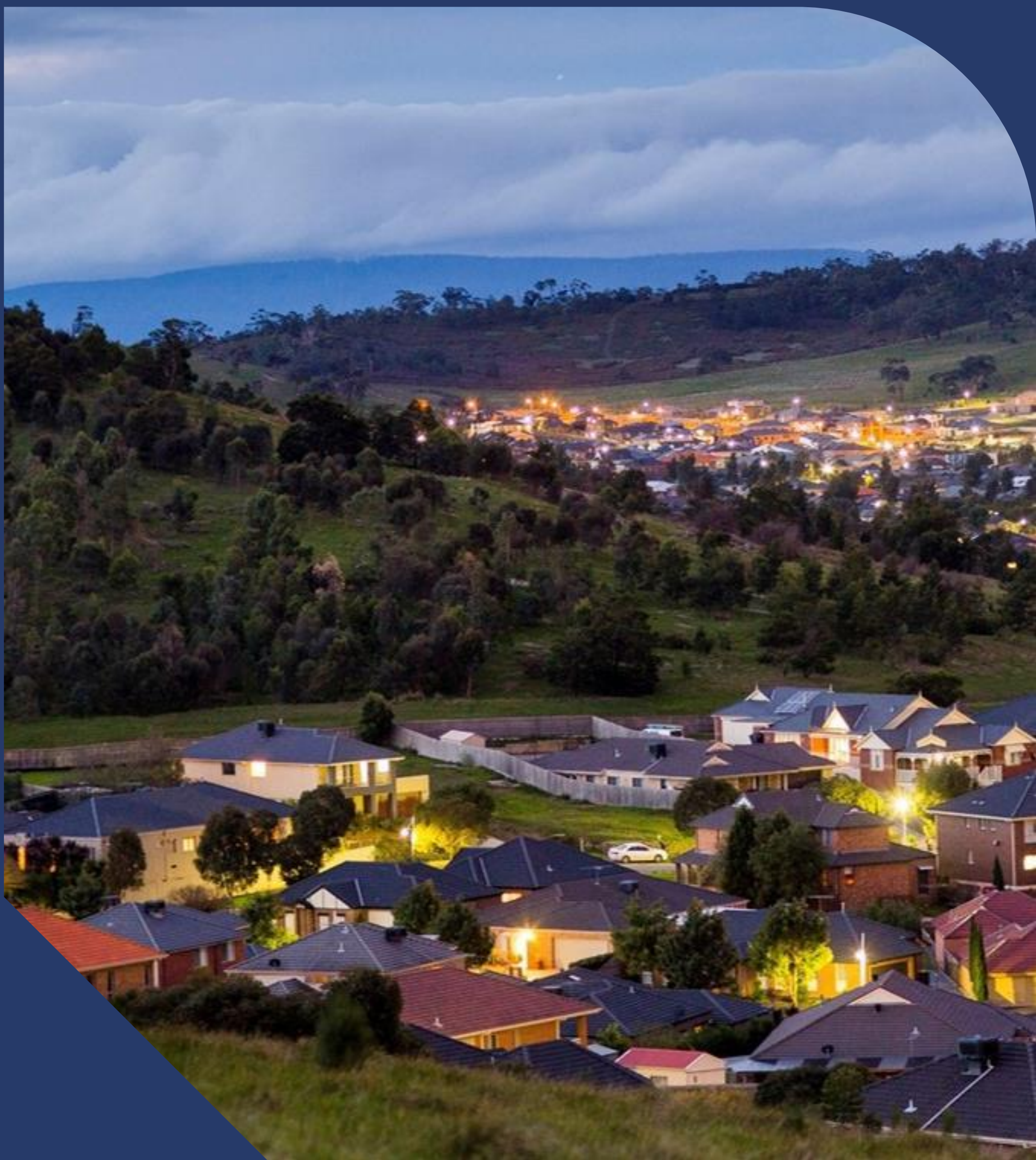
AusNet

Protection and Control Systems

AMS – Electricity Distribution Network



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1. Executive Summary

This document is part of the suite of Asset Management Strategies relating to AusNet's electricity distribution network. The purpose of this strategy is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of protection and control schemes and Supervisory Control and Data Acquisition (SCADA) Remote Terminal Units (RTU) in AusNet' Victorian electricity distribution network.

The AusNet electricity distribution network has approximately 3480 protection and control relays and 100 RTUs located in its Zone Substations (ZSS). The protection and control relays consist of both digital technology types, made up of 62.3% Intelligent Electronic Devices (IEDs), 1.7% microprocessor based and analogue technology types, 22.2% electro-mechanical and 13.6% electronic types. The RTU consist of a variety of types, with 18% of RTUs installed at zone substations consist of the older obsolete [CIC].

Relay and RTU are analysed using asset service life data for likelihood assessment. Weibull distribution is then used to determine parameters for calculating probability of failure (PoF) and its remaining life. The consequence of failure has been determined, based on safety, environment and customer unserved energy impact from failure to operate correctly. Using PoF and consequence, a risk assessment for relay and RTU was performed to establish an economically justified replacement program.

Proactive management of protection and control relay and RTU, application, inspection, maintenance, refurbishment and replacement practice are required to ensure that stakeholder expectations of cost, safety, reliability and environmental performance are met. The summary of proposed asset strategies is listed below.

1.1. New Asset

- All new and replacement assets will be designed in accordance with the Station Design Manual (SDM) and current design standards, undertake replacement of complete protection systems (i.e. X, Y, backup and necessary control and monitoring systems) associated with individual items of primary plant/network sections, rather than individual protection schemes/relays
- Replacement activities shall be incorporated within primary plant replacement, station refurbishment or network augmentation activities as far as practicable, in order to maximise operational efficiency and minimise network disruption

1.2. Maintenance

- Continue to maintain protection and control assets as per PGI 02-01-04 and the SPP 02-00-01 suite of documents
- Maintain PGI 02-01-04 and the SPP 02-00-01 suite of documents consistent with AMS 01-09

1.3. Spares

- Continue to maintain sufficient spares to ensure ongoing maintainability of in-service devices
- Maintain decommissioned assets in appropriate working condition as spares, as required to ensure the ongoing serviceability of in-service, poor condition/obsolete assets pending retirement
- Continue to consider device obsolescence, as advised by asset manufacturers and suppliers, in preparation of asset spare and replacement strategies

1.4. Replacement

Prioritize proactive replacement

- High risk 66kV line protection systems incorporating obsolete and/or poor condition static-electronic and first-generation microprocessor-based distance protection relays ([CIC]-type devices)
- High risk transformer and 66kV bus protection systems incorporating obsolete and/or poor condition electromechanical, static-electronic and first-generation micro-processor based transformer protection relays ([CIC] devices) and electromechanical and static electronic high-impedance bus protection relays ([CIC]-type devices)
- High risk 22kV bus, back-up earth fault (BUEF) and master earth fault (MEF) protection systems incorporating obsolete and/or poor condition electromechanical and static-electronic high-impedance bus protection relays ([CIC]-type devices), electronic bus distance protection relays ([CIC]-type devices), electromechanical, static electronic and early generation digital BUEF protection relays ([CIC]-type devices) and electromechanical and static-electronic based MEF protection relays ([CIC]-type devices).
- 22kV feeder protection schemes incorporating obsolete [CIC] relays
- 22kV capacitor bank protection schemes incorporating obsolete [CIC] relays
- Obsolete, high-risk [CIC]-type voltage regulation relays
- Restricted capability voltage regulation control systems at zone substations affected by significant load growth, and/or as required to accommodate ongoing penetration of low voltage distributed generation
- Obsolete and over-utilised [CIC]-type remote terminal units.

1.5. Research and Development

- Develop alternative standard design and plan for spare [CIC] relays which will become obsolete in 2025
- Continue to evaluate process bus applications
- Continue to refine 22kV earth fault management strategy in response to evolving technologies
- Investigate opportunities and strategies for integrating non-conventional instrument transformers
- Research and develop 4G / 5G and NBN solutions for protection signalling (including backup inter-trip) applications to address increasing penetration of distributed generation
- Investigate ways to improve primary asset monitoring and maintenance using existing secondary infrastructure

2. Introduction

2.1. Purpose

The purpose of this document is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of protection and control assets. This document is intended to be used to inform asset management decisions and communicate the basis for activities.

In addition, this document forms part of our Asset Management System for compliance with relevant standards and regulatory requirements. It is intended to demonstrate responsible asset management practices by outlining economically justified outcomes.

2.2. Scope

Included in this strategy are the following assets:

- Protection and Control relays, as employed within network protection and control schemes located within zone substations across the regulated distribution network
- Peripheral equipment, including trip relays and timers, isolating/test links and secondary AC and DC wiring circuits that work in conjunction with the protection and control relays to actuate protection and control functions
- Relays and similar devices used in station voltage regulation schemes, and
- Station RTUs and all associated equipment including SCADA Human Machine Interfaces (HMIs).

Excluded from this strategy are the following assets:

- Station Auxiliary Power Systems and associated monitoring and control equipment – refer AMS 20-80.
- Distributed protection devices, such as Automatic circuit reclosers (ACRs), sectionalisers and fuse savers, that are located outside of the zone substation boundaries – refer AMS 20-60.
- Communications infrastructure, such as multiplexors and physical carriers, used for protection signalling (protection and communications boundaries of responsibilities assumed to be located at Comms ITC) – refer AMS 20-81.
- Power Quality Meters and Revenue Meters – refer AMS 20-15.

2.3. Asset Management Objectives

The high-level asset management objectives are outlined in *AMS 01-01 Asset Management System Overview*.

The electricity distribution network objectives are stated in *AMS 20-01 Electricity Distribution Network Asset Management Strategy*.

