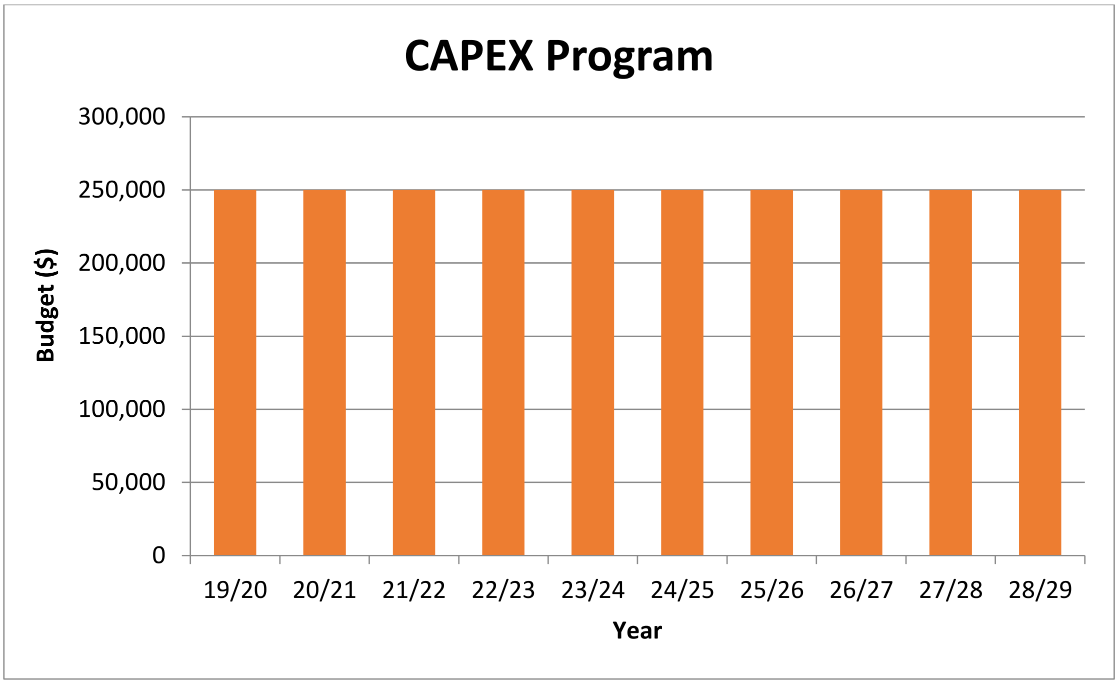

Figure 12: CAPEX Program for Distribution Protection Assets

S.No	Project Title	Proposed Budget	Nominated Year
1	Distribution substation protection replacement of old electromechanical and static relays	$750k	2019-2024
2	Distribution network translay protection upgrade	$500k	2019-2024

Table 16: Secondary CAPEX Distribution Protection Replacement Program

7.3 Budget Forecast

This section provides a 10 year forecast for the CAPEX & OPEX budgets.

Total Budget	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29
CAPEX	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**230,000**	**220,000**	**265,000**
OPEX	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**
Planned Maintenance (OPEX)	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Unplanned Maintenance (OPEX)	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Condition Monitoring (OPEX)	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000

Table 17: 10 Year Forecast for CAPEX and OPEX Budgets

The replacement projects have been confirmed through an individual Project Justification Report.

Appendix A Maintenance Plan Details

Appendix A provides additional details of the data used in evaluation of the asset management strategy options, including the costing and budget forecasting.

A.1 Maintenance Task Costing

Unit costs for work on this asset class have been estimated by Program Development Branch. Details of the estimate are available in \\jeeves\energynetwk\Program of Work\future pow\AMP Reg Submission.

