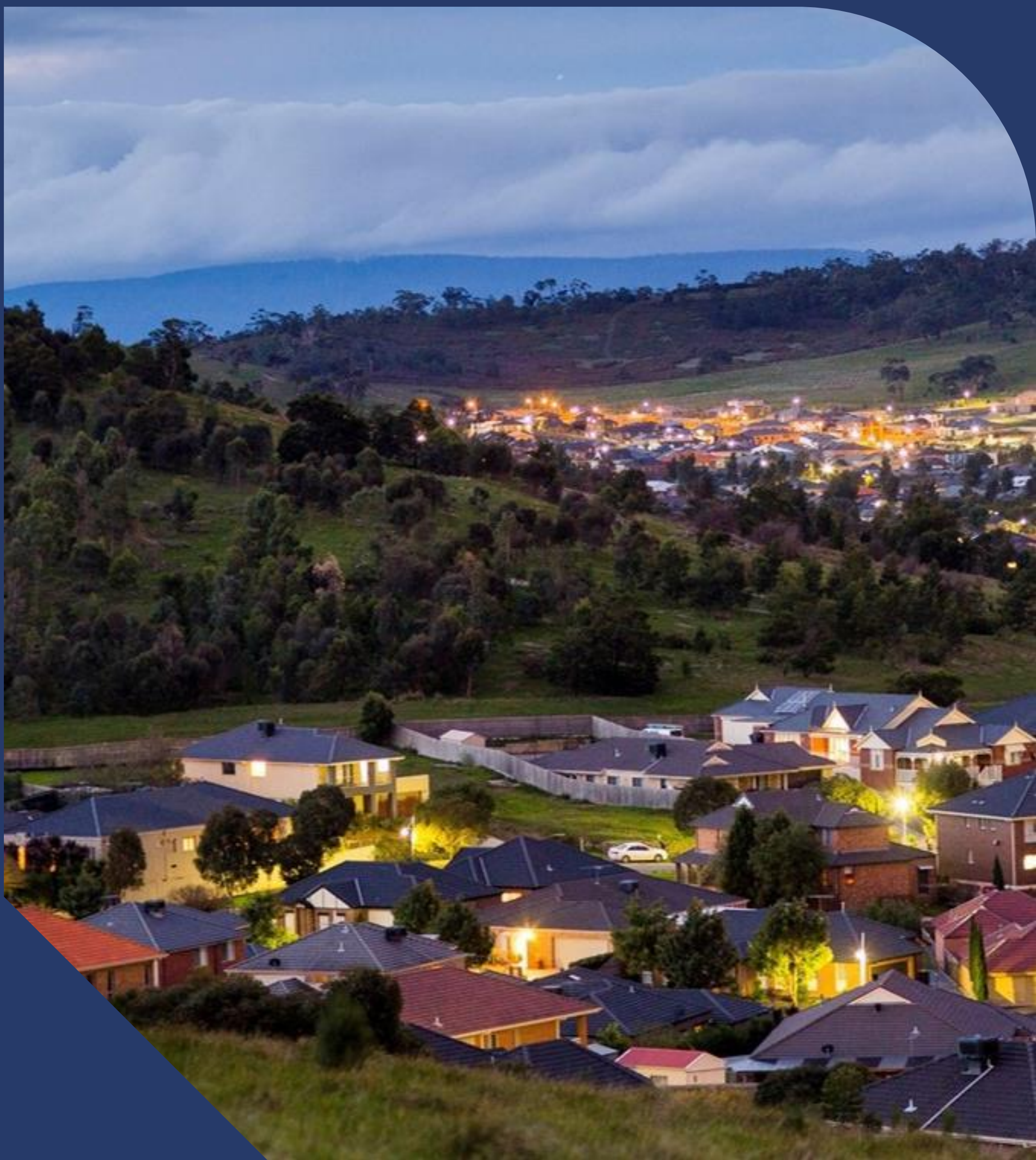
AusNet

Secondary Systems

(Protection, Control & Monitoring Assets)

Asset Management Strategy



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Abbreviations and Definitions

TERM	DEFINITION
AEMO	Australian Energy Market Operator
CB	Circuit Breaker
CoF	Cost of Failure
DIC	Digital Interface Cubicles
ESMS	Electricity Safety Management Scheme
HMI	Human Machine Interfaces
IEDs	Intelligent Electronic Devices
LoC	Likelihood of Consequence
PGI	Plant Guidance and Information
PoF	Probability of Failure
RTU	Remote Terminal Units
SCADA	Supervisory Control and Data Acquisition
SPP	Secondary Practice and Procedure
VUE	Value of Unserved Energy

1. Executive Summary

Protection systems in the transmission network are critical for detecting electrical faults and initiating rapid disconnection of faulted circuits via circuit breakers. These systems safeguard personnel and the public from hazardous electrical conditions, minimise damage to network equipment, and maintain reliable energy supply by ensuring the network operates within defined electrical parameters.

Control and monitoring systems provide automatic or remote manual control of primary assets, enabling efficient power flow management through functions such as voltage regulation, cooling system control, reactive power control, load shedding, and runback schemes.

The transmission network's secondary systems have evolved significantly, transitioning from electromagnetic and analogue technologies to digital and microprocessor-based systems. Today's Intelligent Electronic Devices (IEDs) offer superior integration, programmability, and configurability. However, these systems typically reach obsolescence within 15 years due to limited vendor support, evolving industry standards, technical incompatibilities, skills gap or inability to meet evolving industry standards. As a result, they require more frequent maintenance to remain operational, particularly given their limited diagnostics and increasing failure rates. The Remote Terminal Units (RTU) fleet comprises various models, with most units installed at terminal stations being older, obsolete types that have limited or no support from the original vendors.

Asset condition and service life data are used to assess the probability of failure (PoF) for protection relays and RTUs. Weibull distribution modelling supports the calculation of probability of failure and remaining asset life. Consequence of failure is evaluated based on safety, market impact, and value of unserved energy VUE. These inputs inform a risk-based assessment to guide economically justified replacement programs. Following the development of economic and Weibull models, a structured validation process is conducted based on asset criticality, obsolescence and grid modernisation requirements to assess the practicality of asset replacement option or changes to maintenance regimes. This validation process complements the economic modelling by ensuring decisions are technically sound and operationally feasible.

Proactive management of secondary systems including application, inspection, maintenance, refurbishment, and replacement is essential to meet stakeholder expectations for cost efficiency, safety, reliability, and environmental performance. This strategy supports the long-term sustainability and resilience of AusNet's transmission network.

1.1. Asset Strategy Summary

The asset management strategy for secondary systems outlines a structured approach ensuring reliability and efficiency across the network. New and replacement assets are designed in line with the Station Design Manual and current standards, with a preference for replacing entire protection systems rather than individual components. These activities are integrated with broader station refurbishments or network upgrades to minimise disruption.

Maintenance and inspection will proceed according to current procedural guidelines, including Plant Guidance Information REF: PGI 02-01-02 and the Secondary Practice and Procedure REF: SPP 02-00-01. These procedures are consistent with Asset Risk Assessment Overview REF: AMS 01-09. Spare management is a key focus, with sufficient equipment maintained to support rapid recovery during failures. Decommissioned assets may be retained in working condition to support ageing or obsolete systems, and emergency replacement plans are prepared for complex equipment.

Replacement strategies will be aligned with major infrastructure projects where economically viable, prioritising assets in poor condition or at high risk of failure. Modernisation efforts include transitioning to SCIMS station architecture, retiring outdated mimic panels, and adopting IEC 61850 standards for enhanced interoperability, faster communication, and future-proof digital substations.

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 all regulated secondary systems assets located within terminal stations in AusNet regulated Victorian electricity transmission network. This document intends 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. This document demonstrates responsible asset management practices by outlining economically justified outcomes.

2.2. Scope

This Asset Management Strategy applies to all regulated secondary systems assets located within terminal stations in the AusNet regulated transmission network. The broad classes of secondary and monitoring assets included in this strategy are as follows:

- Protection and Control relays, as employed within network protection and control schemes located within transmission stations across the regulated transmission network.
- Peripheral equipment, including trip relays, 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 and other control schemes,
- Station RTUs and all associated equipment including Supervisory Control and Data Acquisition (SCADA) Human Machine Interfaces (HMI)
- Weather monitoring systems.

Excluded from this strategy are the following assets:

- Station Auxiliary Power Systems and associated monitoring and control equipment – refer Auxiliary Power Systems REF: AMS 10-52.
- 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 REF: AMS 10-56.
- Power Quality Meters and Revenue Meters.

2.3. Asset Management Objectives

As stated in the Strategic Asset Management Plan REF: AMS 01-05, asset management objectives are:

Trusted to bring the energy today and build a cleaner tomorrow							
Strategic Pillars						Ambition	
Safely deliver our customer's energy needs today				Create the energy network of tomorrow	Enable the transition to a net zero future	Be a leader in asset management practice	
Asset Management Objectives						Enabling AMOs	
Safety: Minimise risk to our people, contractors, customers and communities AFAP across our networks	**Reliability:** Meet the reliability expectations of our customers and communities, and meet our reliability targets	**Resilience:** Improve the resilience of our network to adapt to a changing climate and energy system environment	**Compliance:** Comply with all legislation, regulations, relevant standards and industry codes	**Planning and decision-making:** Deliver valued planning and network outcomes through optimising asset lifecycle management	**Sustainability:** Build stakeholder trust and deliver social value. Reduce our environmental impact. Operate efficiently to sustain financial value creation.	**Competency and capability:** Develop asset management capability and competency in the organisation	**Continuous improvement:** Continually improve asset management maturity for effective delivery of services

3. Asset Description

3.1. Function

3.1.1. Protection & Control Assets

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 terminal stations 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 "transformer, line, bus"). 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 to maintain a very high level of protection system reliability. According to Australian Energy Market Operator (AEMO) requirements, both relays must always remain operational, except during an eight-hour planned maintenance window or a twenty-four-hour unplanned protection outage. Otherwise, the line may need to be removed from service. For more information on each protection type used in AusNet regulated transmission network refer to Protection Electrical Operating Procedure – Transmission REF: TOC 10-27

3.1.1.1. Transformer Protection

Transformer protection is provided by duplicated independent (X and Y) relays in separate panels that may include a number of protection functions, the chief one being differential protection.

Differential protection compares the currents in the High Voltage, Medium Voltage and Low Voltage transformer connections and scales them appropriately for magnitude and phase angle so that the normal net sum of the currents is zero under healthy circuit conditions. At a very high level if the current sum is not zero; differential protection schemes send tripping signals to relevant circuit breakers. An internal restraint circuit prevents tripping upon transformer energisation.

Modern intelligent transformer relays can also provide overload detection on any connection and receive signals from external devices such as Buchholtz (oil surge) relays and temperature sensors. These relays provide Circuit Breaker (CB) failure protection for faults detected by protection elements within the relay. The relays are connected to SCADA and provide instrumentation and event information to the control centre.

Intelligent relays record currents during transformer faults and are of great value in analysing a transformer failure, allowing faster repair and remedial action to prevent similar failures on other transformers.

3.1.1.2. Bus Protection

Duplicated protection schemes (X and Y) may be implemented on primary circuit busbars across all voltage levels within terminal stations. The most used bus protection methods include high impedance differential protection and overcurrent protection.

Electromechanical relays continue to be the preferred choice for high impedance differential schemes even in modern installations due to, their robust design and inherent operational stability. This preference contributes to the high prevalence of electromechanical relays in bus protection applications compared to other technologies. However, to meet growing system monitoring and data logging requirements, IEDs are increasingly being deployed, offering enhanced visibility and diagnostic capabilities.