3. Abbreviations and definitions

TERM	DEFINITION
4G / 5G	Fourth and Fifth generation wireless network
ACR	Automatic circuit reclosers
BUEF	Backup Earth Fault
CoF	Cost of Failure
DFA	Distribution feeder automation
DIC	Digital Interface Cubicles
DNSP	Electricity Distribution Network Service Provider
EDDAM	Enhanced Data-Driven Asset Management
ESV	Energy Safe Victoria
HMI	Human Machine Interfaces
IEDs	Intelligent Electronic Devices (IEDs)
LoC	Likelihood of Consequence
MEF	Master Earth Fault
NBN	Australia's National Broadband Network
PoF	Probability of Failure
REFCL	Rapid Earth Fault Current Limiters
RTU	Remote terminal units
SCADA	Supervisory Control and Data Acquisition
SRC	Scheme Replacement Cost
VRR	Voltage regulation relay
VUE	Value of unserved energy
PGI	Plant Guidance and Information
SMI	Standard Maintenance Instruction
SPP	Secondary Practice and Procedure
CB	Circuit Breaker
SF6	Sulphur Hexafluoride gas
AEMO	Australian Energy Market Operator
ESMS	Electricity Safety Management Scheme

4. Asset Description

4.1. Function

Protection and control systems are used throughout the AusNet electricity distribution network to:

- Detect fault conditions and, by operating the appropriate circuit breakers, de-energise the faulted portion of the network in order to minimise the risk to human life, minimise property and equipment damage, and maintain reliability and quality of supply to customers
- Monitor and maintain operating voltages within the limits of the Electricity Distribution Code of Practice
- Provide specialised control functions, including anti-islanding and runback control for generator connections
- Facilitate network switching via supervisory control and data acquisition (SCADA) system or distribution feeder automation (DFA).
- Provide monitoring of primary plants such as SF6 critical levels in Circuit Breakers (CBs), high oil level of power transformer etc.
- Provide instrumentation capabilities including measurement of voltage, current and power, as well as plant operating temperatures and environmental conditions to facilitate network operations and control

Protection and control relays form the basis of schemes and systems used to provide protection and control functions for the primary electrical network. Protection and control relays are installed within zone substations and, in conjunction with specialised peripheral circuits, are combined in schemes intended to provide electrical protection and control of a defined primary asset or network section. Each scheme is specifically designed to accommodate the unique characteristics of the associated primary plant/network element (i.e. the “application”). Two or more independent protection and/or control schemes always operate in parallel (i.e. as a “protection system”) for each primary asset or network section in order to maintain a very high level of protection system reliability.

Remote terminal units (RTUs) provide SCADA services at zone substations by serving as an interface between the station protection and control schemes and the SCADA system. The SCADA system gathers station information, including instrumentation data (volts, amps, frequency, watts, vars, operating temperatures, conductor strain etc), circuit breaker and plant status information and alarms, and interprets and displays that information in a useful format to local and remote operations personnel.

Each station RTU plays an essential role in the operation of distributed feeder automation (DFA) systems by providing the necessary plant status information and logical processes necessary for coordinated operation of station circuit breakers and distributed ACRs and sectionalisers (refer AMS 20-60).

4.2. Population

4.2.1. Population Considerations

The population profile for Protection and Control Systems is crucial for effective lifecycle management. This profile includes detailed data on the quantity, types, locations, and specifications of these assets within the electrical distribution network.

A comprehensive understanding of the population profile allows asset managers to:

- **Identify critical assets:** Determine which protection and control systems are essential for maintaining the integrity and reliability of the network. For example, a particular protection relay serving a critical industrial zone might be deemed essential and may require more frequent maintenance to ensure uninterrupted service.
- **Allocate resources efficiently:** Plan and allocate maintenance resources effectively by knowing the exact number and location of assets. For instance, knowing that a certain region has a high concentration of first-generation microprocessor-based relays can help in scheduling maintenance activities more efficiently.
- **Risk management:** Assess and manage risks associated with different assets.
- **Optimise maintenance schedules:** Develop optimised maintenance schedules based on the distribution and condition of assets. For instance, electro-mechanical protection relays for high consequence protection

schemes might be scheduled for more frequent inspections and maintenance to prevent any potential failures.

- **Enhance reliability and safety:** Ensure that all components, including RTUs and SCADA systems, meet the required standards for reliability and safety. For example, if the profile reveals that certain RTUs have outdated software that no longer meets safety standards, these can be prioritised for replacement.
- **Support strategic planning:** Inform long-term strategic planning and investment decisions. For instance, the population profile might show that a significant portion of electro-mechanical relays in a rapidly developing suburban area need upgrading to support increased demand, guiding future investment in that region.

4.2.2. Geographic Impact Areas

The AusNet electricity distribution network provides electricity to 802,000 customers across eastern and north-eastern Victoria, and in Melbourne's north and east. This region encompasses a diverse range of geographic locations, each with specific environmental impacts on protection and control systems. Understanding these impacts is essential for effective asset management within the AusNet electrical distribution network.

Notable examples include:

Corrosive Areas: Coastal areas where salt are prevalent can cause corrosion of metallic components in electro-mechanical protection and control relays.

4.2.3. Population by Type

Electro-mechanical relays

- **Summary Explanation of Form and Function:** Electro-mechanical relays are single-function relays with mechanical measurement registers, rotating disc mechanisms, mechanical bearings, and spring-based energy storage. They do not have function supervision capabilities.
- **Purpose within the Asset Class:** Electro-mechanical relays serve as the basis for traditional protection and control schemes within the network.
- **Purpose within the Network Design:** These relays are used across most protection and control applications, providing essential protection functions such as overcurrent and transformer protection.
- **Process Function:** The relay operates by mechanical movement to open or close contacts based on electrical conditions, thereby protecting the network from faults.

Electronic relays

- **Summary Explanation of Form and Function:** Electronic relays are single-function relays that use discrete electronic components such as transistors and simple integrated circuits to complete logical operations. Some electronic relays have basic functional supervision capability.
- **Purpose within the Asset Class:** These relays provide more advanced protection and control functions compared to electro-mechanical relays.
- **Purpose within the Network Design:** They are used in various applications, including bus and circuit breaker failure protection, enhancing network reliability.
- **Process Function:** The relay uses discrete capacitors for analogue current and voltage measurement to protect network from electrical faults.

First Generation Microprocessor-based relays

- **Summary Explanation of Form and Function:** Microprocessor-based relays are single-function devices where analogue measurements are carried out by microprocessor calculation. They have functional supervision capability and will alarm under predefined failure conditions.
- **Purpose within the Asset Class:** These relays provide more precise and reliable protection functions, essential for modern network operations.
- **Purpose within the Network Design:** They are particularly used for transformer protection, reflecting bulk replacement projects from the early 2000s.

- **Process Function:** The relay processes electrical signals digitally, allowing for complex protection schemes and improved fault detection and response times.

Intelligent Electronic Devices (IEDs)

- **Summary Explanation of Form and Function:** IEDs are multi-function devices with sophisticated programming and configuration capabilities. They undertake protection functions, as well as control functions via a direct SCADA interface and are inherently supervised.
- **Purpose within the Asset Class:** IEDs represent the latest technology in protection and control systems, providing comprehensive protection and control functions.
- **Purpose within the Network Design:** They are used across most protection and control applications, particularly for feeder and line protections, supporting advanced network automation and reliability.
- **Process Function:** The IEDs integrate multiple protection and control functions into a single device, communicating with SCADA systems via RTU to enhance network management and fault response.

Remote Terminal Units (RTUs)

- **Summary Explanation of Form and Function:** RTUs are devices that interface between the station protection and control schemes and the SCADA system. They gather station information and facilitate network operations and control.
- **Purpose within the Asset Class:** RTUs are essential for providing SCADA services, enabling remote monitoring and control of AusNet distribution network.
- **Purpose within the Network Design:** They are installed at zone substations to control and monitor assets, support and enable DFA and coordinated operation of network elements.
- **Process Function:** RTUs collect and transmit data on network conditions, allowing for real-time monitoring and control, which is crucial for maintaining network stability and reliability.

4.2.4. Population Profile

Asset Class Summary

Protection and control relays are reported in the "FIELD DEVICES" regulatory information notice (RIN) category. Zone substation protection and control system assets account for 60% (approximately) of the listed assets. Remote Terminal Units account for 2% of listed zone substation protection and control system assets.

For asset management purposes, protection and control relays are classified according to their technology type. There are four (4) different technology types: Electro-mechanical, Electronic, (First Generation) micro-processor and intelligent electronic devices (IEDs). Electromechanical relays represent the oldest relay technology, whilst IEDs are the most modern. Almost all new relays installed on the network are IEDs. Alternative technology relays are not used for new or replacement schemes, and the proportion of these relays in service will continue to decrease over the next 10 years, while the number of in-service IEDs increases. As IEDs are generally able to complete the functions of multiple single-function electromechanical, electronic or microprocessor-based relays, the overall population of relays may decrease as older protection and control schemes are replaced with IED-based schemes.