A.1.1 Planned Maintenance Tasks

Unit Costs			
Asset Type	**Task**	**Cost Basis**	**Unit Cost**
Battery Chargers (Distributions)	Maintain Distribution Battery Charger	Test and prove asset integrity in accordance with standard asset procedures and Relay Test Instructions	$454
Distribution Substation Protection	Maintain – Distribution Substation Protection	Test and prove asset integrity in accordance with standard asset procedures and Relay Test Instructions	$907

Table 18: Planned Maintenance Task Unit Costs

A.1.2 Condition Monitoring Tasks

Unit Costs			
Asset Type	**Task**	**Cost Basis**	**Unit Cost**
Protection	Maintain Distribution Battery Charger	Inspect, test and service distribution battery chargers	$907
Protection	Maintain – Distribution Substation Protection	Inspect, test and service distribution substation protection relays	$907

Table 19: Condition Monitoring Task Unit Costs

A.1.3 Reactive Maintenance Tasks

Unit Costs			
Asset Type	**Task**	**Cost Basis**	**Unit Cost**
Battery Chargers (Distributions)	Reactive repairs	Test and prove asset integrity in accordance with standard asset procedures and Relay Test Instructions	$454
Protection	Replacement of relay & rewire device	Purchase of relay, re-design of protection scheme, development of a new RTI, configuration of relay(s), rewire, testing, protection integration and commissioning	$15,000

Table 20: Reactive Maintenance Task Unit Costs

Appendix B Risk Definitions

Appendix B provides reference information for how the severity of an effect, the probability of failure and the likelihood of detection are defined and ranked for the analysis of risk.

B.1 Severity

Effect	SEVERITY of Effect	Ranking
Catastrophic	Hazardous-without warning Very high severity ranking, potential failure mode affects safety, noncompliance with policy and without warning.	10
Extreme	Hazardous-with warning Very high severity ranking, potential failure mode affects safety, noncompliance with policy with warning.	9
Very High	Item inoperable, with loss of primary function.	8
High	Item operable, but primary function at reduced level of performance.	7
Moderate	Equipment operable, but with some functions inhibited	6
Low	Operable at reduced level of performance.	5
Very Low	Does not conform. Defect obvious.	4
Minor	Defect noticed by routine inspection.	3
Very Minor	Defect noticed by close inspection.	2
None	No effect	1

B.2 Occurrence

PROBABILITY of Failure	Failure Probability	Failure rate Lamda "λ"	Ranking
Very High: Failure is almost inevitable	Very High: Failure is almost inevitable Possible Failure Rate >= 1 every week	0.1429	10
	Very High: Failure is almost inevitable Possible Failure Rate >= 1 every month	0.0333	9
High: Repeated failures	High: Repeated failures Possible Failure Rate >= 1 every 3 months	0.0111	8
	High: Repeated failures Possible Failure Rate >= 1 every 6 months	0.0056	7
Moderate: Occasional failures	Moderate: Occasional failures Possible Failure Rate >= 1 every year	0.0027	6
	Moderate: Occasional failures Possible Failure Rate >= 1 every 3 years	0.0009	5
	Moderate: Occasional failures Possible Failure Rate >= 1 every 5 years	0.0005	4

PROBABILITY of Failure	Failure Probability	Failure rate Lamda "λ"	Ranking
Low: Relatively few failures	Low: Relatively few failures Possible Failure Rate >= 1 every 8 years	0.0003	3
	Low: Relatively few failures Possible Failure Rate >= 1 every 15 years	0.0002	2
Remote: Failure is unlikely	Remote: Failure is unlikely Possible Failure Rate >= 1 every 20 years	0.0001	1

B.3 Detection

Detection	Likelihood of DETECTION	Ranking
Absolute Uncertainty	Control cannot prevent / detect potential cause/mechanism and subsequent failure mode	10
Very Remote	Very remote chance the control will prevent / detect potential cause/mechanism and subsequent failure mode	9
Remote	Remote chance the control will prevent / detect potential cause/mechanism and subsequent failure mode	8
Very Low	Very low chance the control will prevent / detect potential cause/mechanism and subsequent failure mode	7
Low	Low chance the control will prevent / detect potential cause/mechanism and subsequent failure mode	6
Moderate	Moderate chance the control will prevent / detect potential cause/mechanism and subsequent failure mode	5
Moderately High	Moderately High chance the control will prevent / detect potential cause/mechanism and subsequent failure mode	4
High	High chance the control will prevent / detect potential cause/mechanism and subsequent failure mode	3
Very High	Very high chance the control will prevent / detect potential cause/mechanism and subsequent failure mode	2
Almost Certain	Control will prevent / detect potential cause/mechanism and subsequent failure mode	1