3.1.1.3. EHV Line Protection (220 kV, 275 kV, 330 kV and 500 kV)

Protection for 220 kV and higher voltage (EHV) lines is provided by duplicated independent (X and Y) relays in separate panels. There are two main operating principles: distance (impedance) and current differential. Distance relays are connected to the line current and voltage transformers and measure the line impedance. They operate if the impedance is lower than the actual line impedance. The distance relays at each end of the line must be interconnected by a communications link to show that the AEMO specified fault clearance times are met.

Current Differential relays are connected to current transformers (CTs) on the line and continuously compare the currents at each end of a line via a high-speed digital communications link. These relays operate to trip the line if a difference between the terminal currents is observed. Current differential protection offers a more clearly defined protected zone than distance protection and is applied when a suitable communications link is available between the stations.

Present generation relays may include both distance and current differential operating principles included with either or both in service and other protection functions (i.e. CB failure, auto reclose). The latest relays are also able to undertake line instrumentation functions for SCADA and transmit backup protection signals via differential channel without the need of external I/O devices. These relays require healthy communication link with relays at remote stations for fault isolation.

3.1.1.4. HV Line Protection (66 kV)

Protection for 66 kV lines is provided by duplicated independent (X and Y) relays. As with the EHV protection, there are two main operating principles: distance (impedance) and current differential.

The protection clearance times for HV lines are less stringent than for EHV lines and communications links between stations are generally not necessary when distance protection is used. However, there are significant benefits associated with grading of protection schemes when differential schemes are used, and for this reason current differential protection is preferred when a suitable communications link is available. Overcurrent and/or pilot wire protection is used for some older feeders. Pilot wire protection is similar to current differential protection but uses electromechanical relays and analogue communication over dedicated copper telephone wires.

The present generation protection schemes for 66 kV feeders have two intelligent relays (X and Y) each including distance and/or differential, but with the additional functions of CB Failure detection, CB control, automatic reclose and instrumentation. In some applications, distance protection is required to facilitate adequate backup protection is provided for downstream assets.

3.1.1.5. Reactive Plant Protection

Reactive plant includes fixed capacity Capacitors and Reactors, and Static VAR Compensators.

For fixed capacity Capacitors and Reactors:

Protection for fixed capacity reactors is like that used for transformers: differential, overcurrent and Buchholtz (gas). For fixed capacitors, overcurrent protection that operates from the total current into the capacitor is used. A separate sensitive current balance overcurrent circuit is also provided to detect failure of a pre-determined number of capacitor cans in each phase of a capacitor bank. Detection of the unbalanced current and subsequent tripping of the capacitor bank will prevent further failure of remaining capacitor cans due to overvoltage. Some relays also have a thermal overload function based on an internal model of the capacitor characteristic.

For Static VAR Compensators (SVC):

Static VAR Compensators (SVC) comprise of individual capacitor and reactor elements switched by thyristors. Protection for the capacitors and reactors is by individual overcurrent, overvoltage and differential relays, comprising up to 20 individual relays. The high voltage thyristors are connected in series, with their combined rated voltage limit greater than the system voltage. Each thyristor is monitored so that when failure of one thyristor is detected, the SVC will be turned off to prevent overvoltage failure on the remaining thyristors. There are also protection circuits to detect failure of the water-cooling systems for the thyristors.

A special case is the Series Capacitor installations on the two DDTS-SMTS 330 kV lines. The Series Capacitors are effectively part of the lines and protection against primary insulation failure is provided by the 330 kV line protection. However, special protection is needed to detect sudden high currents during 330 kV line faults. Excessive voltage across the series string of 180 cans triggers an arc in the air gap provided. This arc effectively shunts the cans and protects them from overvoltage failure. The short circuit provided by the spark gap is immediately backed up with the closure of a Bypass CB. A separate monitoring circuit integrates ambient temperature, current and time to prevent thermal overload.

3.1.1.6. Circuit Breaker Management & Control

Circuit breaker management relays in legacy assets integrate multiple functions including CB failure protection, auto-reclose, local/remote control, and instrumentation into a single device. In modern schemes, these relays replace discrete control and instrumentation components, enabling strategic upgrades across the transmission network. This integration supports the phased retirement of analogue systems and obsolete infrastructure while enhancing operational capability.

These relays provide intelligent control of circuit breakers, delivering status and alarm information to both local HMIs and the control centre. They also perform synchronism checks, interlocking CB close commands with system voltage conditions, and execute CB failure protection by tripping adjacent breakers when a faulted CB fails to open. The relays interface with CB current transformers, voltage transformers on both sides of the breaker, CB control circuits, and trip circuits for adjacent breakers.

Historically, a single CB failure relay served both X and Y primary protection groups. As part of the upgrade strategy, independent backup protection is now being implemented for each group at 220kV and above. Additionally, this functionality is being extended to 66kV line and transformer protection relays to improve fault isolation and overall system reliability.

3.1.2. Monitoring Assets

3.1.2.1. Station SCADA (RTUs / HMI / SCIMS)

RTUs are critical components in terminal stations, acting as the interface between station protection/control schemes and the Supervisory Control and Data Acquisition (SCADA) system. These systems enable real-time monitoring, control, and automation across the transmission network.

RTUs collect and transmit a wide range of station data to SCADA systems, including:

- **Instrumentation data**: Voltage, current, frequency, watts, VARs, transformer temperature, conductor strain, and environmental conditions.
- **Equipment status**: Circuit breaker positions, plant operational states.
- **Alarms and events**: Faults, abnormal conditions, and operational triggers.

SCADA systems interpret this data and present it in a user-friendly format to both local and remote operations personnel, supporting informed decision-making and efficient network control. Most SCADA systems currently in service are First Generation and Third Generation Microprocessor types. These systems are reliable but increasingly challenged by obsolescence, limited processing capability, and integration constraints with modern digital substations.

3.1.2.2. Weather Stations

Weather stations have historically been deployed across terminal stations and along transmission corridors to monitor environmental conditions critical to asset performance and operational safety.

These weather stations were installed to provide AEMO the following information via Remote Terminal Units:

- Wind speed – anemometer and ultrasonic
- Wind direction
- Ambient temperature
- Barometric pressure

Not all stations transmit all available data to the Network Control Centre. Table 1 summarises the sensors installed at terminal stations and data available at the Network Control Centre for environmental monitoring.

ID	LOCATION	TEMPERATURE	ANEMOMETER WIND SPEED	ULTRASONIC WIND SPEED	WIND DIRECTION	BAROMETRIC PRESSURE
1	BATS	X	X	X	X	X
2	BETS	X	X	X	X	X
3	CBTS	X	X	X	X	X
4	DDTS	X				
5	EPS	X				X
6	FTS	X	X	X	X	X
7	GNTS	X				X
8	GTS	X	X	X	X	X
9	HOTS	X	X	X	X	X
10	HWTS	X	X	X	X	X
11	HYTS	X				
12	KGTS	X	X	X	X	X
13	KTS	X	X	X	X	X
14	MBTS	X	X	X	X	X
15	MLTS	X	X	X	X	X
16	MTS	X	X	X	X	X
17	RCTS	X	X	X	X	X
18	ROTS	X	X	X	X	X
19	RTS	X				
20	SHTS	X	X	X	X	X
21	SVTS	X	X			
22	TGTS	X			X	X
23	WOTS	X				
24	WETS	X	X	X	X	X
25	YPS	X	X	X	X	X

Table 1: Weather Sensors and data availability to Network Control Centre

For weather stations installed on lines following data is available at network control centre.

ID	LOCATION	TEMPERATURE	WIND SPEED	HUMIDITY	WIND DIRECTION
1	MLTS-BATS 1	X	X	X	X
2	MLTS-BATS 2	X	X	X	X
3	KTS-GTS 1,3	X	X	X	X
4	BATS-BETS	X	X	X	X
5	HWPS-ROTS 1,3	X	X	X	X
6	YPS-ROTS 7,8	X	X	X	X
7	YPS-ROTS 5,6	X	X	X	X

8	BETS-SHTS T570	X	X	X	X
9	BETS-SHTS T672	X	X	X	X
10	ARTS-CWTS T245	X	X	X	X
11	KMTS-RCTS T156	X	X	X	X
12	KMTS-MRTS T365	X	X	X	X
13	KGTS-WETS T117	X	X	X	X
14	KGTS-WETS T264	X	X	X	X
15	MLTS-TGTS T147	X	X	X	X

Table 2: Line monitoring data

3.2. Population & Age

There are approximately 5382 protection and control relays, 78 station remote control RTUs and 87 Comms RTUs operating in the AusNet Regulated Terminal Stations supported by other peripheral equipment, including trip relays and timers as reported in Ausnet [C.I.C] database.

3.2.1. Population Considerations

Effective lifecycle management of Protection and Control Systems within the transmission network relies on a comprehensive understanding of the asset population profile. This profile encompasses detailed data on the quantity, types, locations, age, and specifications of assets such as protection relays, RTUs, and SCADA systems.

A well-maintained population profile enables asset managers to:

- **Identify Critical Assets**: Determine which systems are vital for network reliability. For example, protection relays serving critical high-voltage transmission corridors or industrial zones may require prioritised maintenance or accelerated replacement schedules.
- **Allocate Resources Efficiently**: Maintenance and upgrade resources can be optimally distributed by understanding asset concentrations. For instance, regions with a high density of First-Generation Microprocessor SCADA systems may be targeted for phased upgrades.
- **Manage Risk Proactively**: Assess risks associated with aging or obsolete technologies. Electro-mechanical relays and legacy RTUs may pose reliability and cybersecurity risks, necessitating mitigation strategies.
- **Optimise Maintenance Schedules**: Maintenance planning can be tailored to asset condition and criticality. High-consequence protection schemes using older relay technologies may be scheduled for more frequent inspections to reduce failure risk.
- **Enhance Reliability and Safety**: Maintain all components to support and meet current operational and safety standards. RTUs with outdated firmware or unsupported communication protocols should be flagged for upgrade or replacement.
- **Support Strategic Planning and Investment**: The population profile informs long-term planning, including technology transitions and capital investment. For example, a growing suburban transmission zone with legacy protection systems may be prioritised for digital upgrades to support future load growth and automation.

This population-based approach supports and maintains the transmission protection and control systems to remain resilient, secure, and aligned with evolving network demands, while supporting regulatory compliance and strategic asset management goals

3.2.2. Population and age Profile

3.2.2.1. Protection & Control Relays

For asset management purposes, protection and control relays are classified into four distinct technology types:

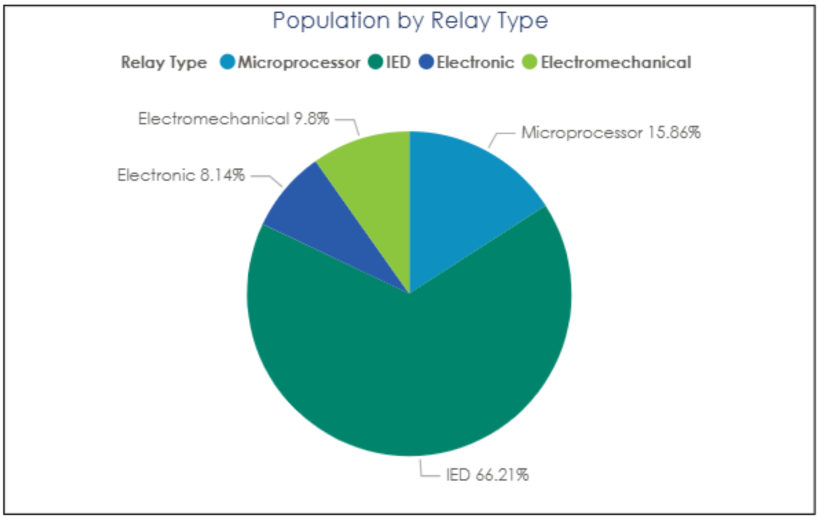


Figure 1: Protection relay types and age

Figure 1 provide an overview of the relative proportions of both protection and control relays of each type currently in service across AusNet regulated transmission network.