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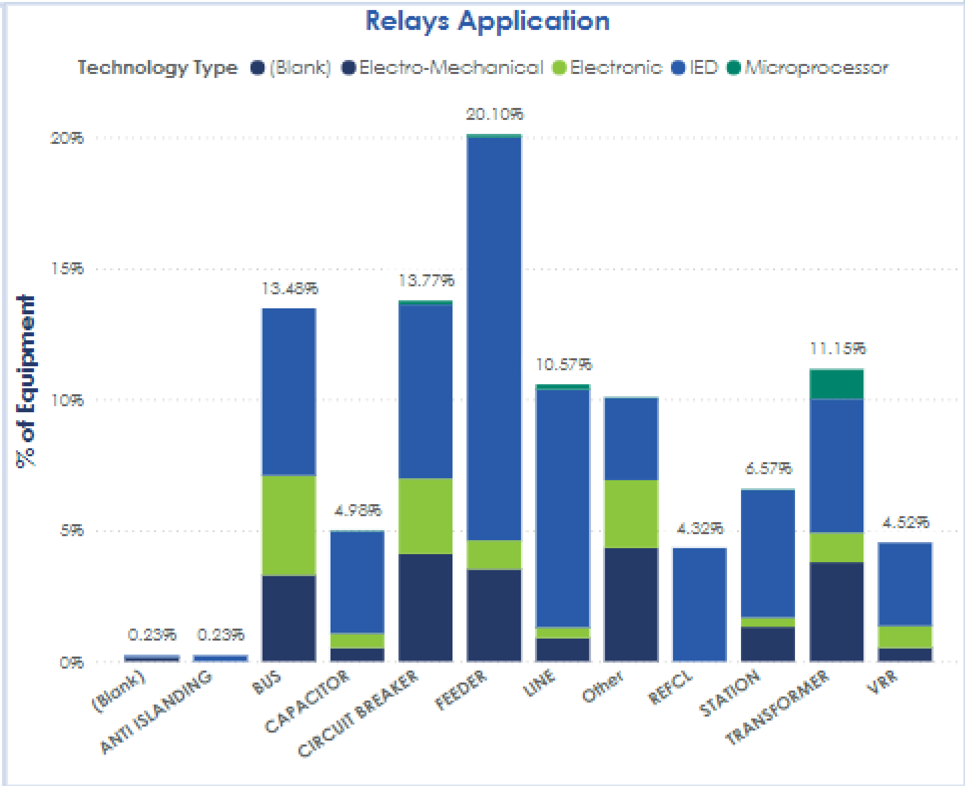

Figure 2 provide an overview of the relative proportions of relays of each type currently in service across AusNet' electricity distribution network, their time in service (age) and their applications.

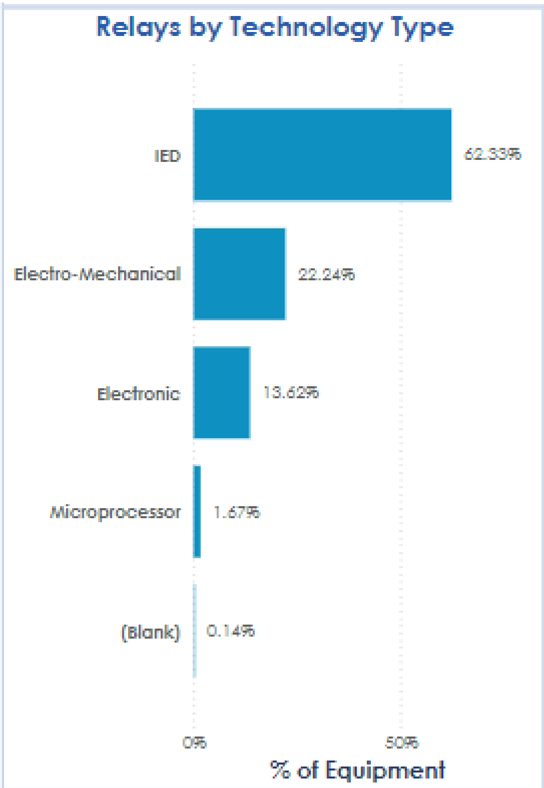

Figure 1: In-service Relays by Type

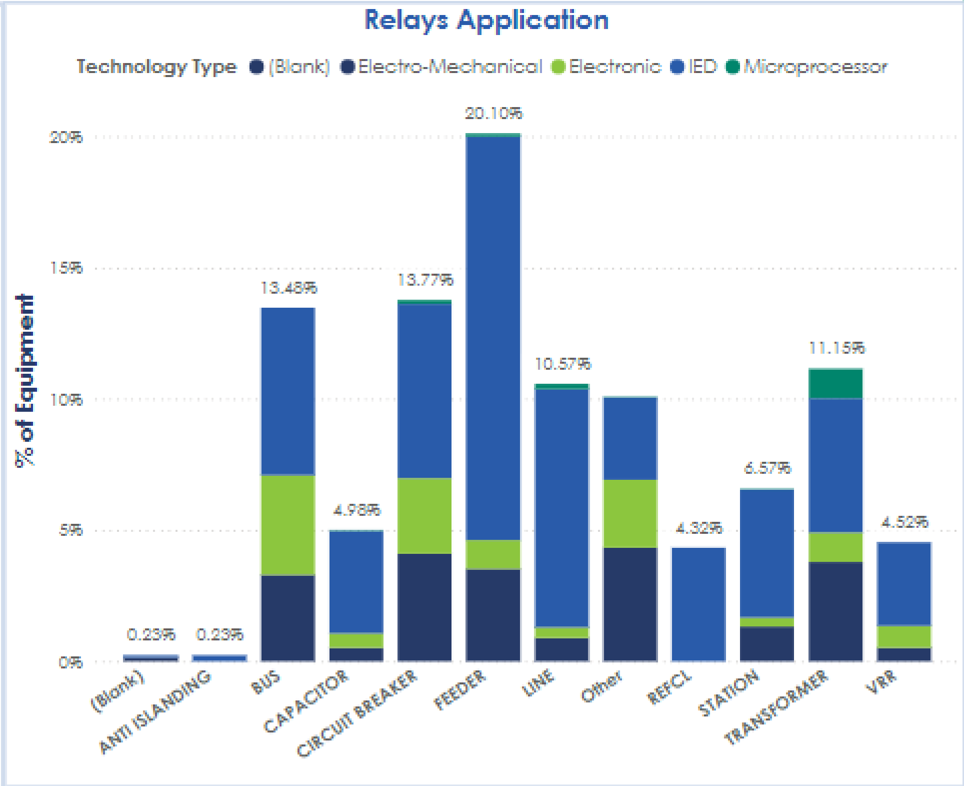

Figure 2: Application Distribution of In-Service Relays by Type

Bulk station voltage regulation (VRR) scheme replacements, necessitated by load growth and the increasing penetration of low voltage distributed generation will, as described in AMS 20-15 (Quality of Supply network strategy), also markedly change the technology profile in this area over the next 5 years.

Lifecycle Management Context

Electro-mechanical relays

Electromechanical relays are single function relays with mechanical measurement registers, rotating disc mechanisms, mechanical bearings and spring-based energy storage. Electromechanical relays do not have function supervision capabilities.

22.2% of the total population of protection and control schemes in service are based on electromechanical relays, which have an average age of 29.8 years.

Electromechanical relays are used across most protection and control applications, as indicated in

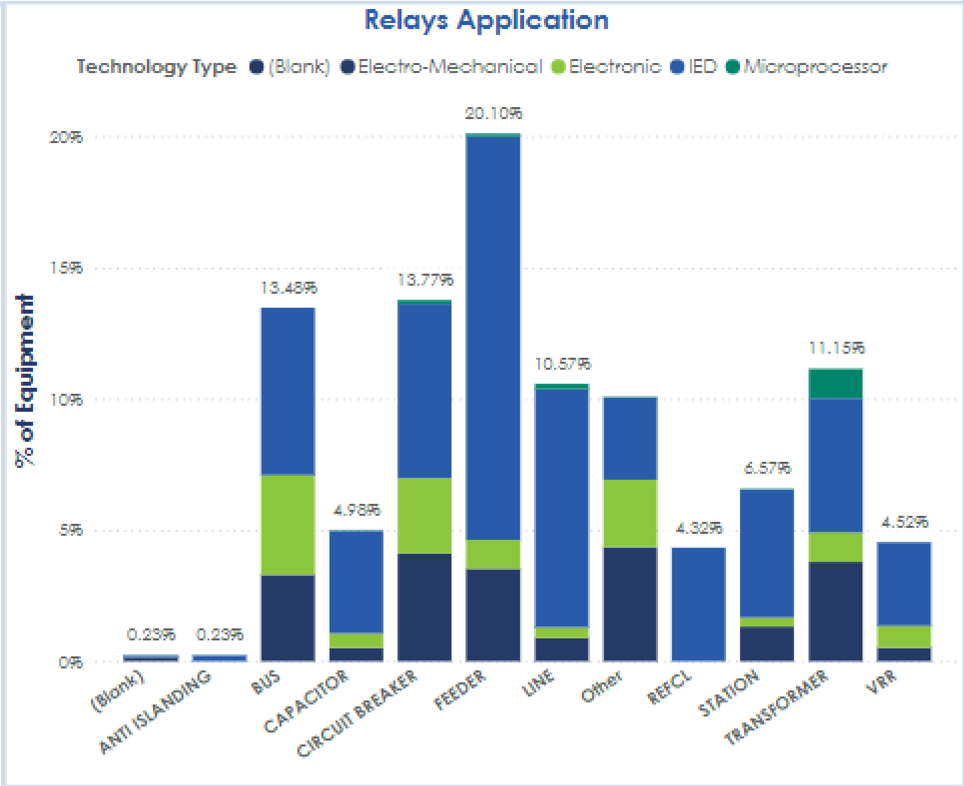

Figure 2, but in particular bus protection (3.3% of the total population of relays), circuit breaker failure protection (4.1%) and transformer protection (3.8%). Those indicated to be employed on lines and feeders (total 4.4%) are generally overcurrent protection relays deployed for protection of 66kV lines supplying coal mines in the Latrobe Valley, or voltage relays used to provide neutral displacement detection on 66kV lines, pending upgrade of primary line protection schemes from distance to digital differential protection as appropriate communication facilities become available. Electromechanical relays are no longer employed as primary line or feeder protection relays elsewhere on the network.

The number of electromechanical relays employed across all applications will continue to decrease over the next 10 years.

Electronic relays

Electronic relays are single-function relays that use discrete electronic components such as transistors and simple integrated circuits to complete logical operations. Electronic relays employ discrete capacitors for analogue current and voltage measurement. Some electronic relays have basic functional supervision capability.

Electronic relays represent 13.6% of the total relay population and have an average age of 20 years.

