Asset Management Plan
Protection Relays

Part of the Energy Queensland Group

Executive Summary

This Asset Management Plan (AMP) covers the class of assets known as Protection Relays, which falls in the category of Field Devices.

Protection relays are designed to trip circuit breakers in response to network faults or abnormal network conditions to prevent or minimise damage to plant and equipment, and play a significant role in protecting staff and the public during these events. EQL manages approximately 25,000 protection relays comprising of approximately 7,900 units in the Ergon Region (Ergon Energy) and approximately 17,400 units in Energex Region (Energex). Protection relays are relatively low-cost assets which are typically managed on a site-by-site basis using periodic inspection and maintenance for condition and serviceability, and through systemic review of age, failures, and defects. Protection relays used by EQL are classified differently depending on the type of technology used in the relay. The different technology types include:

- Electromechanical
- Static or Analogue
- Microprocessor

Electromechanical relays are considered robust with the longest life expectancy, but they have limited functionality, reduced level of spares and do not have self-diagnostics capability to initiate alarms to report their failed or defective condition.

Static or Analogue relays have improved functionality compared to electromechanical relays, but they also lack spares and self-diagnostics capability.

Microprocessor relays are not only the most procured type of relay due to their availability and multi-functionality, but they have the highest normalised failure rate and therefore expected to have a significant impact on the future replacement strategy of protection relays. With their expected operational life being less than half of electromechanical relays, it is expected that there will be many microprocessor relay replacements in the upcoming AER period.

Protection relays play a significant role in keeping the network safe and reliable. Failure of these assets can lead to catastrophic consequences such as major damage to primary assets e.g., transformers. EQL employs the following measures to ensure protection relays are reliable and operational:

- Maintain updated asset registers of all protection relays.
- Conduct site audits as required to validate and improve protection relay data.
- Monitor and report protection relay failures and defects monthly.
- Plan and if required, adjust maintenance cycles in the PoW.
- Analyse relay failures and defects to determine high risk relays for replacement.
- Manage relay spares, including strategic spares.

Revision History

Revision date	Version number	Description of change/revision
31/01/2019	1	Document Initial release
27/11/2023	2	Updated release

Document Approvals

Position title	Date
General Manager Asset Maintenance	Jan 2024
Chief Engineer	Jan 2024

Stakeholders / Endorsements

Title	Role
Manager Asset Strategy	Endorse
Manager Secondary Plant and Auxiliary Systems	Endorse

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1 Introduction

Energy Queensland Limited (EQL) was formed on 1 July 2016 and holds Distribution Licences for the following regions:

- Energex Region (Legacy organisation: Energex Limited); and
- Ergon Region (Legacy organisation: Ergon Energy Corporation Limited).

Energy Queensland is committed to maximising value from its assets for the benefits of its customers, stakeholders, and the communities in which it operates. In line with our corporate vision and purpose, EQL will look to safely deliver secure, affordable, and sustainable energy solutions to its communities and customers by optimally managing its assets throughout life cycle.

There are variations between the EQL regions as a result of geographic influences, market operation influences and legacy organisation management practices. This Asset Management Plan (AMP) reflects the current practices and strategies for all assets managed by EQL, recognising the differences that have arisen due to legacy organisation management. These variations are expected to diminish over time with integration of asset management practices.

1.1 Purpose

EQL has shaped the strategic planning approach to consider what we need to do deliver financial sustainability whilst balancing our ability to transform in an environment of significant market disruption and increased competition as we evolve towards an ‘electric life’ and renewable targets as described in Queensland Energy and Jobs Plan (QEJP).

The purpose of this document is to demonstrate the responsible and sustainable management of protection relays on the EQL network. The objectives of this plan are to:

1. Deliver customer outcomes to the required level of service.
2. Demonstrate alignment of asset management practices with EQL’s Strategic Asset Management Plan and business objectives.
3. Demonstrate compliance to regulatory requirements.
4. Manage the risk associated with operating the assets over their lifespan.
5. Optimise the value EQL derives from the asset class.