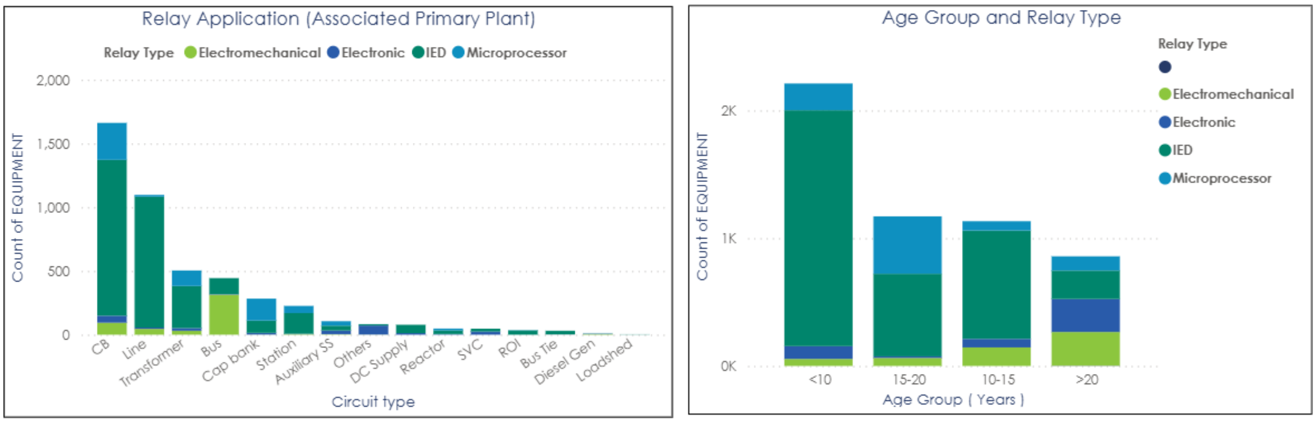


Figure 2: Relay application and age profile

Figure 2 shows relay types, their applications and age. CBs, Transformers, and Lines have the highest concentration of IEDs, reflecting modernisation efforts in critical infrastructure. Bus protection and cap banks show a mix of technologies, suggesting transitional zones where partial upgrades have occurred. The replacement program prioritises the replacement of obsolete relays at critical terminal stations that have already exceeded their service life.

Electromechanical Relays

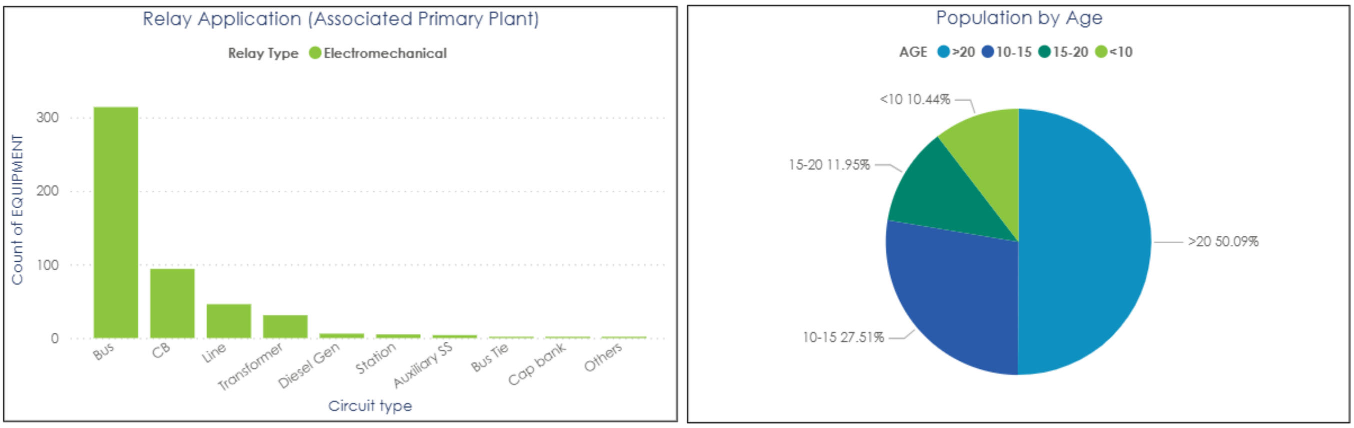


Figure 3: Electromechanical relays application and profile

The electromechanical relays are based on principles of mechanical movement and magnetic induction. These relays represent the oldest generation of protection technology. While known for their robustness, these devices are significantly limited in terms of functionality, flexibility, and have no remote monitoring capabilities. They are still commonly deployed for bus protection and circuit breaker control. However, their increasing repair times, frequent maintenance needs, spares availability and inability to integrate with modern digital infrastructure highlight their obsolescence and the need for their replacement.

Replacing them with modern, intelligent electronic devices (IEDs) will enhance system reliability, enable remote diagnostics, and support compatibility with contemporary protection and control schemes.

Electronic Relays

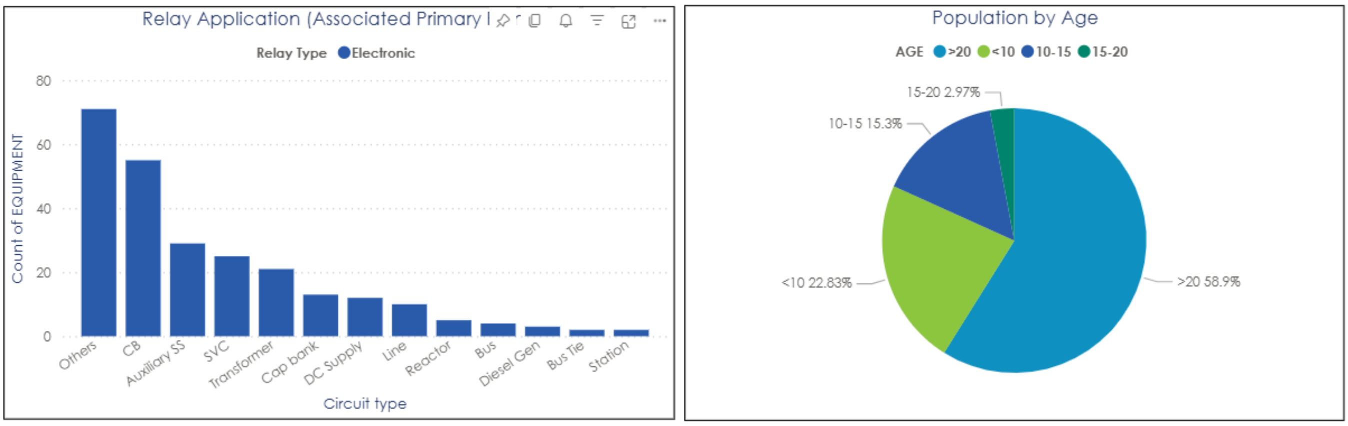


Figure 4: Electronic relays application and age profile

These are early-generation relays, which use analogue and discrete electronic components. These relays offer improved performance over electromechanical types but lack programmability and advanced communication features. They are typically used for secondary or auxiliary applications such as potential selectors, circuit breaker fail timers, and low-voltage auto changeovers. While these electronic relays are not the primary driver of the replacement program, they are often replaced in conjunction with primary protection upgrades, where modern IEDs can consolidate multiple functions into a single device, improving system efficiency and maintainability.

Microprocessor-Based Relays (First Generation)

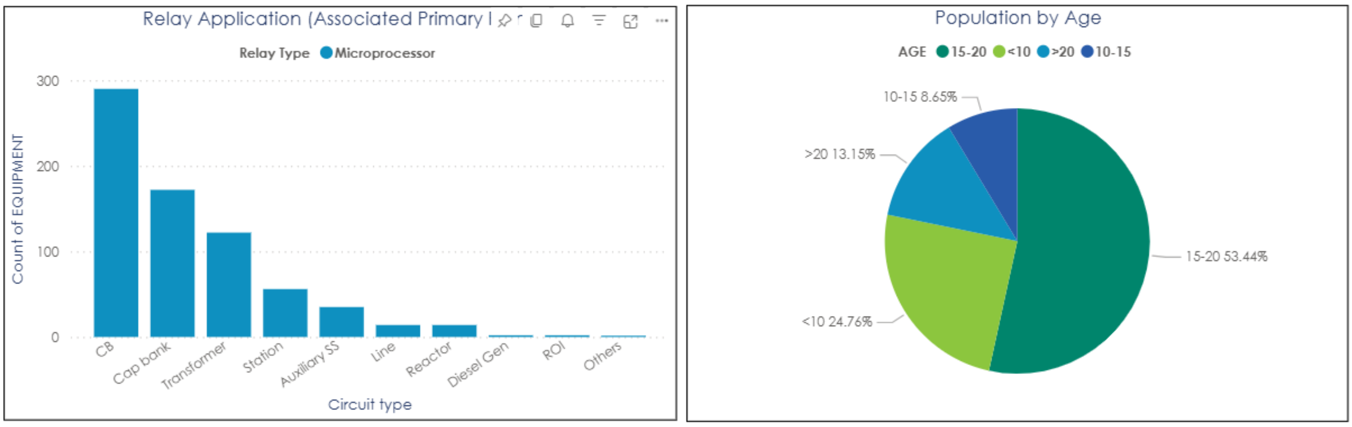


Figure 5: Microprocessor relays application and age profile

Microprocessor-based relays marked a significant advancement over earlier technologies by introducing digital processing capabilities, enabling more sophisticated logic and configuration options. When rolled out, these relays were widely adopted for various protection and control applications for critical infrastructure. However, they have since been superseded by modern Intelligent Electronic Devices (IEDs) that offer enhanced programmability, communication, and integration features. These relays are still in use for circuit breaker control, line protection, capacitor bank protection, transformer protection and few other applications. With increased programable logic and remote connectivity needs for modern assets, these relays now classified as legacy assets, face growing challenges due to limited functionality, lack of vendor support, restricted configuration capabilities and software limitations. As such, they are no longer aligned with current operational and technological standards and require emergency upgrades with modern devices when failed. As part of our replacement program, these legacy relays along with electromechanical relays have been identified as priority candidates for upgrade.

Intelligent Electronic Devices

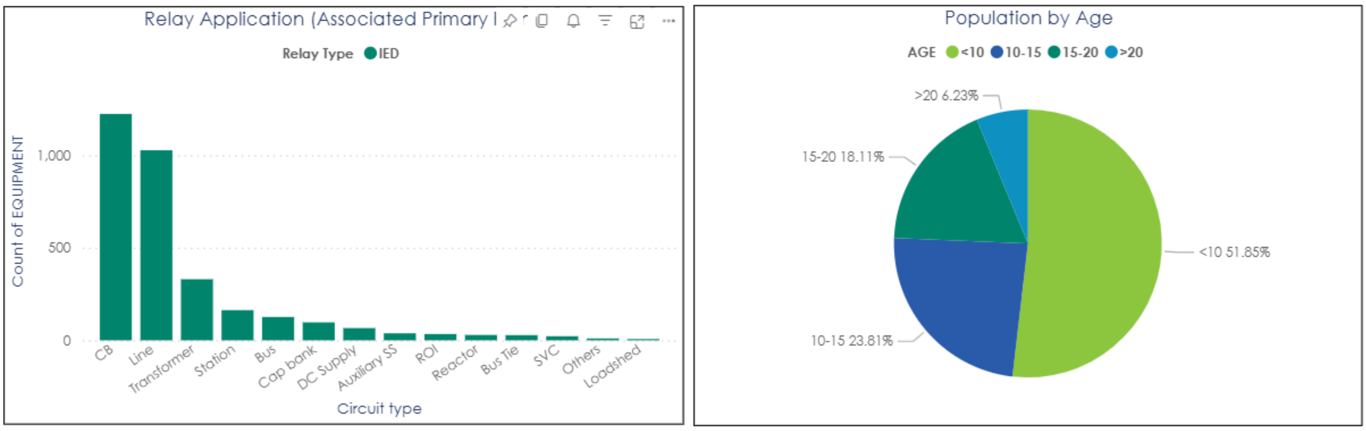


Figure 6: IEDs application and age profile

Intelligent Electronic Devices (IEDs) represent the most advanced generation of relay technology, integrating protection, control, monitoring, and communication functions into a single unit. They may support modern features such as IEC 61850 protocols, remote configuration, and detailed event logging, and are now widely used across most protection and control applications. However, early-generation IEDs installed during the initial rollout of digital technology as shown above with age > 15 years in the transmission network are now considered outdated. These older devices have limited capabilities, legacy remote connectivity and reduced flexibility. As a result, they are increasingly incompatible with evolving system requirements and modern infrastructure. Under the replacement program, these legacy IEDs are being targeted for upgrade to maintain alignment with current standards and better spares management.