Electronic relays are used across a number of protection and control applications, as indicated in

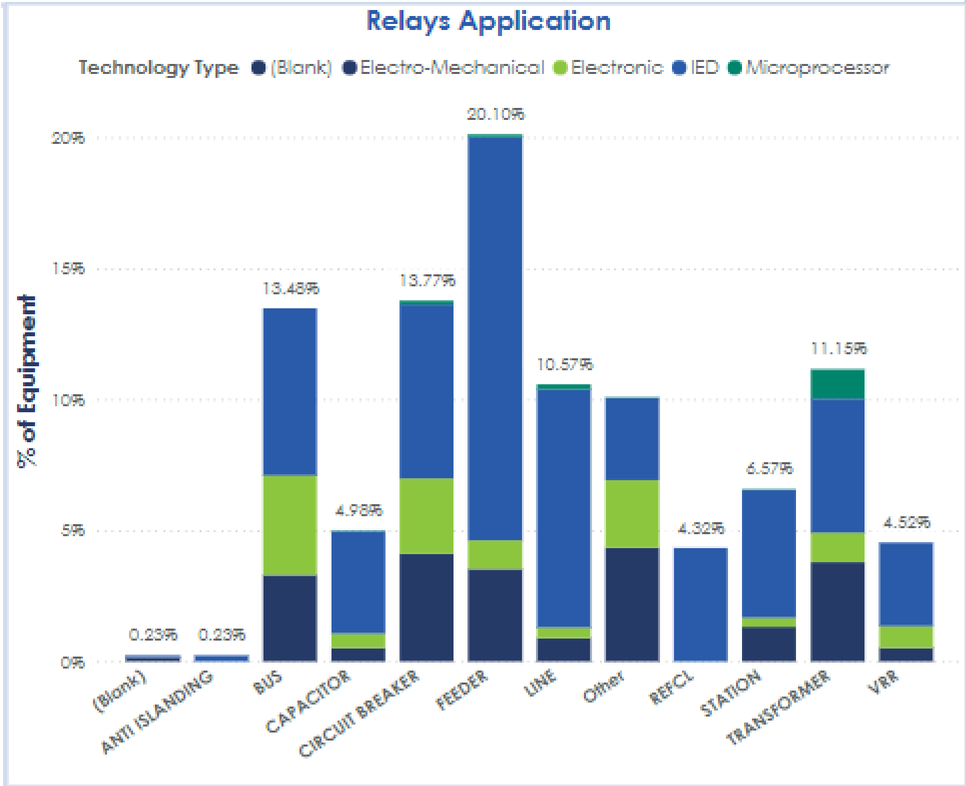

Figure 2, but in particular for bus protection (3.8% of total population of relays), circuit breaker failure protection (2.9%) and transformer protection (1.1%).

The number of electronic relays employed across all applications will continue to decrease over the next 10 years.

First Generation Microprocessor- based relays

Microprocessor relays are usually single function devices, in which analogue measurements are carried out by microprocessor calculation. Inherently, microprocessor relays have functional supervision capability and will alarm under predefined failure conditions.

Microprocessor-based relays represent 1.7% of the total relay population and have been in service for 22.3 years on average.

Microprocessor-based relays are used across a number of protection and control applications, but in particular for transformer protection (1.1% of the total population of relays). This application profile reflects bulk transformer protection replacement projects that were undertaken during the early 2000s across various rural and suburban zone substations.

The number of microprocessor-based relays employed across all applications will continue to decrease over the next 10 years.

Intelligent Electronic Devices

IEDs, also referred to as digital relays, are multi-function devices with sophisticated programming and configuration capabilities. IEDs undertake protection functions, as well as control functions via a direct SCADA interface and are inherently supervised.

IEDs represent 62.3% of the total relay population with an average age of 9.2 years.

IEDs are used across most protection and control applications, as indicated

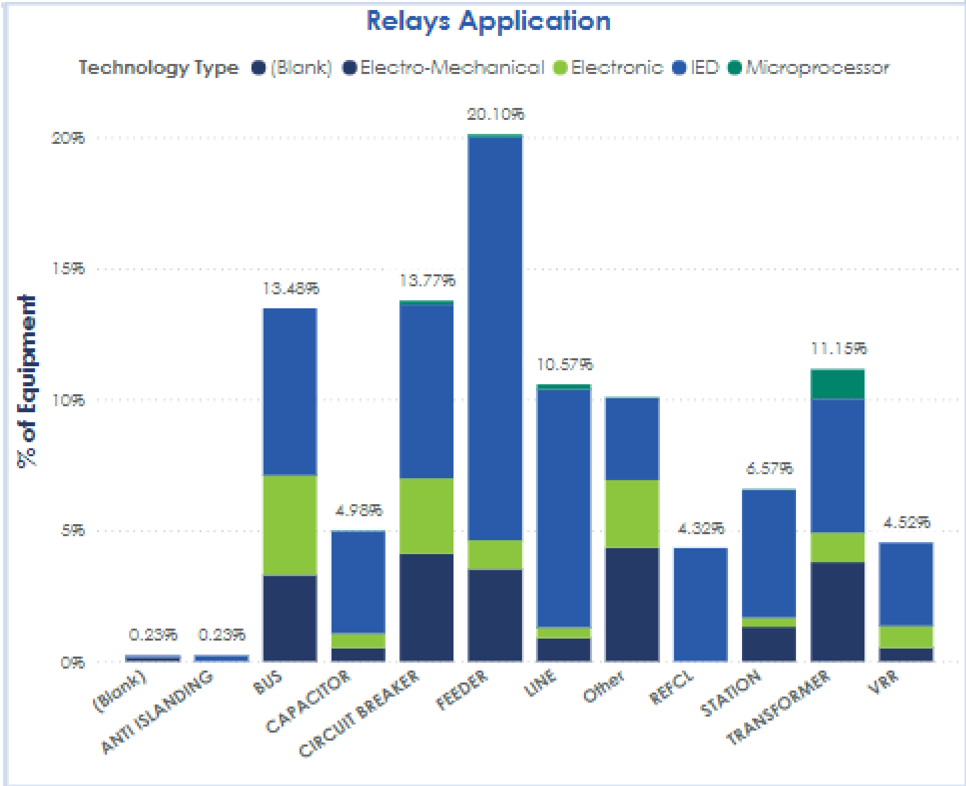

Figure 2, but in particular feeder and line protections (25.9% of total population of relay). This application profile reflects bulk line/feeder augmentation and protection upgrade projects that have been undertaken within the last decade.

The number of IED-type relays employed across all applications will continue to increase significantly over the next 10 years, as IED-based protection schemes replace protection schemes using alternative technology devices.

Remote Terminal Units

There are four models of RTUs currently in service on the AusNet distribution network. Figure 3 provides an overview of the population distribution.

[CIC]

Figure 3: Overview of RTU types deployed across AusNet distribution network

[CIC] RTUs are the next oldest RTU type currently in service. SCADA services to 18.6% of distribution zone substations are currently supplied via RTUs of this type.

The [CIC] RTU was introduced to the market about 20 years ago. AusNet commenced installation of these RTUs about 15 years ago, in place of the already obsolete [CIC]. 35.1% distribution zone substations are connected to SCADA via RTUs of this type.

The [CIC] RTU is the latest specification unit deployed within the distribution network. All pending RTU upgrades will involve replacement of the existing unit with a unit of this type. [CIC] RTUs currently service only 46.4% of SCADA-connected zone substations, however this number will increase significantly over the next 10 years as the current in-service population of [CIC] units are replaced.

4.3. Age

4.3.1. Age Considerations

Understanding the age profile of Protection and Control Systems is essential for effective asset management and lifecycle planning. Knowing the age distribution of these assets helps in predicting their remaining useful life and planning maintenance, upgrades, or replacements accordingly.

- **Electro-mechanical relays:** The age profile of electro-mechanical relays can indicate potential issues related to mechanical wear and lack of function supervision. Older relays may require more frequent inspections and condition assessments to ensure they continue to operate safely and efficiently.
- **Electronic relays:** Over time, electronic relays can experience component degradation and reduced reliability. By analysing the age profile, asset managers can identify relays that are at higher risk of failure and prioritise them for maintenance or replacement.
- **First Generation Microprocessor-based relays:** These relays can experience obsolescence issues as technology advances. Understanding their age profile allows for targeted interventions to replace or upgrade outdated units.
- **Intelligent Electronic Devices (IEDs):** These relays can experience obsolescence issues as technology advances. Understanding their age profile allows for targeted interventions to replace or upgrade outdated units.
- **Remote Terminal Units (RTUs):** The age profile of RTUs can indicate when upgrades or replacements are needed to maintain compatibility with modern SCADA systems and ensure reliable data transmission.

Age Profile

Figure 4 below provide an overview of the relays of each type currently in service across AusNet' electricity distribution network and their installed date (age).

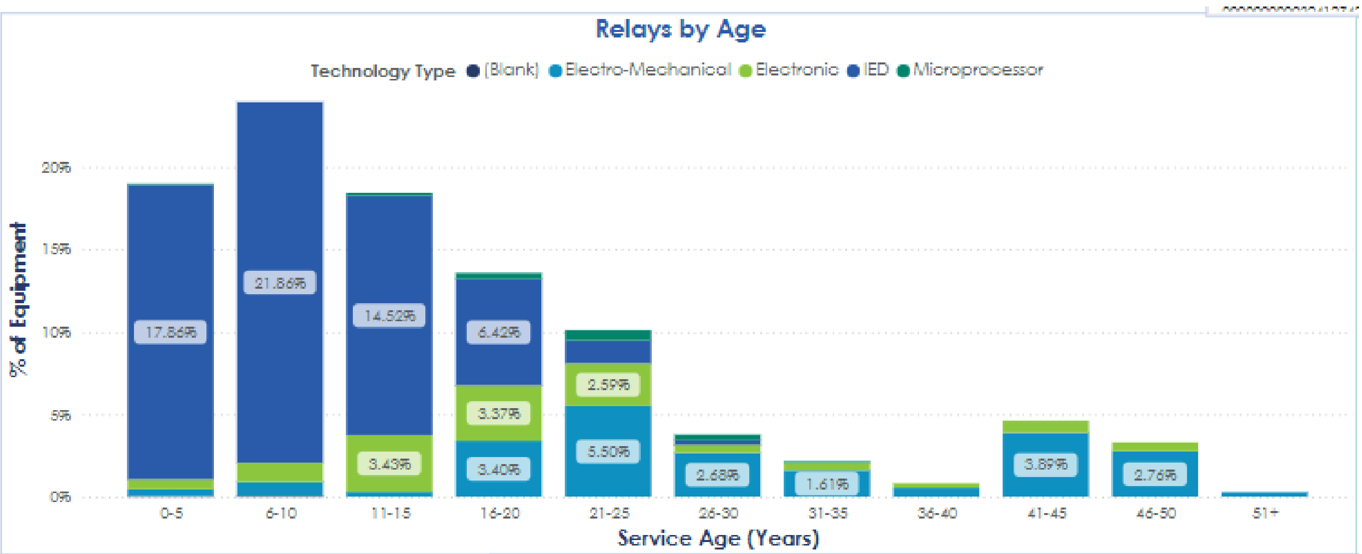

Figure 4: Age Profile of In-Service Relays by Type

5. Asset Risk

AusNet maintains a risk management system designed in accordance with AS ISO 31000 Risk Management – Guidelines to ensure risks are effectively managed to provide greater certainty for the owners, employees, customers and the communities in which we operate. The risk of each asset is calculated as the multiplication of probability of failure (PoF) of the asset and the consequence of failure (CoF). The risk is then extrapolated into the future accounting for forecast changes in PoF and CoF.