This AMP will be updated periodically to ensure it remains current and relevant to the organisation and its strategic objectives. Full revision of the plan will be completed every five years as a minimum.

This AMP is guided by the following legislation, regulations, rules, and codes:

- *Electricity Act 2002 (Qld)*
- *National Electricity Rules (NER)*
- *Electrical Safety Act 2002 (Qld)*
- *Electrical Safety Regulation 2013 (Qld)*
- *Queensland Electrical Safety Code of Practice 2010 – Works (ESCOP).*
- *Work Health & Safety Act 2014 (Qld)*

- *Work Health & Safety Regulation 2011 (Qld)*
- Ergon Energy Corporation Limited Distribution Authority No D01/99.
- Energex Limited Distribution Authority No. D07/98.

This AMP forms part of EQL's strategic asset management documentation as shown in Figure 1. It is part of a suite of Asset Management Plans, which collectively describe EQL's approach to the lifecycle management of the various assets which make up the network used to deliver electricity to its customers. Appendix 1 contains references to other documents relevant to the management of the asset class covered in this plan.

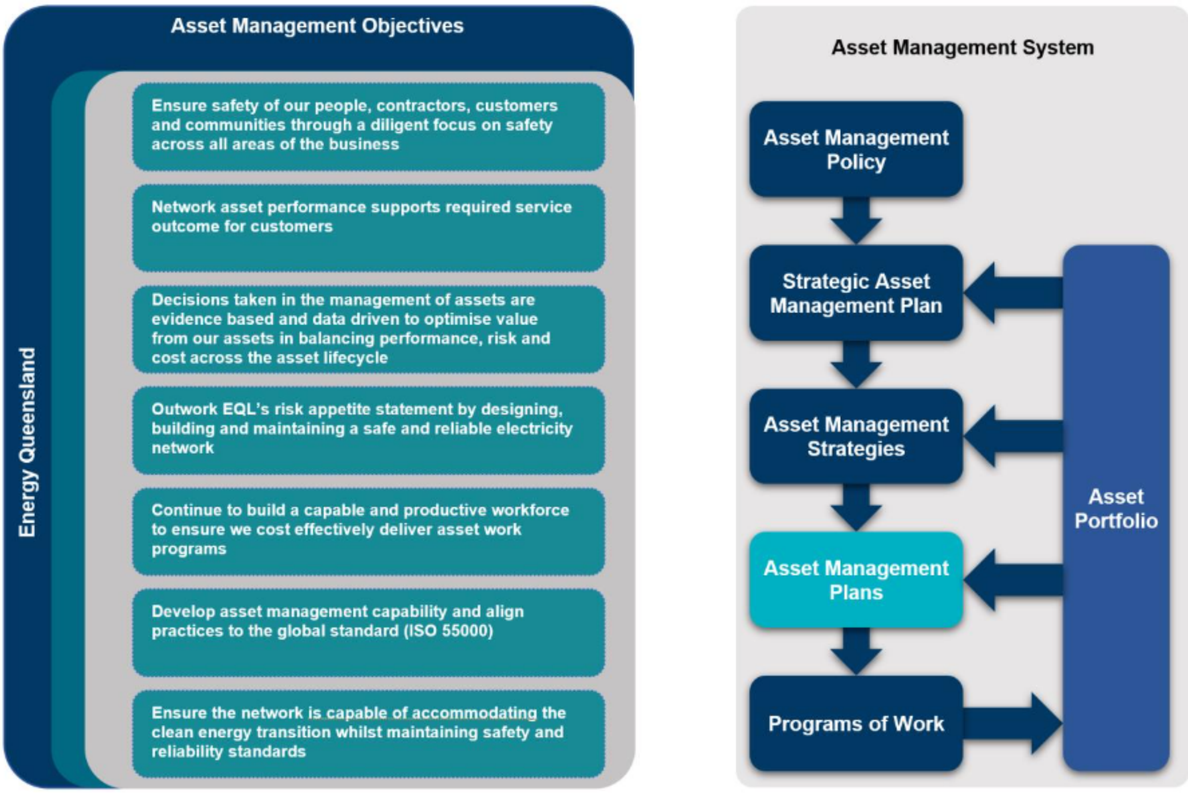


Figure 1: EQL Asset Management System

1.2 Scope

This AMP covers all protection relays within the EQL electricity network and associated maintenance programs for the 2025-2030 period for the three technology types below:

- Electromechanical
- Static or Analogue
- Microprocessor.

This report does not include items which are inherent components of other plant items (e.g., temperature indicators for transformers), and control relays closely related to telecommunications and Supervisory Control and Data Acquisition (SCADA) plant. Additionally, the electrical wiring and housing apparatus that include protection relays are not covered in this report.