Technology Transition and Population Trends

- IEDs dominate new installations: Almost all new protection and control schemes deployed across the transmission network use IEDs due to their multifunctional capabilities and integration flexibility.
- Decline of legacy technologies: Electromechanical, electronic, and first-generation microprocessor relays are no longer used in new or replacement schemes. Their population is expected to decline steadily over the next decade.
- Population reduction through consolidation: As IEDs replace older schemes, the overall number of relays may decrease, since a single IED can perform the functions of multiple legacy relays. This consolidation supports simplified maintenance and improved system reliability.
- Transitioning to IEDs enables X and Y segregation, standardisation of protection schemes, reducing complexity and improving interoperability.

The replacement program is structured to upgrade entire protection schemes associated with primary plant assets, rather than replacing individual relays in isolation. This approach has proven more effective in reducing maintenance complexity, minimising the frequency and duration of outages, and enhancing overall asset lifecycle management. Historically, replacing individual relays introduced significant integration challenges due to the mix of different technologies, particularly when interfacing with existing relay circuits and legacy wiring. These partial upgrades often required complex modifications, increasing the risk of errors and compromising system reliability and require more outages. By modernising the complete protection system, the program facilitates seamless integration, greater reliability, and alignment with current operational and technological standards.

3.2.2.2. Remote Terminal Units (RTUs)

There are 78 station remote control RTU's installed at regulated terminal station and 87 comms RTUs installed at both regulated terminal stations and radio sites as reported in [C.I.C].

Station Remote Control RTUs:

Station remote control RTUs are essential components of substation automation systems, providing the interface between field devices and the control centre. They enable remote monitoring, control, and data acquisition from both primary plant and secondary equipment, ensuring real-time operational visibility across the network. These RTUs collect and transmit alarms and status indications from protection relays, circuit breakers, and other substation assets. They also facilitate remote operation of key equipment such as circuit breakers, isolators, and tap changers supporting both routine switching operations and emergency response scenarios. In addition, station RTUs play a critical role in enabling remote special protection schemes, including load-shedding, auto-reclose blocking, and intertrip functions. They also gather analogue and digital measurements (e.g., voltages, currents, breaker positions) for integration into SCADA systems and for use in historical analysis and event diagnostics.

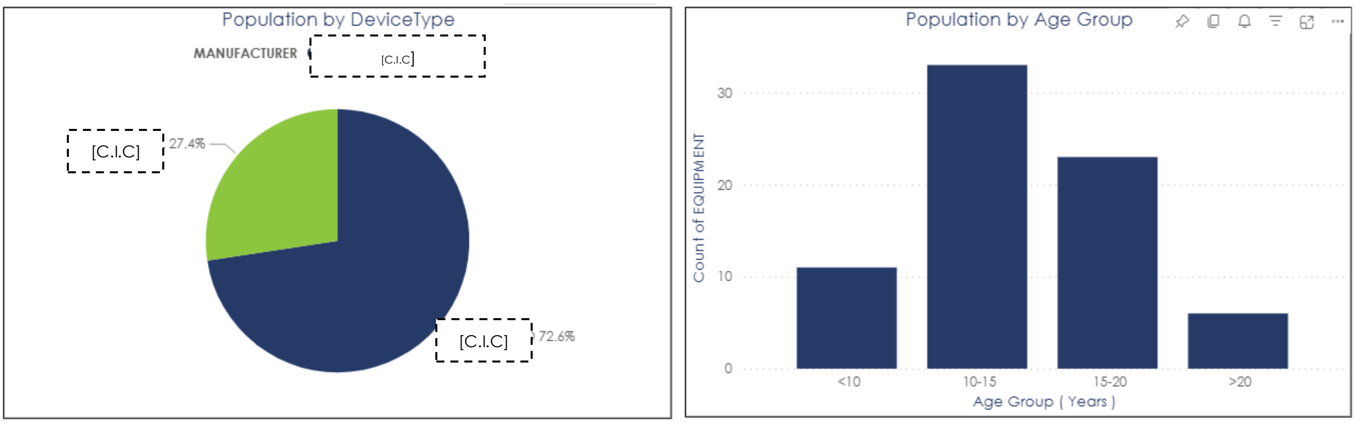


Figure 7: Population by type and age station Remote control RTUs

Figure 7 illustrates the distribution of devices by manufacturer and age, highlighting the dominance of [C.I.C] and [C.I.C], which accounts for 72.6% of the total remote control RTUs installed at regulated terminal stations. The population includes:

- [C.I.C]: 37
- [C.I.C]: 16
- [C.I.C]: 25

Comms RTUs

Communications RTUs deployed at terminal stations and radio sites serve a vital role in maintaining the integrity and visibility of the communications infrastructure that supports the power system. These RTUs are specifically configured to monitor the operational status of communications equipment and provide real-time alarms in the event of failures or abnormal conditions.

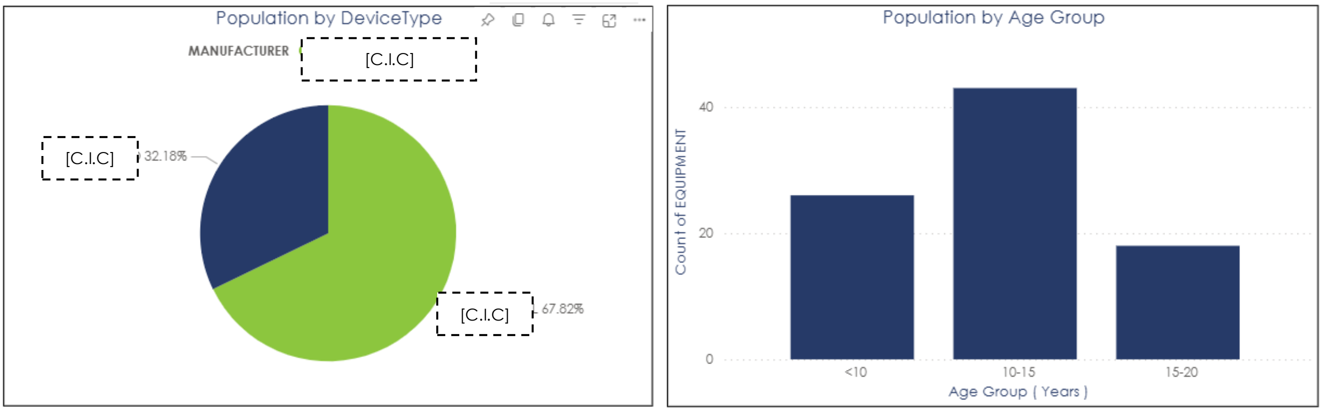


Figure 8 : Population by type and age comms RTUs

[C.I.C] accounts for 67.82 % of the total comms RTUs installed at both station and comms sites. The population includes:

- [C.I.C]: 14
- [C.I.C]: 14
- [C.I.C]: 59

[C.I.C] and [C.I.C] have reached end of life status and have no vendor support making their continued operation increasingly unsustainable. [C.I.C], and flexible configuration options required for today's digital substations. To maintain network reliability and facilitate the availability of critical spares, these legacy RTUs will be strategically replaced over time as part of broader replacement program. The upgrade path involves transitioning to [C.I.C] or [C.I.C] prioritising the replacement at critical sites in the current replacement program. This targeted approach not only enhances system performance and supportability but also helps free up spare units for remaining installations.

3.2.2.3. Weather Stations

There are 25 weather monitoring installations located within AusNet Services terminal stations and 14 weather stations situated along transmission lines in regulated network. They are located at following stations for environmental monitoring purpose:

- BATS
- BETS
- CBTS
- DDTS
- EPS
- FTS
- GNTS
- GTS
- HWTS
- HYTS
- KGTS
- KTS
- MBTS
- MLTS
- MTS
- RCTS
- RTS
- SHTS
- SVTS
- TGTS
- WOTS
- WETS
- YPS

- HOTS
- ROTS

and on transmission lines at following locations for line monitoring purposes:

- BATS-BETS
- CWTS-ARTS
- 2 x SHTS-BETS
- 2 x MLTS-BATS
- MRTS-KMTS
- KTS-GTS
- 2 x KGTS-WETS
- 2 x YPS-ROTS
- MLTS-TGTS
- HWPS-ROTS

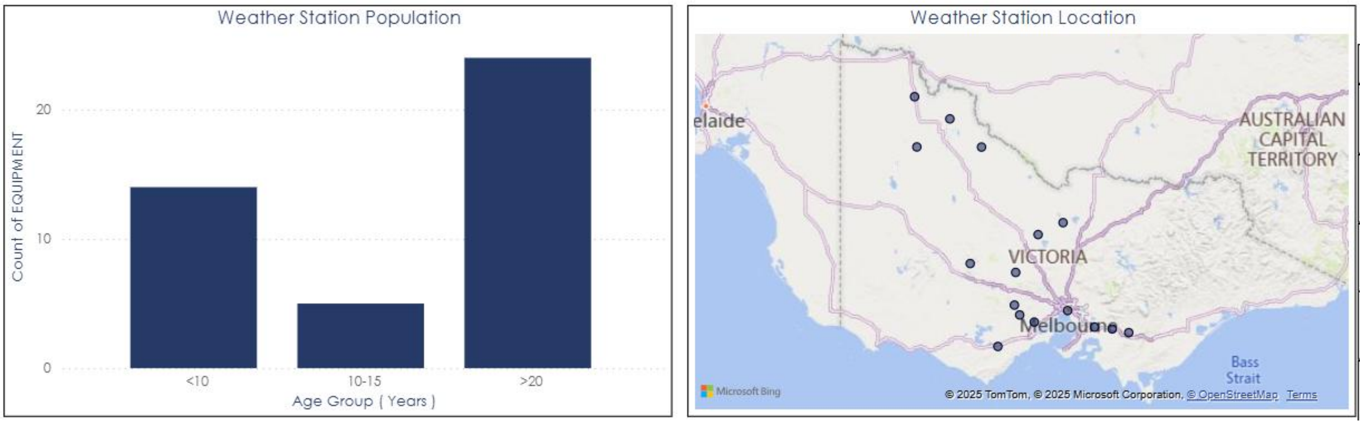


Figure 9 : Weather stations population and age profile

A significant number of these weather stations were installed decades ago, often as part of legacy monitoring schemes. These weather stations have worked well since installation. A significant number of existing weather stations are approaching or have exceeded their expected service life with custom modifications done to keep them operational. The majority lack compatibility with modern SCADA systems and advanced analytics platforms, reducing their utility in predictive maintenance and real-time decision-making. Upgrading to modern weather stations offers several benefits with real-time data streaming, reduced maintenance through self-diagnostics and remote calibration and enhanced grid reliability. A systematic replacement program is proposed to for the progressive renewal of weather stations with prioritisation for the ones installed on transmission lines to provide continued reliability, compliance, and alignment with modern monitoring and control requirements.