In the distribution network, AusNet aims to maintain risk. Risk treatments required to achieve this over time include replacement, refurbishment, and maintenance activities, and are developed based on current risk and extrapolated risk. The overall approach to quantified asset risk management is detailed in AMS 01-09. Section 5.1, 5.2 and 5.3 of this document describe the considerations and methodologies to determine PoF, CoF and risk treatment that are unique to relay asset.

5.1. Probability of Failure

Refer to *AMS 01-09 Asset Risk Assessment Overview*, section 2.3.2.2 for probability of failure methodology. The analysis of each asset should include four categories: asset service life, asset utilisation/duty factor, location, and the measured or observed physical condition of the asset. However, relay probability of failure is only based on asset service life whereas RTU likelihood of failures is based on asset service life, asset utilisation / duty factor and the measured or observed condition of the asset.

5.1.1. Failure Modes

Understanding failure modes is an important tool that supports measuring the criticality of assets, especially when assessing the risk of potential failures and their potential impact on the overall system. By identifying and analysing the various ways in which an asset can fail (including the root causes and mechanisms of failure), asset managers can better predict and mitigate risks. This understanding allows for a more accurate assessment of the probability of failure (PoF) and the consequence of failure (CoF), which, as noted above, is a core aspect of how AusNet approaches determining asset criticality.

Failure Modes by Asset Class and Type

Electro-mechanical Relays

- Mechanical Wear: Over time, mechanical components such as rotating discs and springs can wear out, leading to slower or incomplete operation.
- Contact Erosion: Repeated operation can cause erosion of the relay contacts, affecting their ability to open or close circuits reliably.
- Corrosion: Exposure to moisture or corrosive environments can lead to rust and degradation of metal parts.
- Calibration Drift: Mechanical components may lose calibration over time, leading to inaccurate operation.

Electronic Relays

- **Component Degradation:** Electronic components such as capacitors and resistors can degrade due to thermal stress and aging.

- **Environmental Sensitivity:** Exposure to harsh conditions such as high humidity, dust, or corrosive environments can lead to failure.
- **Signal Interference:** Electromagnetic interference (EMI) can disrupt the operation of electronic relays, leading to malfunctions.
- **Power Supply Issues:** Fluctuations or interruptions in power supply can cause electronic relays to fail or reset.

First Generation Microprocessor-based Relays

- **Firmware Corruption:** Software or firmware within the relay can become corrupted or incompatible with current computer system, leading to operational issue in term of required changes to the relay.
- **Overheating:** Excessive current flow or poor ventilation can cause the microprocessor to overheat, resulting in failure.
- **Aging Components:** As microprocessor relays age, internal components such as microchips can fail.
- **Moisture Ingress:** Entry of moisture can lead to short circuits or corrosion of electronic components.

Intelligent Electronic Devices (IEDs)

- **Software Bugs:** Complex software in IEDs can contain bugs that lead to incorrect operation or failures.
- **Cybersecurity Vulnerabilities:** IEDs connected to networks can be susceptible to cyber-attacks, leading to unauthorized access or control.
- **Configuration Errors:** Incorrect configuration or settings can cause IEDs to malfunction or not perform as intended.
- **Component Failure:** High-density electronic components can fail due to manufacturing defects or thermal stress.

Remote Terminal Units (RTUs)

- **Communication Failures:** Loss or degradation of communication links to downstream relay can disrupt the transmission of real time data between RTUs and control center.
- **Hardware Failures:** Physical components within RTUs, such as power supplies or communication modules, can fail due to aging or environmental stress.
- **Software Issues:** Bugs or glitches in the RTU software can lead to incorrect data reporting or operational failures.

5.1.2. Probability of Failure Assessment

Refer to *AMS 01-09* section 2.3.2.2.1.2 for methodology of likelihood assessment

Relay is analysed using only asset service life data for likelihood assessment. Weibull distribution is then used to determine parameters for calculating probability of failure (PoF) and its remaining life. The analysis of electro-mechanical relay is done separately due to its nature of failure modes.

RTU is analysed using asset service life, asset utilisation / duty factor and the measured or observed condition of the asset. for likelihood assessment. Weibull distribution is then used to determine parameters for calculating probability of failure (PoF) and its remaining life.

5.1.3. Likelihood Profile

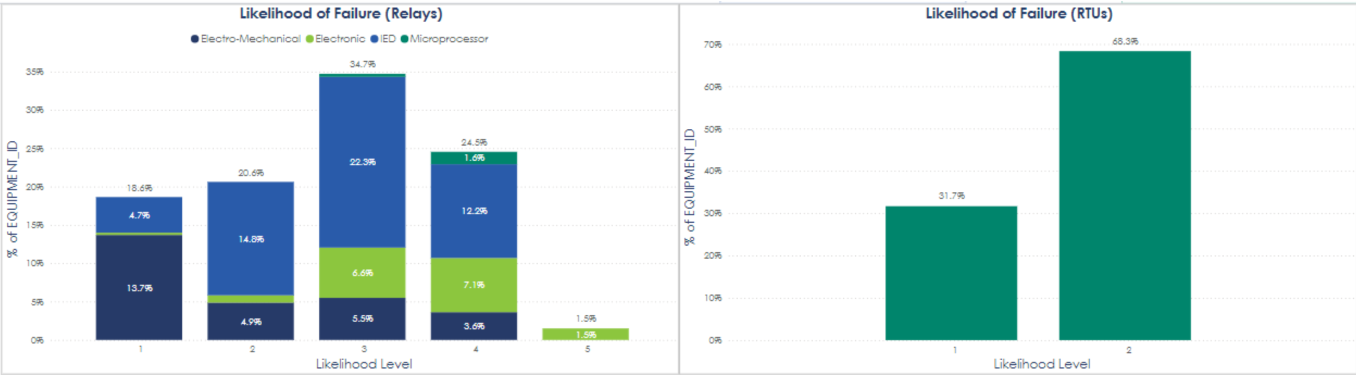

Figure 5: Relay and RTU Likelihood of Failure

5.2. Consequence of Failure

Refer to *AMS 01-09* section 2 for methodology of consequence of failure.

Failure of relay or RTU has the potential of resulting in failing to supply customers with energy. There is also a possibility the failed relay injures an employee or member of the public or affect the environment. For instance, failure of both X and Y relays at the same time as failure of primary plant such as sub-transmission line or transformer etc… may potentially result in fatality or injury to an employee or member of the public. Failure of REFCL relay at the same time as failure of feeder conductor may potentially result in bushfire.

The cost resulting from relay / RTU failure (cost of failure) is generally viewed through three lenses: Safety, Environment, and Customer / Reputation where it is applicable. Each type of protection relay / RTU may result in one or all of consequence lens. For example, environmental cost of failure is only applicable to REFCL relays or safety cost of failure is only applicable to protection relays of line, transformer, circuit breaker and not RTU. **Error! Reference source not found.** is a summary description for each lens.

CONSEQUENCE LENSES	DESCRIPTION
SAFETY	Threat to health and safety of public and employees – Primary protection relays
ENVIRONMENT	Bushfire damage – REFCL protection relays
CUSTOMER AND REPUTATION	Loss of Supply to Customer Loss of primary plant

Table 1 – Consequence Lenses of Relay / RTU

5.2.1. Safety Cost of Consequence

The Safety Cost of Consequence which incorporates all potential health and safety effects that could impact the public, customers, and employees is only applicable to protection relays related primary plants, line and feeder. This cost is further modified by a disproportion factor (DF) of six which recognises the high-risk nature of the electricity industry.

Event tree analysis is employed to determine the safety consequences of relays. It considers the probability of redundant protection scheme failure within ZSS (if any), the probability of primary, line or feeder conductor asset failure and the likelihood of a person in the vicinity of these assets.

Refer to *AMS 01-09-02* for event tree diagram of relay safety consequence of failure.

5.2.2. Environmental Cost of Consequence

The Environmental Cost of Consequence covers consequences relating to the environment which includes bushfire, flooding, contamination, community disruption, and/or pollution. This consequence is only applicable to REFCL protection relays. This cost uses bushfire cost of failure calculated for 22kV feeder.

Event tree analysis is employed to determine the environment consequences of relays. It considers the probability of redundant REFCL scheme failure within ZSS (if any), the probability of feeder conductor asset failure and the likelihood of fire start.

Refer to *AMS 01-09-02* for event tree diagram of relay environmental consequence of failure.

Note: The environmental consequences and Likelihood of Fire Start is taken from conductor model.