Many customers, typically those with high voltage connections, own and manage their own protection relays and switchboards. EQL does not provide condition and maintenance services for third party assets, except as an unregulated independent service. This AMP relates to EQL owned assets only and excludes any consideration of such commercial services.

1.3 Total Current Replacement Cost

Protection relays fall under the asset class of field devices. Assets of the field device class are generally high-volume, low-cost assets and are typically asset managed on a population basis using periodic inspection for condition and serviceability as well as systemic review of performance records.

Based upon asset quantities and replacement costs, EQL field devices, of which protection relays contributes towards, has a replacement value in the order of $2.97 billion This valuation is the gross replacement cost of the assets, based on the cost of replacement of modern equivalents, without asset optimisation or age assigned depreciation.

Figure 2 provides an indication and comparison of the relative financial value of a variety of EQL Assets.

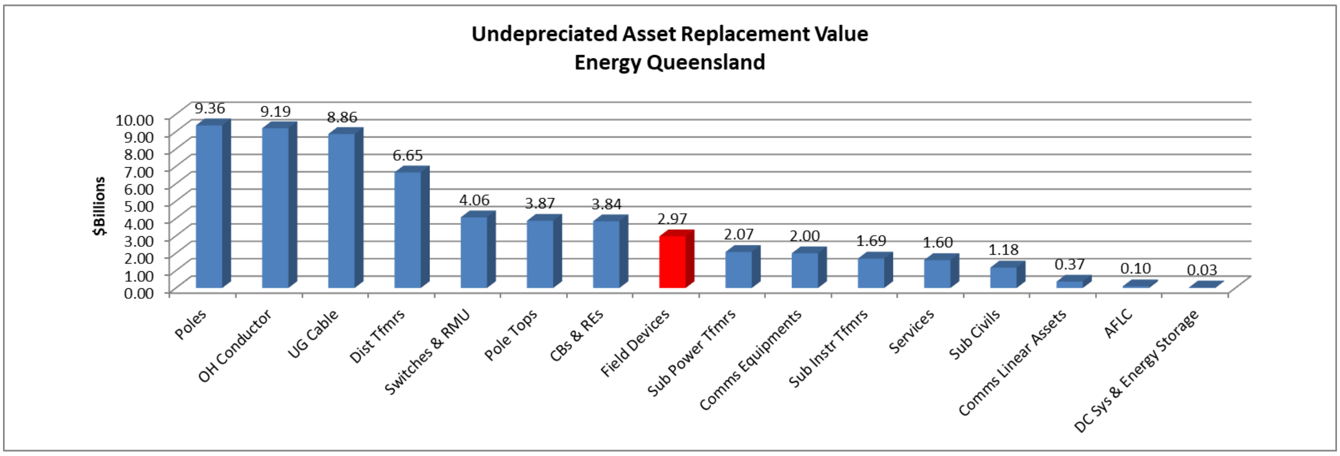


Figure 2: EQL Total Current Asset Replacement Cost Function and Strategic Alignment

The function of a protection relay is to protect plant and equipment by isolating them from, or eliminating, any fault that it is designed to detect. There are many different types of protection relays, each created for certain protection functionalities which target specific abnormal situations or faults that may occur within the network.