4. Performance

Performance assessments are a critical component of the lifecycle management strategy for the secondary systems. These assessments provide essential insights into the condition and reliability of key components. By analysing failure trends, effort required to replace the relays and the impacts of system faults, AusNet can make informed decisions regarding asset maintenance, refurbishment, and replacement. This proactive approach supports long-term asset reliability and reduces the likelihood of unexpected failures. AusNet Services logs each failure event in [C.I.C], enabling traceability and analysis.

Across all secondary systems, failure modes that can be seen as notifications includes the following:

- Mechanical wear
- Component failure
- Component degradation
- Signal interference
- Power supply issues
- Communication failure
- Hardware failures
- Incorrect settings
- Firmware corruption
- Overheating
- Aging components
- Moisture ingress
- Software bugs
- Cyber security vulnerabilities
- Configuration errors
- Communication failure

4.1. Protection and Control

The core objective of protection systems within the transmission network is to detect and isolate faults quickly, safely, and effectively. This minimises risks to personnel and public safety, prevents equipment damage, and helps maintain network stability. Transmission protection systems are designed to be fully duplicated and independent. This redundancy supports continued operation in the event of a single system failure.

Figure 10: Key Prot & Ctrl failure notifications raised per year

Figure 10 shows the count of ZA and ZK notifications of relays per calendar year, until September 2025.

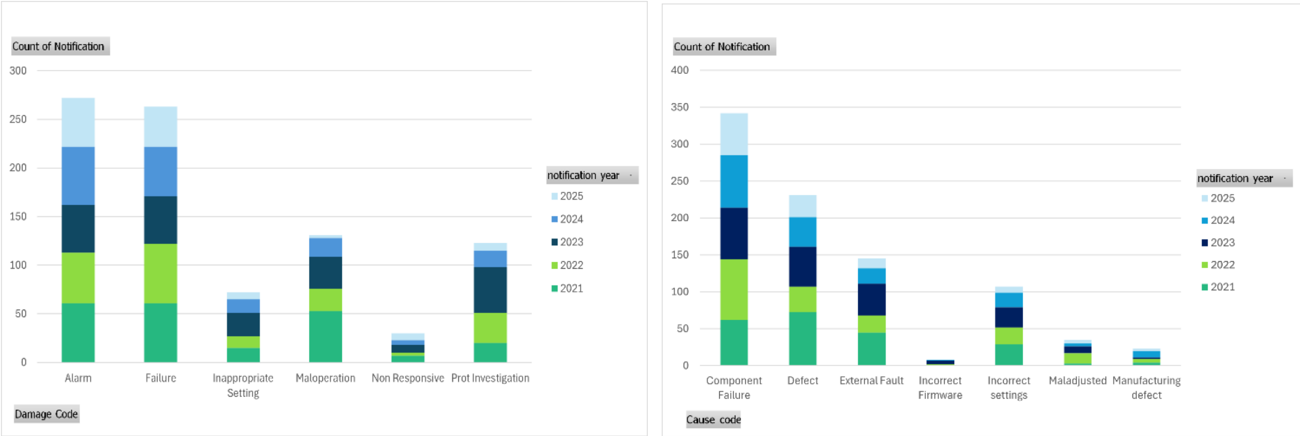


Figure 11: Prot Control notifications by damage and cause vs age

Figure 11 presents notifications categorised by initial damage and causes types. The most prevalent issues are component failures, incorrect settings, maloperations due to card damage, and communication failures. The "Failure" category includes notifications triggered by failure alarms, which typically lead to either relay replacement or further diagnostic investigation. The "Setting Issues" category captures notifications related to changes in protection and control relay settings. These are usually initiated following detailed investigations into system behaviour or performance anomalies. The "Nonresponsive" category refers to loss of communication with SCADA systems. These cases require further investigation to identify the root cause, which may involve hardware, configuration, or network-related issues. Notifications under "Protection Investigation" involve relays that failed to operate during fault conditions. These require deeper analysis to determine whether the issue lies with the relay itself, its configuration, or external factors. The "alarm" category includes events where alarms are logged in

SCADA and notification raised for further field investigations.

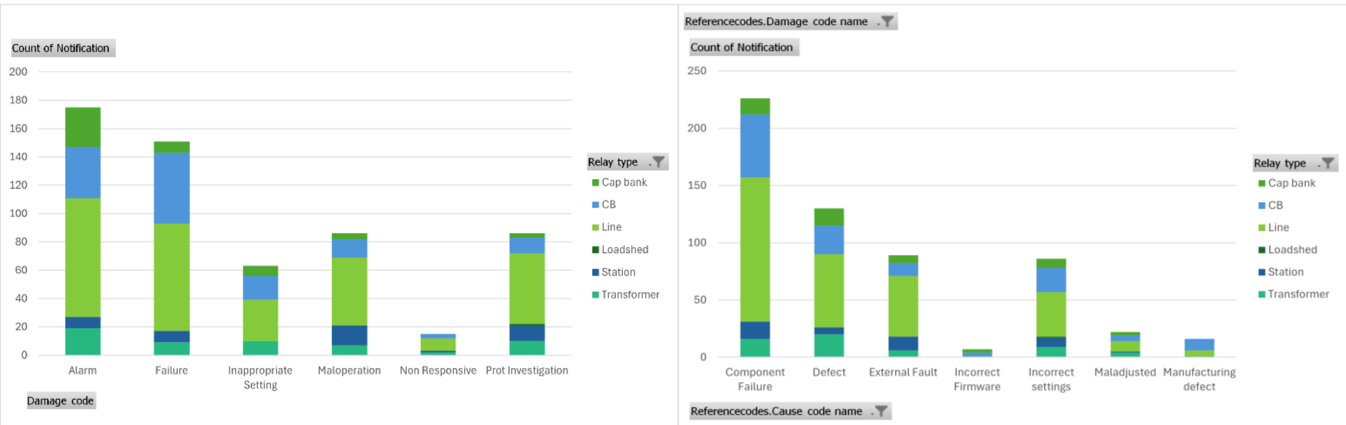


Figure 12: Prot Control notifications by damage and cause vs application

The "Failure" category slightly exceeds the total number of notifications and primarily involves relays protecting critical primary plant assets, such as transmission lines and CB management relays for CB control and CB failure backup protection applications. The higher frequency of issues in this category may be attributed to the extended in-service life of these relays, often surpassing their intended operational lifespan leading to frequent component failures. This may be due to communication card failure for differential comms between two relays at remote stations or input / output cards.

Failures in older and obsolete relays often result in prolonged repair times due to the need for emergency redesigns to address obsolescence and the lack of available spare units and firmware mismatches. Furthermore, the performance and reliability of these protection relays are adversely impacted by outdated firmware, especially when vendors no longer provide updates or technical support. Obsolete firmware may lack essential bug fixes, security enhancements, and compatibility with modern systems, increasing the risk of operational inefficiencies. AusNet Services logs each failure event in [C.I.C], enabling traceability and analysis.

4.2. Remote Terminal Units

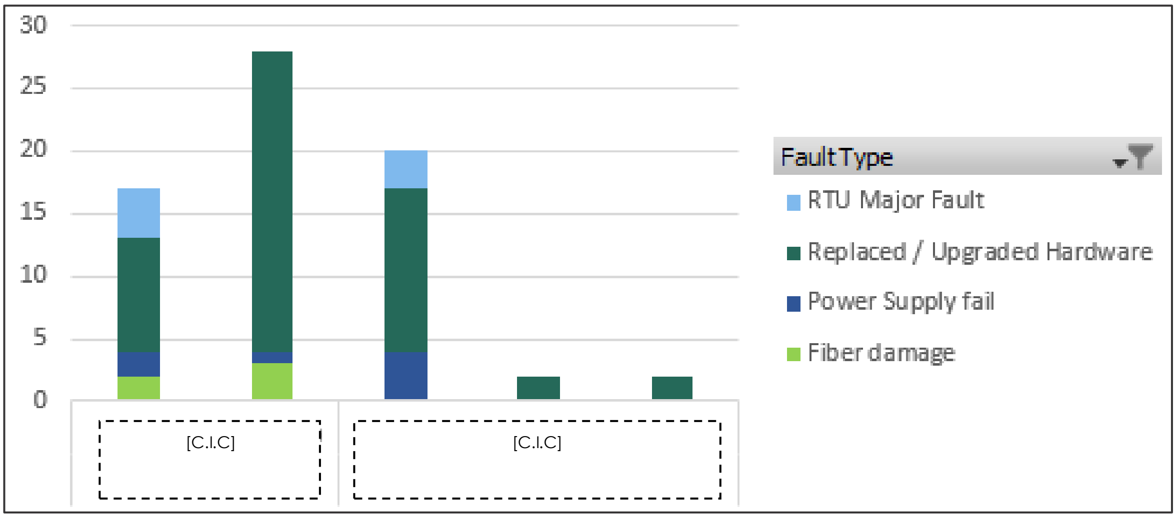


Figure 13 : RTU key notifications reported for each model since 2015

Figure 13 illustrates the key notifications raised for RTUs with critical issues between 2015 and 2025. These notifications are categorised into four groups: hardware-related issues, power supply issues, fibre damage and major RTU breakdowns. Other notifications raised for the investigation of station equipment connectivity issues are excluded. Hardware failure requires replacement of the failed component. A failed input, output or analogue card results in the loss of a subset of telemetry data supplied to SCADA via the RTU. Failure of the microprocessor or DC supply components results in the loss of visibility of the entire terminal station and necessitates that the station be manned for manual supervision and control pending RTU repair. When no spares are available, as may be the case with older, obsolete units, replacement of the entire RTU is necessary (a costly, time and labour-intensive exercise).

Software constraint is generally associated with a longer repair time due to lack of support or long lead/response times from the unit manufacturer. Manufacturer product support is thus an important aspect of software and firmware management. Without support, the RTU is associated with an increased risk of software glitches due to lack of options for firmware upgrade. It is for this reason that obsolescence and manufacturer support are a key input to asset condition assessment. Hardware failure and software constraint are declared failure modes, that are recognisable to the network operator via assertion of alarms or observable unit non-responsivity. Both [C.I.C] and [C.I.C] have reached end-of-life status and are no longer supported by the manufacturer. Due to their incompatibility with modern IEDs and to free up spares for fleet management, these RTUs are being prioritised for phased replacement, with critical sites included in the current upgrade program.

4.3. Weather monitoring stations

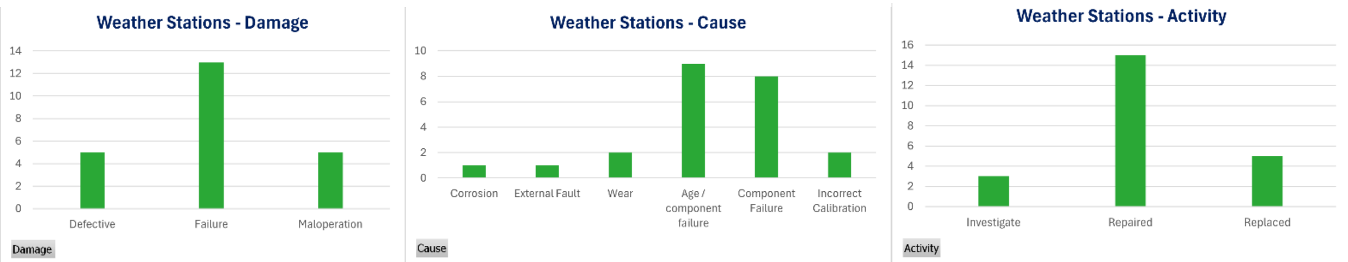


Figure 14 : Weather stations Batteries Damage, cause and activity notifications

Figure 14 shows incidents reported in [C.I.C]between 2021 to 2025 with investigations, and resolutions related to weather stations and line monitoring systems installed at terminal station and transmission lines. The data supports a reactive maintenance approach with a strong emphasis on customised repairs over replacements due to obsolete fleet, aging assets already exceeded their design life. Aging components are a recurring issue, suggesting the need for a strategic upgrade program. Sensor failures and incorrect readings can significantly impact forecasting and compliance, especially with AEMO and customers connected on the network. Line monitoring system installed on transmission towers may require line offloading and wider coordination with line crew to identify and rectify the faults in minimum possible time.