5.2.3. Customer Cost of Consequence

The Community and Reputation financial costs which arise from customers not being supplied with energy and the energy market not dispatching the cheapest generators is applicable to both protection & control relay and RTU assets.

Event tree analysis is employed to determine the customer consequences of relays and RTU. It considers the probability of redundant scheme failure within ZSS (if any), the probability of primary asset failure, the VUE associated with these assets and the time taken to repair.

Refer to *AMS 01-09-02* for event tree diagram of relay and RTU customer consequence of failure.

5.2.4. Consequence Profile

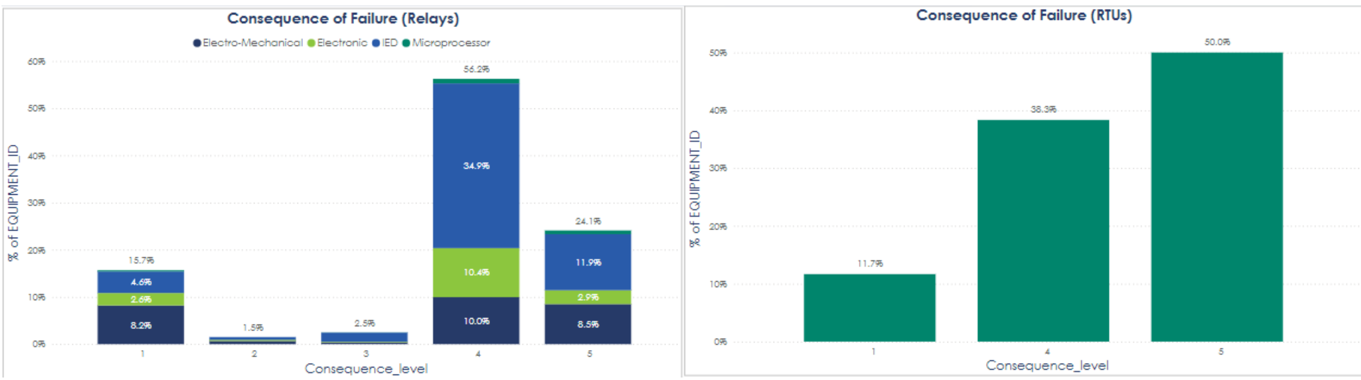

Figure 6: Relay and RTU Consequence of Failure

Figure 6 displays the consequences profile of protection relays and RTU. 80% of protection relays has level 4 and 5 consequences of failure and 26% of protection relay has level 4 and 5 likelihoods as shown in figure 5. This is significant compared to the previous period which results in an increase of 119% in number of relays replacement or 204% increase in total cost of replacement proposed in this period. It is noted that the unit rate of protection relay replacement has an increase of 39%.

5.3. Risk Treatment

Risk treatments are required to maintain risk by targeting reduction of PoF or CoF depending on the nature of the risk. Treatment measures include asset replacement, asset refurbishment, inspections, testing or system redesign, and are achieved through capital projects or operational expenditures. Risk treatment options are described in the section on 'Risk Treatment' in AMS 01-09.

Capital replacement is a major component of asset risk management. The prerequisites for replacing assets:

- Replacement of an asset will result in a material risk reduction
- Risks can't be feasibly managed through maintenance or refurbishment
- Monetised risk exceeds the replacement cost – i.e. replacement is economic

6. Performance

Performance assessments are a critical element of lifecycle management for protection and control systems. These assessments provide vital information on the current state and performance of relays, peripheral equipment, and RTUs, enabling informed decision-making regarding maintenance, repair, and replacement. Understanding how assets perform over time allows for proactive management, reducing the risk of unexpected failures. The assessment employed by AusNet involves analysing failure trends and any significant impacts resulting from failure, which provides valuable insights into the health and reliability of the assets.

6.1. Performance Profile

Figure7 below show the percentage of total number of ZA (Condition Based Maintenance) and ZK (Fault) notifications per calendar year during the period 2015 – 2024. The total number of notifications in this period is 748. The notifications per year do not change much throughout the period of 10 years accept. Year 2024 has not come to an end at the creation time of this graph.

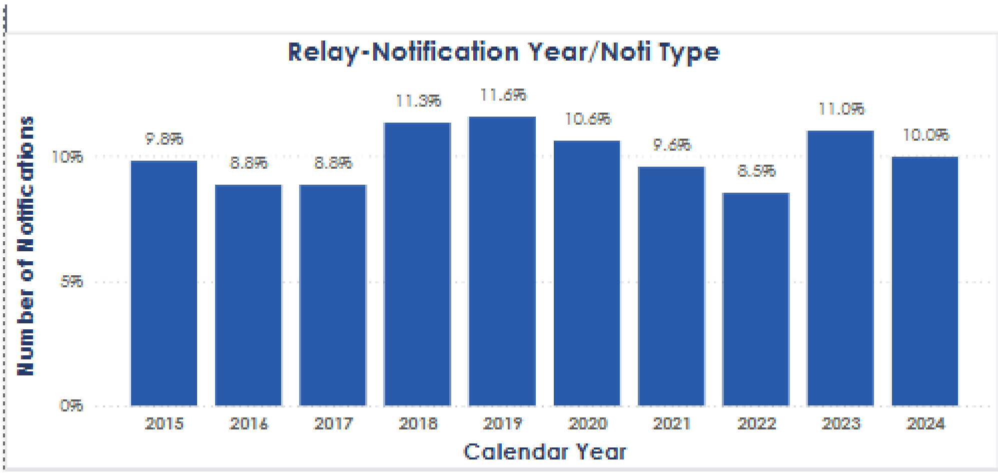

Figure 7: Relay notification per calendar year

Figure 8 below shows the ZA and ZK notifications of relay types versus their age. The figure shows percentage of total number of notifications.

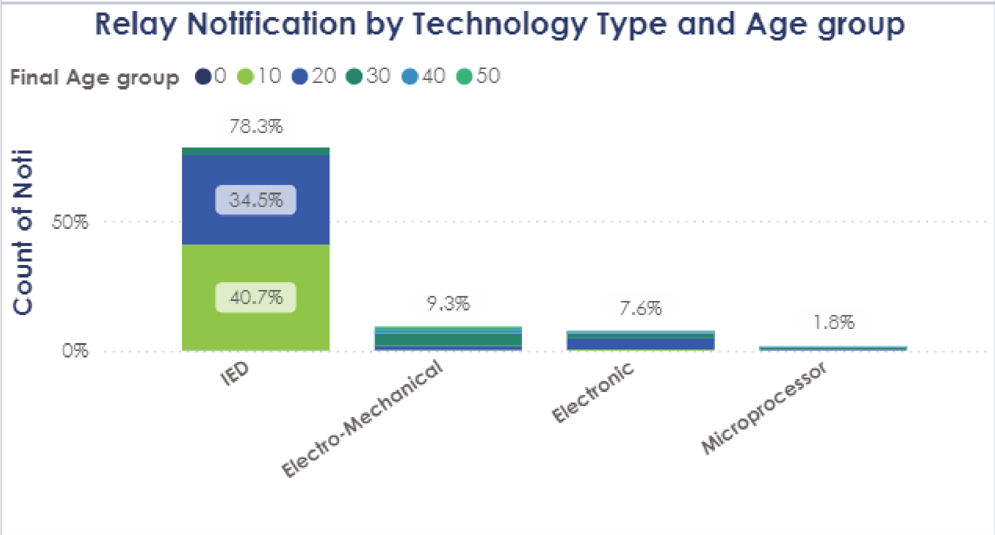

Figure 8: Relay notification by Type and Age group

Figure 9 below shows the ZA and ZK notifications of defect categories during the period 2015 – 2024. The figure shows percentage of total number of notifications.

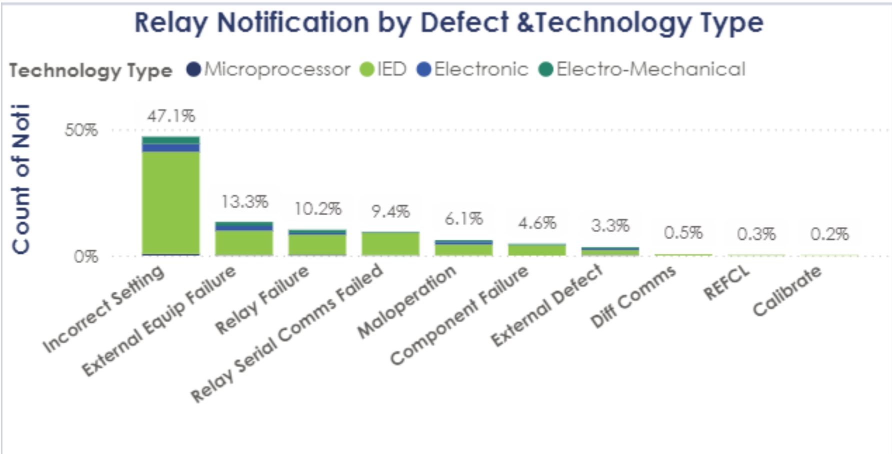

Figure 9: Relay notification by Defect and Relay Technology Type

Incorrect Setting category refers to any setting changes to protection and control relays as result of investigations. Incorrect setting category is about 47% of all notifications and mainly results from IED relays which have comprehensive self-monitoring, diagnostic and alarming capability. This makes them more likely to experience diagnosed failure or inappropriate monitoring settings compared to schemes based on non-digital relay technologies. However, the consequences associated with diagnosed failure of a digital scheme is generally significantly less compared to spurious operation, non-operation or protection system unavailability of hidden failure and unsupervised electronic, microprocessor and electro-mechanical relays.

Relay Failure category refers to replacement of relays due to failure. It is slightly more than 10% of all notification and consists of IED, Electronic and Electro-mechanical relay types which protect critical primary plants such as bus, transformer, line and station earth fault or regulate station voltage. This may be due to their extended in-service life compared to their useful life. Failure of single function Electronic and Electro-mechanical relays often results in longer repair time due to emergency design for obsolescence and un-spared relay in case of failure.