Recent Events

Ambient Temperature Sensor Malfunction

Site 1: Ambient temperature reading of -10°C triggered an alert. Investigation was initiated to validate sensor accuracy and environmental conditions. The affected sensor was part of a very old and obsolete fleet, with limited compatibility and restricted availability of replacement parts. The legacy design of the sensor infrastructure made troubleshooting and repair more complex, requiring specialised components no longer readily stocked. Concurrent cutover works on another critical line created scheduling conflicts, making it difficult for line crews to secure shutdown windows for fault rectification.

Site 2: A critical issue was reported at a key terminal station involving the ambient temperature sensors. The sensors intermittently recorded extreme low values of -40°C, which is the minimum threshold set in SCADA. These readings were not reflective of actual environmental conditions and were indicative of a sensor fault. The erroneous readings directly affected customer maximum and minimum demand forecasting, which relies on accurate temperature data. The fault posed a risk of disrupting AEMO's operational planning, especially during periods of high demand or volatile weather conditions. The sensors involved were part of an aging fleet, and the fault was consistent with component degradation or calibration drift. The event highlighted the vulnerability of legacy sensors in critical forecasting applications.

Environmental Analogue Signals Failure

All environmental analogue signals from the weather station at a key terminal station failed unexpectedly. Initial diagnostics confirmed that the RTU cards were operational, ruling out SCADA or communication faults. The root cause was traced to a component failure within the old / obsolete weather station itself. The failure disrupted real-time environmental data critical for electricity demand forecasting, which relies heavily on ambient temperature and humidity data. The absence of accurate weather data introduced forecasting errors, potentially affecting dispatch decisions and grid stability. Again, the legacy design, obsolete fleet made it more challenging for replacing failed components.

Legacy Weather Station Failure and Adaptive Upgrade

A significant fault was identified at a key terminal station involving its ambient temperature sensor, part of a legacy weather station installation. The sensor, a HMP45A model, had been in service for many years and showed clear signs of deterioration covered in dirt, dust, and spiderwebs, and hard-wired from the top of the mast to its transducer. Sensor output readings confirmed a complete failure of the temperature sensor. The HMP45A, now obsolete, was found to be incompatible with modern replacements, specifically the newer HMP155 sensor. The installation had undergone multiple modifications over its life, further complicating the upgrade process.

The failure triggered false temperature readings, risking unnecessary alerts to AEMO and compromising forecasting accuracy. To prevent system instability, the faulty sensor was dressed out of service with an artificial value, suppressing false SCADA alerts until a permanent fix could be implemented.

Contributing factors

REF	DETAILS
01	**Delayed Replacement Planning** Aging weather stations with lifecycle customized modifications and incompatibility with modern fleet pose serious challenges for maintenance and upgrade efforts.
02	**Inadequate Availability of Spares** Spare components not available in stores with increased dependability on manufacturer lead times.

Table 3: Weather station issue contributing factors

Recent incidents involving ambient temperature sensor malfunctions and environmental analogue signal failures have underscored the urgent need to accelerate the replacement of aging infrastructure. At multiple critical sites, obsolete sensors and weather stations, many of which are incompatible with modern components have produced erroneous readings, triggered false alerts, and disrupted demand forecasting essential to AEMO's operational planning. These legacy systems, often modified over time and lacking readily available spare parts, complicate fault diagnosis and repair, especially when compounded by scheduling conflicts during concurrent cutover works. The failures not only highlight the technical limitations of outdated equipment but also the operational risks they pose to grid stability. As such, the current replacement program is strategically aligned to address these issues, prioritising the upgrade of weather stations that had already exceeded their service life with modern equipment to support reliable data acquisition, streamlined maintenance, and improved forecasting accuracy.

5. Asset Health

Protection & Control, RTUs and Weather Monitoring Stations are critical components of terminal station infrastructure, enabling primary plant protection during fault, real-time data acquisition, remote control, and environmental monitoring. Over time, many of these assets have aged beyond their intended service life, with several units showing signs of wear, calibration drift, and component degradation. Legacy relays and RTUs often face firmware limitations and compatibility issues with modern SCADA systems, while older weather stations such as those using [C.I.C] sensors are increasingly difficult to maintain due to obsolete designs and limited parts availability. Environmental exposure further accelerates deterioration, particularly for mast-mounted sensors. These condition challenges not only affect operational reliability but also compromise forecasting accuracy and regulatory compliance, underscoring the need for a well-planned and structured asset renewal and upgrade strategy.

5.1. Protection & Control

Protection and control relays are critical components in the transmission network, responsible for detecting faults and initiating appropriate control actions. Their ability to perform reliably and integrate with modern systems is essential for maintaining network safety, stability, and operational efficiency. The condition of each relay has been assessed using a structured framework that evaluates obsolescence status and manufacturer support and modernisation potential and integration capability. This assessment supports strategic asset management decisions, including prioritised replacement, targeted investment, and risk-based maintenance planning.

Condition Assessment Framework

Obsolescence Rating

This rating evaluates the extent of manufacturer support, software availability, and the operational viability of each relay:

RATING	DESCRIPTION
1	Relay manufactured within the last two years; full manufacturer support and all software updates readily available.
2	Relay is fully supported by the manufacturer but based on an older platform; software remains available and compatible.
3	Relay is no longer in production but still supported; spare parts and compatible software are available, though usability is gradually declining.
4	Manufacturer has indicated a phase-out; software remains compatible but is increasingly difficult to use and maintain.
5	Relay is no longer supported by the manufacturer; limited resources and tools are available, resulting in high operational risk.

Table 4: Protection & Control Obsolescence criteria

Modernisation Rating

This rating assesses the relay's capability to meet current and future operational, communication, and integration standards:

RATING	DESCRIPTION
1	Fully modern relay supporting IEC 61850, DNP3, waveform capture, remote engineering access, and settings upload.
2	Relay supports DNP3, waveform capture, remote engineering access, and settings upload, but lacks IEC 61850 capability.
3	Relay has basic functionality; lacks serial communication and remote engineering access, with limited event recording.
4	Relay lacks event recording and diagnostic capabilities; minimal integration potential.

5	Relay is incompatible with current standards and cannot be integrated into modern systems.

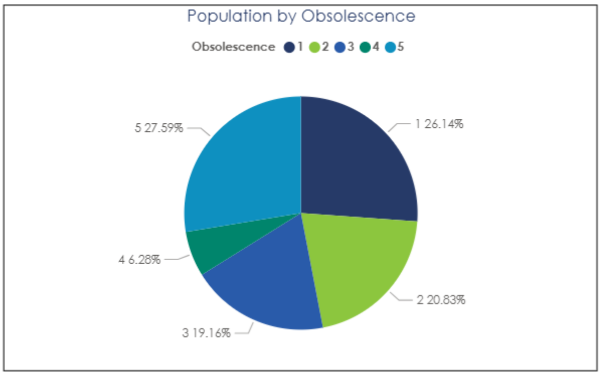
Table 5: Protection & Control Modernisation criteria

This dual classification enables prioritised replacement of high-obsolescence, low-modernisation assets, targeted investment in interoperable, future-ready technologies, risk-based maintenance strategies for legacy equipment and strategic alignment with digital substation and automation initiatives.

Example Scenarios:

- Obsolescence 4 / Modernisation 5 → High priority for replacement
- Obsolescence 2 / Modernisation 1 → Low-risk asset; minimal intervention required

Asset Condition



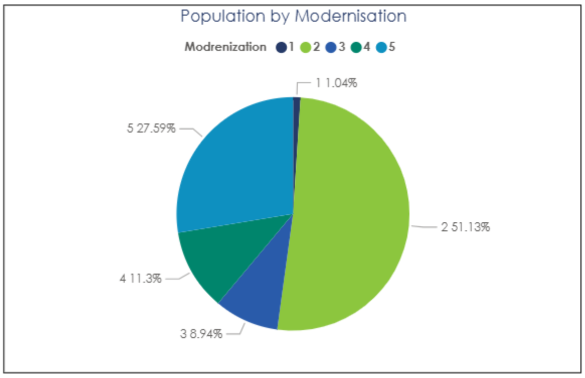


Figure 15 : Population by Obsolescence and Modernisation

Figure 15 presents the distribution of protection relay assets across the five levels of obsolescence and modernisation.

Obsolescence and Modernisation Distribution

More than a quarter of the population falls under Obsolescence and Modernisation Level 4 and 5, indicating a significant portion of assets are outdated, have limited event logging and reporting capability and pose operational risks. This is primarily driven by legacy CB management relays such as T2E, and backup protection relays P143 and P145 followed by transformer, cap bank and bus protection relays.

Relay application Distribution

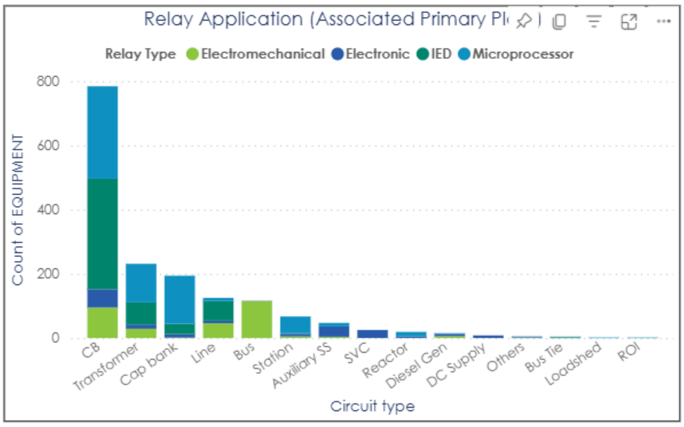


Figure 16: Relay application with condition score C4 and C5

Figure 16 highlights the significant contribution of CB management and backup protection relays within the C4 and C5 condition categories. These assets are characterised by the absence of available spares, limited workforce expertise in handling associated hardware and software, and inherent technological limitations. Their continued operation poses elevated risks to network reliability and maintainability. Following this group, legacy microprocessor-based transformer and capacitor bank protection relays also show signs of obsolescence and reduced integration capability. Additionally, a subset of line protection relays still relies on outdated technology with limited remote monitoring functionality. These should be prioritised for upgrade to advanced standard protection relays that offer enhanced fault detection, diagnostics, and remote access capabilities, aligning with modern protection philosophies and digital substation initiatives. The replacement program includes a targeted initiative to upgrade legacy backup protection relays, particularly for circuits undergoing primary protection replacement. This approach supports the deployment of redundant X and Y backup protection scheme and free up spares for the rest of the fleet.

Obsolete Relays

To maintain system reliability and align with modern protection standards, we are progressively replacing following obsolete relays in current replacement program across key protection systems to manage spares. The following table summarises the current population of these relays by category:

FUNCTION	MANUFACTURER	MODEL	QTY ON NETWORK
Line Protection	[C.I.C]	[C.I.C]	2
	[C.I.C]	[C.I.C]	10
	[C.I.C]	[C.I.C]	6
	[C.I.C]	[C.I.C]	23
	[C.I.C]	[C.I.C]	16
	[C.I.C]	[C.I.C]	74
Transformer Protection	[C.I.C]	[C.I.C]	101
	[C.I.C]	[C.I.C]	18
	[C.I.C]	[C.I.C]	3
	[C.I.C]	[C.I.C]	34
Cap Bank Protection	[C.I.C]	[C.I.C]	5
	[C.I.C]	[C.I.C]	25
Breaker Failure Protection	[C.I.C]	[C.I.C]	169
CB Controls, Voltage regulators, IO modules	[C.I.C]	[C.I.C]	384
Transformer voltage regulator	[C.I.C]	[C.I.C]	67

Table 6: Obsolete relays on regulated transmission network

5.2. Remote Terminal Units

The condition of RTUs across the network has been evaluated using a structured framework that considers operational performance, obsolescence, and modernisation readiness. This assessment supports strategic asset management, risk mitigation, and compliance with AEMO operational standards.

Condition Assessment Framework

Each type of RTU is accessed based on following criteria and their weightage and with proposed recommended actions to be taken for system reliability.

- Operational Standards for Satisfactory Operation 40%
- Obsolescence 40%
- Modernisation 20%

Operational Standards for Satisfactory Operation

This criterion evaluates the RTU's ability to meet AEMO's operational standards for control, telemetry, and redundancy.

- Systems must demonstrate independent local and remote communication paths, ensuring that failure of any single component does not compromise both control layers.
- RTUs are expected to deliver control, status, and alarm data to the Control Centre SCADA within 4 seconds, measured end-to-end from primary plant to SCADA front-end.

- Analogue data must be reported within 6 seconds, and the system must support a minimum resolution of 0.1% of the default range to work towards precision in real-time monitoring and forecasting.

These performance benchmarks are essential for maintaining grid stability, supporting accurate demand forecasting, and ensuring compliance with AEMO's operational protocols.

Obsolescence

This criterion evaluates the technological relevance and lifecycle status of RTUs and station controllers within the fleet. Assets are assessed based on their alignment with current industry standards and vendor support availability.

- RTUs classified as non-obsolete must be current-generation or PC-based systems with robust communication capabilities, including TCP/IP support, IEC 61850 MMS (Server and Client), and GOOSE messaging compliance.
- Hardware interfaces must include fibre optic (100FX) and serial ports (RS232, RS422, RS485) to support compatibility with diverse field devices.
- RTU or gateway must still be in active production and supported by the manufacturer, ensuring access to firmware updates, spare parts, and technical assistance.

Assets meeting these criteria are considered low-risk and suitable for continued operation within a modernised SCADA environment.

Modernisation

This criterion assesses the RTU's capability to support future-ready digital infrastructure and scalable network operations.

- RTUs must be able to manage a minimum of 20,000 database points and connect with at least 150 Intelligent Electronic Devices (IEDs) over serial and/or Ethernet interfaces.
- Systems should support event storage of at least 30 events per point, ensuring robust historical data retention. Modern RTUs must also enable advanced features such as Role-Based Access Control (RBAC), SNMPv3, and Programmable Logic Control, along with independent Ethernet ports configurable with unique IP, subnet, and gateway addresses.
- Compatibility with engineering file formats like SSD, SCD, SCL, ICD, and CID is essential for seamless integration and configuration.
- RTUs must support remote access for firmware and configuration updates, and offer secure communication protocols including IPv4, IPv6, external authentication, and traffic encryption.
- Operating system support must extend to Windows 7 or higher, and time synchronisation should be enabled via IEEE 1588 (v2 and Power Profile), NTP, SNTP, IRIG-B, and DNP.
- These capabilities support the RTU is aligned with modern utility standards and scalable for future grid demands.

This rating assesses the equipment's capability to meet current and future operational, communication, and integration standards.

Asset Condition

Based on above criteria condition scores are assigned to each type of fleet as mentioned in following Table and roadmap is advised with possible recommended actions.

TECHNOLOGY TYPE	MANUFACTURER	MODEL	QTY	CRITERIA 1 (SATISFACTORY OPERATION)	CRITERIA 2 (OBSOLESCENCE)	CRITERIA 3 (MODERNIZATION)	FLEET BASED CONDITION SCORE
First Generation	[C.I.C]	[C.I.C]	30	1	5	3	C5
Third Generation	[C.I.C]	[C.I.C]	25	1	3	1	C3
Third Generation	[C.I.C]	[C.I.C]	51	1	4	3	C4
Fourth Generation	[C.I.C]	[C.I.C]	5	1	1	1	C1
Fourth Generation	[C.I.C]	[C.I.C]	Under Test	1	1	1	C1

Fourth Generation	[C.I.C]	[C.I.C]	Under Test	1	1	1	C1
Small factor RTU	[C.I.C]	[C.I.C]	59	1	1	1	C1

Table 7: Fleet assessment and condition score

Due to their limited functionality, advanced age, and confirmed obsolescence, the RTU-50 units have been assessed as Condition C5, indicating very poor serviceability and high operational risk. These RTUs are no longer in production and unsupported by the original manufacturer, with no spare parts available to facilitate repairs in the event of failure. Critically, the RTU-50 lacks the capability to communicate with modern Intelligent Electronic Devices (IEDs), making it incompatible with current and future station automation requirements.

The remaining in-service units are operating near full capacity and cannot be scaled to accommodate the increasing data demands of smart grid technologies. Additionally, the RTU-50's power supply is prone to frequent failure, creating a single point of failure that can result in complete loss of station visibility within SCADA systems. These units are underperforming and unreliable and are prioritised to be replaced at the earliest practical opportunity to maintain operational integrity and support network modernisation.

The SCD5200 RTU is a first-generation unit with limited functionality and compatibility with modern network requirements. It supports serial communication and basic TCP/IP but lacks critical features such as IEC 61850 MMS and GOOSE protocol compliance, and does not include a fibre optic interface, which restricts its integration with digital substations. The product is obsolete, with no manufacturer support and limited spare parts availability, posing a significant risk in the event of hardware failure.

While these capabilities provide minimal operational coverage, the lack of modern protocol support, vendor backing, and scalable architecture makes the [C.I.C] unsuitable for long-term deployment. Its remaining service life is estimated at less than five years. These units be scheduled for phased replacement in current replacement program to align with network modernisation and reliability goals.

5.3. Strategic Implications

The asset condition analysis provides a clear roadmap for:

- Lifecycle replacement programs targeting high-risk assets
- Technology refresh initiatives to improve interoperability
- Skill development and training for legacy systems
- Improved asset performance and network resilience

The condition assessment of each asset plays a vital role in guiding asset management strategies across the transmission network. By evaluating each asset's operational viability, technological relevance, and integration capability, the analysis supports the investment decisions are data-driven, risk-informed, and aligned with the long-term vision for a modern, automated transmission network that balances risk, performance, and investment. Ultimately, it works towards asset interventions are data-driven, risk-informed, and aligned with the long-term vision of a modern, automated, and resilient transmission network.

6. Related Matters

6.1. Regulatory Framework

6.1.1. Compliance Factors

Regulatory and Legislative Reference

Effectively managing compliance obligations specific to legislation and regulatory frameworks is a core element of Asset Class Planning and supports the sustainable operation and management of transmission network assets. Adherence to relevant laws, codes, and standards helps prevent legal and regulatory breaches, which could result in significant penalties, operational disruptions, and reputational damage.

Technical Standards and Procedures

Compliance with technical standards and operational procedures is essential so that transmission assets are designed, constructed, maintained, and operated in accordance with industry best practices. This enhances safety, reliability, and interoperability across the transmission network. It also supports consistent performance, reduces asset-related risks, and supports alignment with regulatory expectations.

Key regulatory standards

REF	DETAILS
01	*Electricity Safety Act 1998 (Vic)* – Section 98(a) Mandates the safe design, construction, operation, and maintenance of electrical infrastructure.
02	*National Electricity Rules* – Clause 5.2A.4 Outlines obligations for maintaining system security and performance standards in the National Electricity Market (NEM).
03	NER 4.6.5 Partial outage of power protection systems Where there is an outage of one or both protection system of a transmission line, AEMO must determine, in consultation with the relevant Network Service Provider, the most appropriate action.
04	NER Clause S5.1.2.1(d) Network Service Providers (NSPs) must ensure that all protection systems for lines above 66 kV including intercropping schemes are well maintained and available. Protection systems may be out of service only for short periods, specifically not greater than eight hours and only while maintenance is being carried out.

Table 8: Key regulatory standards

6.2. Internal Factors

6.2.1. Training and Competency Factors

Effective training and competency development is a fundamental component of Asset Class Planning. Ensuring that asset managers, engineers, operational staff, and field personnel possess the necessary skills and technical knowledge is critical for maintaining the reliability, safety, and efficiency of the transmission network.

Replacing outdated relays and RTUs with modern devices supports the development of internal competencies in protection and control technologies. Legacy devices often lack documentation, vendor support, and compatibility with modern training tools, making it difficult to upskill staff effectively. Modern devices, on the other hand, are supported by current training programs and vendor resources, enabling staff to stay proficient in the latest technologies. Modern devices built on latest standards simplify training and reduce the need for specialised legacy knowledge. This supports a more streamlined and scalable training program, ensuring staff are equipped with relevant, up-to-date skills.

6.2.2. Resource Management Factors

Modernising protection and control assets enhance resource efficiency by reducing the time and effort required for maintenance, fault response, and integration. 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. Obsolete equipment often requires specialised knowledge and spare parts that are increasingly difficult to source, leading to higher operational costs and increased risk of prolonged outages. Newer devices streamline maintenance and reduce reliance on niche expertise. It simplifies procurement and inventory management by standardising on supported technologies.

6.2.3. Safety Factors

Safety is a paramount concern in the management of electricity transmission network assets, as outlined in Energy Safety Management Scheme REF: ESMS 10-01. 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.

Replacing end-of-life relays and RTUs enhances network safety by reducing the risk of failure and ensuring compliance with current safety standards. Legacy devices may not meet modern safety or cyber security standards, increasing the risk of unsafe operation or undetected faults. Modern devices support advanced diagnostics, remote monitoring, and faster fault isolation, contributing to a safer network.

Protection system failure may have a safety impact including:

REF	DETAILS
Risk to Personnel	Without proper fault isolation, live equipment may remain energised during fault conditions.
Fire and explosion risks	Faults not cleared promptly can lead to overheating, equipment rupture, or ignition of flammable materials.
Delayed fault response	Increases exposure time for maintenance crews and operators to unsafe conditions, especially during fault investigation or manual isolation.
Equipment Damage	Primary plant such as transformers, circuit breakers, and busbars may suffer irreversible damage due to prolonged fault currents.
Oil spills or gas leaks:	Faults in oil-filled equipment or gas-insulated switchgear can lead to environmental contamination.

Table 9: Safety factors

6.3. Future Development

6.3.1. Technology and Innovation Factors

Upgrading to modern, standards-based devices enables integration with digital interface controllers (DICs), supports remote engineering access, and prepares the network for future innovations such as advanced diagnostics.

Effectively managing the process of tracking future technology developments and innovations is a core element of asset class planning. Staying informed about technological advancements works towards promotes 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 can significantly enhance their performance and maintenance. For technology and innovation.

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.
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.

Table 10: Future activities

7. Proposed Program of Work

7.1. Approach

7.1.1. Risk

AusNet's asset management decisions within the transmission network are guided by a risk-based approach, ensuring alignment with our organisational risk appetite. For secondary systems, risk treatment required to achieve this over time involves replacement & maintenance activities. Justification for these projects are developed based on current risk and extrapolated risk.

The risk of each asset is calculated as the product of Probably of Failure (PoF) of the asset and the Consequence of Failure (CoF). This risk is then extrapolated into the future accounting for forecast changes in PoF and CoF.

AusNet's approach to asset risk management is detailed in REF: AMS 01-09 Asset Risk Assessment Overview.

7.1.2. Asset Quantification Methods

7.1.2.1. Probability of Failure

The PoF forecasts for secondary systems are calculated using Weibull distribution. The asset age and failure notifications are analysed using the Weibull distribution to models that determine the PoF for the remaining life of the asset.

7.1.2.2. Consequence of Failure

AusNet assigns a monetised value to CoF which provides an economic basis of calculating potential consequence.

The COF for protection and control assets is assessed through three key lenses: Customer / Market Impact, safety and financial impact. These lenses provide a structured view of the potential impacts resulting in equipment failure or wider network outages.