Figure10 below shows the ZA and ZK notifications of defect categories by relay technology type during the period 2015 – 2024. The figure shows percentage of total number of notifications.

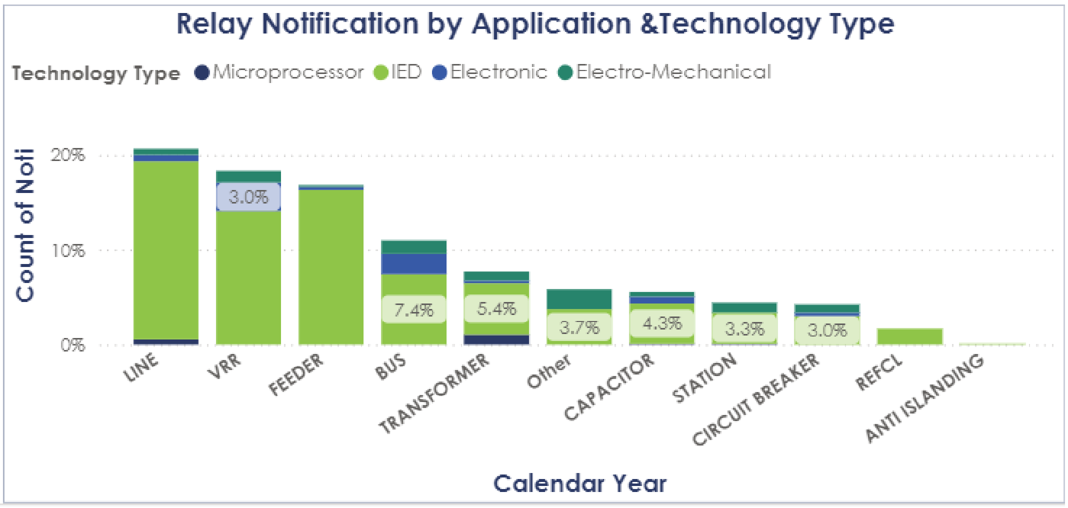

Figure 10: Relay notification by Application and Relay Technology Type

Figure11 below shows the RTU ZA and ZK notifications during the period 2015 – 2024

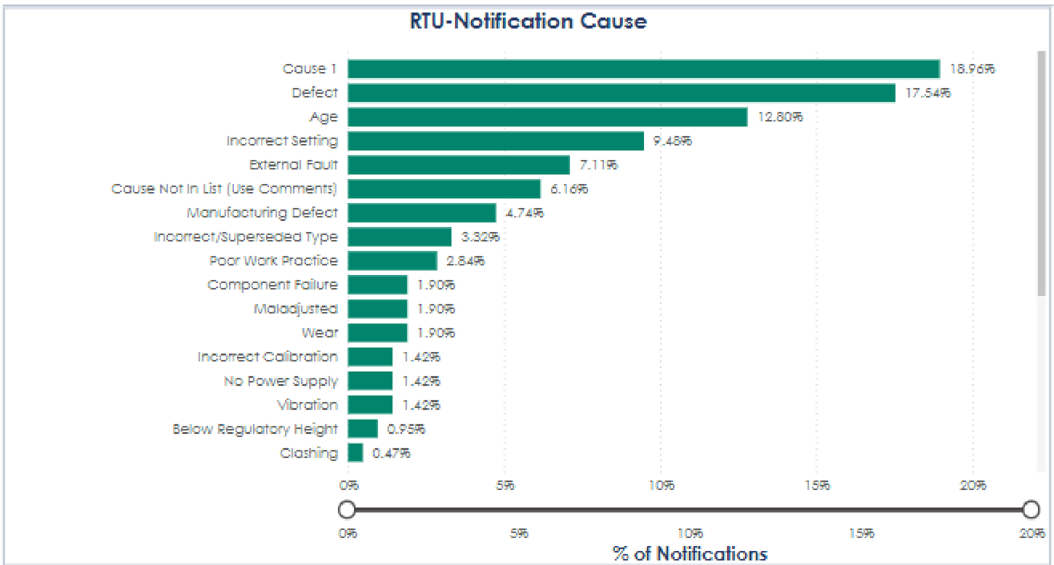

Figure 11: RTU notification

Defect and Age are among the top cause of RTU notification and mainly comprised [CIC] RTU type. These RTU has extended in-service life with limited functional capability. There is high frequency of power supply failures in these RTU type as well as system "lock-up" due to overloading issue. Failure of RTU or DC supply components results in the loss of visibility of the entire Zone Substation, necessitates that the station be manned for manual supervision and control and limit the operation of DFA. These type of RTU is also not suitable for modern relays which provide large amount of diagnostic data over Internet Protocol.

Targeted Activities

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to maintain decommissioned assets in appropriate working condition as spares to ensure the ongoing serviceability of in-service obsolete assets
02	Proactively design replacement for obsolete, no spare relays of critical protection schemes (transformer, bus, line and earth fault) to reduce the risk of protection unavailability
03	Continue to maintain sufficient spares to ensure ongoing maintainability of in-service assets

7. Related Matters

7.1. Regulatory Framework

7.1.1. Compliance Factors

Regulatory and Legislative Reference

Effectively managing compliance obligations specific to legislation and policies is a core element of Asset Class Planning and supports the sustainable operation and management of Network Assets. Ensuring adherence to relevant laws, policies and codes helps prevent legal and regulatory breaches, which can lead to significant penalties, operational disruptions, and reputational damage.

Note: further to the above, **Section Nine (9)** provides a list of legislative and regulatory laws, acts, and policies that are of material consideration for this Asset Class.

Technical Standards and Procedures

Effectively managing compliance with technical standards and operational procedures is an important element of Asset Class Planning. Adhering to these standards ensures that the assets are designed, constructed, maintained, and operated in a manner that meets industry best practices, enhances safety, and ensures reliability. Compliance with technical standards helps prevent asset failures, reduces risks, and ensures interoperability within the electrical distribution network.

Targeted Activities (Compliance Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	**Electricity Safety Act (Section 98(a))**
02	**Electricity Distribution Code (Section 3.3.1(b))**
03	**National Electricity Rule (Clause 6.5.7)**
04	**REFCL and Bushfire Mitigation** The integration of REFCL technologies represents a significant technological change in the management of earth faults on the distribution network. AusNet has developed and continues to refine a comprehensive 22kV earth fault management strategy (PPD 01-07) that will contribute to asset management decisions relating to 22kV asset protection and control schemes. This policy will directly impact decisions relating to the application and replacement of Master and Backup Earth Fault (MEF and BUEF) and ACR Earth Fault protection.

7.2. External Factors

7.2.1. Technical Factors

Not applicable.

7.2.2. Environmental Factors

Not applicable.

7.2.3. Stakeholder/ Social Factors

Social Factors

Understanding social factors is essential for the effective management of critical network infrastructure assets. Social factors, including community expectations, public safety, and environmental impacts, play a significant role in shaping asset management strategies. Ensuring that these social considerations are addressed helps build public trust, maintain social license to operate, and enhance the organisation's reputation.

Targeted Activities (Social Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Update and maintain "Earth Fault Protection Strategy for Zone Substation Supplying the 22kV Network" (PPD 01-07)
02	Research and develop voltage regulation scheme to accommodate load growth and the increasing penetration of low voltage distributed generation

Stakeholder Factors

Understanding the requirements of stakeholders with a direct interest in the assets is an important aspect of effective asset management. Key stakeholders, including customers, ESV, and AEMO, have specific expectations that influence asset management strategies and operational decisions. Ensuring clear communication and alignment with these requirements helps maintain regulatory compliance, enhance service reliability, and build robust partnerships.

Targeted Activities (Stakeholder Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to provide REFCL reports to ESV.

7.3. Internal Factors

7.3.1. Training and Competency Factors

Effective training and competency development is a core element of asset class. Ensuring that asset managers, engineers, operational staff, and field personnel possess the necessary skills and knowledge is crucial for maintaining the reliability, safety, and efficiency of the asset network. Competent staff can effectively perform inspections, maintenance, and repairs, preventing asset failures and minimising downtime. Continuous training helps in keeping up with technological advancements, regulatory changes, and best practices, thereby enhancing overall asset management performance.

Targeted Activities (Training and Competency Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to provide internal staff as well as Ausnet partner in training, education and industry knowledge management of REFCL technology

7.3.2. Resource Management Factors

Resource Management is a core element of asset class planning for Network Assets. Proper oversight ensures that the management of AusNet's resource bases meets stringent quality and performance standards, which is essential for preventing asset failures, managing risks, and maintaining compliance with regulatory requirements. Effective resource management contributes to cost efficiency via activities such as leveraging the expertise of specialised in-house skills and contractors while avoiding hidden costs associated with inefficiencies and non-compliance.

There are three sub-categories of consideration for this factor, which are:

- Resourcing strategies
- Outsourcing
- Supply Chain Management

7.3.3. Economic Factors

Economic factors significantly influence the lifecycle management of network assets, impacting financial stability, investment decisions, and overall network performance. Major contracts being tendered, such as those for infrastructure development, maintenance, and technology upgrades, can materially affect asset management. These contracts involve substantial investments, requiring rigorous management to align with long-term asset goals, mitigate risks, and control costs. Effective contract management ensures that service providers deliver value, supporting the network's reliability and performance while maintaining financial health.

Material developments and significant commercial agreements also play pivotal roles in the economic landscape of asset management. Commercial agreements, including customer service agreements, dictate service levels, performance metrics, and penalties, impacting operational priorities. Regular reviews of these agreements ensure adaptability to changing economic conditions, customer expectations, and regulatory landscapes. Additionally, planned renewal programmes and changes to asset types and purchasing strategies must be evaluated for their financial impact to ensure efficient resource allocation. By addressing these economic factors, AusNet can manage financial risks, optimise investments, and support robust lifecycle models, aligning financial planning with operational goals and regulatory requirements.