CONSEQUENCE LENSES	DESCRIPTION
Safety	Threat to health and safety of the public and employees
Customer / Market	Loss of Supply to Customer Impact on energy market
Financial impact	Asset replacement costs Emergency response

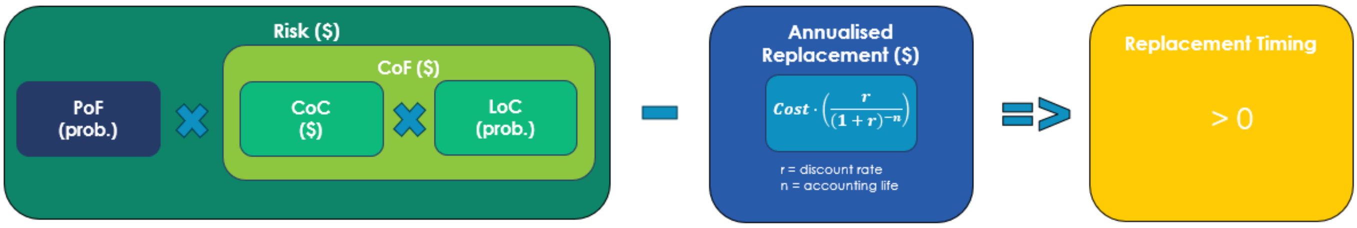
Table 11: Consequence lens description

7.2. Economic Viability

7.2.1. Protection and Control Economic Model

Asset Managers use the calculated risk based on PoF and CoF outputs to identify optimal intervention years, balancing technical feasibility with economic efficiency. These outputs are incorporated into an economic model. The economic model demonstrates the year when the calculated annualised risk is higher than the annualised replacement cost, and as such when the asset becomes economically viable to replace. The concept is shown below.

The economic model is producing a structured approach for each asset in the fleet. The economic model for the justified replacement program is available in asset class economic model REF: ANT – TRR 2028-32 Asset Replacement Economic Model – Transmission Secondary Systems



7.3. Engineering Validation

Following the generation of economic models and asset Weibull models, a structured validation process is undertaken by Senior subject matter experts. This step allows model outputs to be interpreted within the broader context of engineering intervention options, operational experience, and current asset condition knowledge.

SMEs assess whether the asset replacement or refurbishment or change in maintenance regime or no action are reasonably practicable choices. This involves verifying condition data, evaluating operational priorities, and considering strategic timing of interventions. Where appropriate, SMEs may recommend alternative actions based on their professional assessment.

This validation process complements the use of economic model. It supports a balanced and accountable approach to asset management, one that upholds technical integrity while remaining responsive to operational realities.

7.4. Proposed Program

The proposed replacement program of works is developed based on the finding in the economic model and key protection and control assets are picked for replacements that are end of life, already exceeded their life span, have no manufacturer support, have spares limitations to maintain the fleet. We prioritise proactive replacement across different asset categories.

7.4.1. Replacement Strategy

The proposed program allows for targeted, proactive and economic replacement of poor condition, high risk protection and control systems under the following activity categories, consistent with legislation and regulatory requirements to minimise the primary equipment shutdown times due to failure of the protection asset.

The prerequisites for replacing assets:

CRITERIA	DESCRIPTION
Cost-Benefit Justification	Long-term cost savings through reduced maintenance and improved energy efficiency. Avoidance of reactive replacement costs during emergency failures.
Risk Mitigation	Proactive replacement to avoid catastrophic failure or unplanned outages. Supports business continuity and asset management strategy.
End-of-Life (EOL) Status	The asset has reached or exceeded its expected service life. Manufacturer has declared the product EOL, increasing operational risk.

Asset Obsolescence and spares management	The existing equipment is no longer supported by the manufacturer. Spare parts are difficult to source or unavailable. Firmware/software updates are discontinued.
Reliability Concerns	Increased frequency of failures or faults. Historical data shows declining performance or increased maintenance needs

Table 12: Criteria for replacement program

7.4.2. Protection & Control Relays

The replacement program is strategically designed to enhance protection capabilities by addressing performance limitations, operational risks associated with aging and obsolete systems, and safety concerns for both personnel and equipment. A key objective is to free up spare components to support the broader fleet and minimise the requirement of more frequent maintenance on these devices. Many of the obsolete relays currently in service suffer from restricted event logging, limited diagnostic functionality, and declining reliability. Their outdated technology, combined with a lack of available spares and diminishing workforce familiarity, reinforces the urgency for their replacement. The program prioritises the upgrade of these legacy devices including line, transformer, capacitor bank, and bus protection relays with modern, standards-compliant solutions that offer advanced fault detection, remote access, and seamless integration with digital substation architectures.

Table 13outlines the high-risk and poor-health protection relays identified for upgrade as part of the replacement program. The following key obsolete and deteriorated protection assets are proposed for replacement:

- **Line Protection**: Replacement of high-risk and poor-health relays (P543, P544, P546, SEL 321, 7SA522, LFZP112) with advanced line differential protection systems.
- **Transformer Protection**: Replacement of electromechanical and early-generation microprocessor-based relays (Duo_Bias_M, DAD_N, SEL 387, RADSB, CDG14) to enhance reliability and performance.
- **220kV Capacitor Bank Protection**: Upgrade of static-electronic and first-generation microprocessor-based relays (REF 541, REF 545, SPAJ140, SPAJ160C) to meet current protection standards.
- **CB controls / Breaker Failure Protection**: Replacement of obsolete single breaker failure relays (P143) and local CB controls (T2E) with modern equivalents for CB management to maintain full X and Y redundancy.

PROTECTION RELAYS	QTY	LOCATION
Line Protection	29	220kV CBTS-TBTS-1,2, 220kV DDTS-GNTS-1,3, 220kV DDTS-MBTS-1,2, 220kV HWPS-ROTS-1,2.
Transformer Protection	18	BETS: B3, B4 TR, CBTS: B1& B2 TR, KGTS: B1, B2 and B3 TR, RWTS: B2 TR, TSTS: B2 TR.
Bus Protection	4	BETS: 220kV No 1, 2 Bus
Cap Bank Protection	16	RCTS: 220kV 1 & 2 Cap bank, RWTS: 220kV 2 Cap bank,
Circuit Breaker Protection	23	BETS: 220kV B2, B3 TR, CBTS: 220kV CBTS-TBTS-1,2 line, DDTS: 220kV DDTS-GNTS-3 line, GNTS: 220kV DDTS-GNTS-3 line, KGTS: 220kV B1 and B2 TR, BETS-KGTS line, MBTS: 220kV DDTS-MBTS-1,2 line, RWTS: 220kV B1, B2 TR

Table 13: Protection & Control Relays Replacement Program

In addition, these relay types are proposed as part of protection scheme upgrade along with primary plant in Major Stations replacement scope at BATS, DDTS, KTS, MWTS, NPSD, SMTS and TTS sites as it provides the best window to upgrade protection system during major station rebuilds minimising the need of shutting down the primary plant for protection replacement.

7.4.3. Remote terminal Units

The RTU Replacement Program aimed at modernising legacy RTU across the transmission network. The focus is on replacing ageing [C.I.C]RTUs with newer, more capable platforms that align with the organisation's Product Roadmap and long-term asset strategy. Both [C.I.C]consistently rank low due to End-of-life status and lack of vendor support, limited diagnostic and remote management capabilities. The organisation's Product Roadmap outlines a transition to a standardised RTU platform that supports:

- IEC 61850 and DNP3 protocols
- Enhanced cybersecurity features (e.g., secure boot, encrypted comms)
- Remote firmware updates and diagnostics
- Scalable architecture for future automation and analytics

Both [C.I.C] RTUs will be strategically replaced to maintain enough spares and network reliability while transitioning two new fleet. Following sites are considered for replacement of these RTUs in the replacement program.

RTU TYPE	QTY	LOCATION
[C.I.C]	3	GNTS, HOTS, MWTS
[C.I.C]	8	BATS, GNTS, GTS, HOTS, MWTS, RWTS, TGTS and WOTS

Table 14: RTU Replacement Program

7.4.4. Weather monitoring stations

The program focuses on replacing ageing obsolete weather stations specifically those installed more than 40 years ago, to facilitate continued reliability, data accuracy, and compliance with safety and operational standards. Many existing weather stations have exceeded their expected service life. Weather stations at following location will be replaced in this program.

WEATHER STATION TYPE	QTY	LOCATION
Overhead lines (for line monitoring)	5	BETS-SHTS, HWPS-ROTS, YPS-ROTS.
Terminal Stations (For environmental status)	16	BATS, BETS, DDTS, GNTS, GTS, HWTS, HYTS, KTS, MBTS, MLTS, RCTS, ROTS, SVTS, WOTS, YPS.

Table 15: Weather stations Replacement Program

8. Asset Strategies

8.1. New Assets

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

Table 16: New asset targeted activities

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 support 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 02-01-02 and the SPP 02-00-01 suite of documents
02	Maintain PGI 02-01-02 and SPP 02-00-01 suit of documents consistent with AMS 01-09
03	Increase inspection frequency for aging units to reduce unexpected failures.

Table 17: Asset maintenance targeted activities

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 facilitate 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 support ongoing maintainability of in-service devices
02	Maintain decommissioned assets in appropriate working condition as spares, as required to support 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

Table 18: Asset spares targeted activities

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 supports 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
02	Prioritise proactive replacement of: 1. High risk 220kV line protection systems incorporating obsolete and/or poor condition static-electronic and first-generation microprocessor-based distance protection relays REF543, REF5445, SEL321, 7SA522, LFZR, LFZP 2. High risk transformer protection relays Duo_Bias_M, RET521and REB551 incorporating obsolete and/or poor condition electromechanical, static-electronic and first-generation micro-processor-based transformer protection relays 3. High risk single circuit breaker failure protection relays P143 and replace them with redundant X and Y current standards 4. Capacitor bank protection schemes incorporating obsolete ABB REX521, REX541, REX543 and REF545 relays 5. Obsolete, high risk T2E and TAPCON240 type voltage regulation relays 6. Obsolete and unreliable Foxboro RTU-50 and SCD5200 type remote terminal units 7. Obsolete weather stations already exceeded their design life for better and reliable forecasting.

Table 19: Asset replacement targeted activities

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 establishes 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 [C.I.C] and [C.I.C] and [C.I.C] relays which are already obsolete with limited or no manufacturer support
02	Continue to evaluate process bus applications
03	Continue to refine line protection communication requirements in response to evolving technologies
04	Investigate opportunities and strategies for integrating non-conventional instrument transformers
05	Investigate ways to improve primary asset monitoring and maintenance using existing secondary infrastructure
06	Using DIC connection to provide both remote engineering support and SCADA communication instead of serial connection with SCIMS

Table 20: Research and development targeted activities

9. Resource References

NO.	DOCUMENT TITLE
1	Station Design Manual
2	AMS 01-05 Strategic Asset Management Plan
3	Asset Risk Assessment Overview
4	Electricity Transmission Network Asset Management Strategy
5	Summary of Maintenance Intervals – Transmission Plant Guidance and Information
6	General Requirements SECONDARY PRACTICE AND PROCEDURE
7	Electricity Safety Act 1998
8	National Electricity Rule

10. Schedule of Revisions

ISSUE NUMBER	DATE	DESCRIPTION	AUTHOR	APPROVED BY
5	22/11/06	Editorial review	[C.I.C]	[C.I.C]
6	02/02/07	Review and Update	[C.I.C]	[C.I.C]
7	17/03/07	Editorial review	[C.I.C]	[C.I.C]
7.1	30/09/12	Combined Protection, Control & Automation Assets into one strategy	[C.I.C]	[C.I.C]
8	26/11/12	Editorial review	[C.I.C]	[C.I.C]
9	03/07/15	Review and Update	[C.I.C]	[C.I.C]
10	01/06/20	Review and Update	[C.I.C]	[C.I.C]
11	30/09/2025	Review and Update	[C.I.C]	[C.I.C]

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