7.3.4. Safety Factors

Safety is a paramount concern in the management of electricity distribution network assets, as outlined in ESMS 20-01. Effective asset management planning and activities are crucial for protecting employees, contractors, the public, and the environment from potential hazards associated with electrical infrastructure. Ensuring adherence to safety regulations and standards through diligent asset management helps prevent accidents, minimise risks, and maintain the integrity of the network.

Targeted asset management activities include conducting regular safety audits and risk assessments, maintaining a robust Bushfire Mitigation Plan, providing ongoing safety training and competency assessments, regularly reviewing and updating emergency response plans, engaging with the community to raise awareness about electrical safety, and adopting new technologies and practices to enhance network safety. By integrating these safety-focused activities into asset management planning, AusNet can effectively minimise safety risks "as far as practicable," as outlined in the Electricity Safety Act 1998 and reflected in ESMS 20-01.

Targeted Activities (Safety Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to ensure annual compliance of REFCL secondary assets

7.4. Future Developments

7.4.1. Technology and Innovation Factors

Effectively managing the process of tracking future technology developments and innovations is a core element of asset class planning. Staying informed about technological advancements ensures that asset management practices remain up-to-date, efficient, and competitive. Innovations can lead to improved materials, better monitoring systems, and enhanced maintenance techniques that increase the reliability, safety, and longevity of critical infrastructure. For example, advancements in diagnostic tools for detecting early signs of wear and the development of advanced materials for asset components can significantly enhance their performance and maintenance. For technology and innovation, this is a process that looks to existing technologies, processes, or practices that have been proven in the market and have already been taken to market.

Targeted Activities (Technology and Innovation Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	The rapid evolution of digital and other emerging technologies will continue to influence asset management decisions relating to protection and control systems.
02	The IEC61850 standard and associated technologies will continue to mature throughout the next 10 years, and its integration within increasingly “smart” electricity network and equipment will continue to increase. This is also anticipated to increase the requirement and criticality of centralised digital interface assets (referred to as Digital Interface Cubicles (DICs)) for the management of data traffic.
03	DICs also provide the capability for remote engineering access to protection and control assets, allowing relay data to be accessed from a centralised location. This capability provides opportunities to further improve operational efficiencies and decrease network incident investigation and response times. As only IEDs can provide a remote engineering interface, increasing reliance on remote operability will continue to drive replacement of older assets in key locations.
04	The capability and specification of relays will be affected by the increasing prevalence and economic viability of alternative instrument transformer technologies, including optical CTs.
05	Increasing pressure from distributed generators, combined with evolution in telecommunication technologies, is already necessitating research and development of 4G / 5G and NBN solutions for protection signalling applications.
06	Rapid technological evolution places increasing demands on staff capabilities, and ongoing investment in staff training and education, and industry knowledge management in general, will become increasingly critical.

7.4.2. Research and Development Factors

Effectively managing the process of investing in research and development (R&D) and seeking funds for R&D activities is a core element of asset class planning. R&D investment ensures that the organisation stays at the forefront of technological advancements, develops innovative solutions to emerging challenges, and enhances the reliability, safety, and efficiency of its assets.

Targeted Activities (Research and Development Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Evaluate process bus applications for use at 22kV
02	Continue to refine 22kV earth fault management strategy in response to evolving technologies
03	Investigate opportunities and strategies for integrating non-conventional instrument transformers
04	Research and develop 4G / 5G and NBN solutions for protection signalling (including backup inter-trip) applications to address increasing penetration of distributed generation
05	Investigate ways to improve primary asset monitoring and maintenance using existing secondary infrastructure

7.4.3. Continuous Improvement

Not applicable.

8. Asset Strategies

8.1. New Assets

New Asset Considerations

A strategic asset strategy for the introduction of new assets provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of asset upgrades or changes, detailing the conditions under which new assets may be introduced into the network. This is not a like-for-like replacement but rather a strategic change or upgrade to a different type of asset to enhance reliability, improve efficiency, and incorporate advanced technologies. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for integrating new assets into the AusNet network.

Targeted Activities (New Asset)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	All new and replacement assets will be designed in accordance with the Station Design Manual and current design standards, undertake replacement of complete protection systems (i.e. X and Y, main and backup and necessary control and monitoring systems) associated with individual items of primary plant/network sections, rather than individual protection & control schemes/relays
02	Replacement activities shall be incorporated within primary plant replacement, station refurbishment or network augmentation activities as far as practicable, in order to maximise operational efficiency and minimise network disruption

8.2. Maintenance

A strategic plan for maintenance provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the ideal framework and objectives for conducting maintenance activities, such as enhancing reliability, improving efficiency, and incorporating advanced technologies. It serves as a roadmap that guides the decision-making process for establishing comprehensive maintenance protocols within the AusNet network. This involves creating a structured approach to regular maintenance activities to ensure optimal performance and longevity.

Targeted Activities (Maintenance)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to inspect and monitor protection, control and their auxiliary assets as per PGI 02-01-04 and the SPP 02-00-01 suite of documents
02	Maintain PGI 02-01-04 and SPP 02-00-01 suit of documents consistent with AMS 01-09

8.3. Spares

A strategic plan for keeping spares provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the ideal framework and objectives for keeping spare activities. This involves creating a structured approach to ensure sufficient spares for in-services relay especially for relays which are obsolete.

Targeted Activities (Spares)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to maintain sufficient spares to ensure ongoing maintainability of in-service devices
02	Maintain decommissioned assets in appropriate working condition as spares, as required to ensure the ongoing serviceability of in-service, poor condition / obsolete assets pending retirement
03	Continue to consider device obsolescence, as advised by asset manufacturers and suppliers, in preparation of asset spare and replacement strategies

8.4. Replacement

A strategic asset strategy for renewals and replacements provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of asset refurbishments or like-for-like replacements, detailing the conditions under which existing assets may be renewed or replaced within the network. This process ensures continued reliability and efficiency, manages obsolescence, and maintains adequate spares. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for renewing or replacing assets within the AusNet network.

Targeted Activities (Replacement)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to consider device obsolescence, as advised by asset manufacturers and suppliers, in preparation of asset replacement strategies
	Prioritise proactive replacement of: • High risk 66kV line protection systems incorporating obsolete and/or poor condition static-electronic and first-generation microprocessor-based distance protection relays ([CIC]-type devices) • High risk transformer and 66kV bus protection systems incorporating obsolete and/or poor condition electromechanical, static-electronic and first-generation micro-processor based transformer protection relays ([CIC]-type, [CIC] devices) and electromechanical and static electronic high-impedance bus protection relays ([CIC]-type devices) • High risk 22kV bus, BUEF and MEF protection systems incorporating obsolete and/or poor condition electromechanical and static-electronic high-impedance bus protection relays ([CIC]-type devices), electronic bus distance protection relays ([CIC]-type devices), electromechanical, static electronic and early generation digital BUEF protection relays ([CIC]-type devices) and electromechanical and static-electronic based MEF protection relays ([CIC]-type devices).

- 22kV feeder protection schemes incorporating obsolete [CIC] relays
- 22kV capacitor bank protection schemes incorporating obsolete [CIC] relays
- Obsolete, high risk [CIC]-type voltage regulation relays
- Restricted capability voltage regulation control systems at zone substations affected by significant load growth, and/or as required to accommodate ongoing penetration of low voltage distributed generation
- Obsolete and unreliable [CIC]-type remote terminal units

8.5. Research and Development

A strategic asset strategy for research and development provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of safely and efficiently introducing assets into service, detailing the conditions under which it may occur. It ensures that the process is conducted in a way that minimises disruption, manages environmental impacts, and complies with regulatory requirements. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for decommissioning assets from within the AusNet network.

Targeted Activities (Research and Development)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Develop alternative standard design and plan for spare for [CIC] relays which will become obsolete in 2025
02	Continue to evaluate process bus applications
03	Continue to refine 22kV earth fault management strategy in response to evolving technologies
04	Investigate opportunities and strategies for integrating non-conventional instrument transformers
05	Research and develop 4G / 5G and NBN solutions for protection signalling (including backup inter-trip) applications to address increasing penetration of distributed generation
06	Investigate ways to improve primary asset monitoring and maintenance using existing secondary infrastructure

9. Legislative / Rules References

NO.	ACT	LINK
1	Electricity Safety Act 1998	https://content.legislation.vic.gov.au/sites/default/files/2024-06/98-25aa083-authorised.pdf
2	Electricity Distribution Code	https://www.esc.vic.gov.au/electricity-and-gas/codes-guidelines-and-policies/electricity-distribution-code-practice
3	National Electricity Rule	https://energy-rules.aemc.gov.au/ner/611

10. Resource References

NO.	ID (LINK)	DOCUMENT TITLE
1	SDM	Station Design Manual
2	AMS 01-01	Asset Management System Overview
3	AMS 01-09	Asset Risk Assessment Overview
4	AMS 20-01	Electricity Distribution Network Asset Management Strategy
5	PGI 02-01-04	Summary of Maintenance Intervals – Distribution Plant Guidance and Information
6	SPP 02-00-01	General Requirements SECONDARY PRACTICE AND PROCEDURE
7	AMS 01-09-02	Consequence Analysis - Addendum

11. Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE	APPROVED BY
1	31/12/08		Draft for comment	
2	06/04/09	GL	Editorial Update	G Towns
3	07/05/09	DR, GL	Review and Update	G Towns
4	27/08/09	DR, GL	Added neutral earth resistors	G Towns
5	24/11/09	N Bapat	Editorial and minor changes	G Towns
6	17/10/14	L Boustead	Minor Changes to reflect outcome of MWTS incident investigation.	E Viel
7	20/03/15	D Meade K Soodin	Major review and editorial	J Bridge
8	14/06/2020	L Boustead	Review and Update	P Ascione
9	30/06/2020	A Dickinson	Minor formatting and cross-referencing changes. Sections 3.2.5 and 3.4.5 updated information on SCD5200 RTUs.	P Ascione
10	31/01/2025	B Ton	New template and Update	D McCrohan

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