The problems that these devices typically detect are deviations of current or voltage that may be damaging to the health or stability of the electric network. When a fault that is beyond the limit set by a user is found, the relay will send a signal to circuit breaking equipment, causing them to operate. This procedure contributes to a significant reduction in harm to personnel and/or equipment.

Table 1 details how the asset lifecycle management of protection relays contributes to the corporate strategic asset management objectives.

Asset Management Objectives	Relationship of Asset to Asset Management Objectives
Ensure network safety for staff, contractors, and the community	Diligent and consistent maintenance and operations support asset performance and hence safety for all stakeholders
Meet customer and stakeholder expectations	Continued asset serviceability supports network reliability and promotes delivery of a standard quality electrical energy service.
Manage risk, performance standards and asset investment to deliver balanced commercial outcomes	Failure of this asset can result in increased public safety risk and disruption of the electricity network. Asset longevity assists in minimising capital and operational expenditure.
Develop Asset Management capability and align practices to the global ISO55000 standard	This AMP is consistent with ISO55000 objectives and drives asset management capability by promoting a continuous improvement environment
Modernise the network and facilitate access to innovative energy technologies	This AMP promotes the replacement of assets at end of economic life as necessary to suit modern standards and requirements

Table 1: Asset Function and Strategic Alignment

1.4 Owners and stakeholders

The ubiquitous nature of the electrical network means that there are a large number of stakeholders that influence or are affected by operation and performance of EQL's electrical network. Table 2: Owners and Stakeholders lists some of the influential stakeholders that have impacted the strategies defined by this AMP.

Responsible Party	Role
Queensland Government	Development of legislative framework and environment for operation of EQL in Queensland. Development of EQL Distribution Authorities.
Queensland Government as sole shareholder of EQL	Owner of company shares, holding equity in EQL and gaining benefits from EQL financial success.
EQL Board of Directors	Corporate direction, operation, and performance of EQL and its subsidiaries, in compliance with corporate and Queensland law.
Chief Financial officer	Company Asset Owner – ensuring all EQL investments are consistent with EQL corporate objectives with balanced commercial outcomes.
Chief Operating Officer	Overall operational control of EQL networks including maintenance and operation, and execution of project works
Chief Engineer	Overall strategic control of EQL assets, including asset population performance, risk, and financial management.
All employees and contractors of Energy Queensland Limited	Performing all duties as required to achieve EQL corporate objectives.
All unions that are party to the EQL Union Collective Agreement	Promotion of safe and fair working conditions for all EQL and subsidiary company employees.

Queensland Electrical Safety Office	Regulatory overview and control of electrical safety in Queensland.
Australian Energy Regulator	Regulatory overview and control of economic performance of EQL under its Distribution Authorities to promote the long-term interests of all electrical network customers connected to the National Electricity Market.
Powerlink	Queensland Transmission Network Service Provider. Owner and operator of many 110kV to 330kV transmission grid assets and 74 bulk supply substations that connect and deliver energy to EQL networks.
All consumers, prosumers and generators connecting to the Energy Queensland network	Operating within the electrical technical boundaries defined by legislation, regulation, and connection agreements.
All communities and businesses connected to the Energy Queensland network.	Economic prosperity of Queensland.

Table 2: Owners and Stakeholders

2 Asset Class Information

The following sections provide a summary of the key functions and attributes of protection relays covered in this AMP.

2.1 Asset Description

Protection relays exist to protect important assets and infrastructure on the network by detecting faults or abnormal conditions and sending a triggering response to circuit breaking equipment. These devices vary in their core function, offering schemes such as overcurrent and differential detection, as well as their physical and electrical properties.

Protection relays are categorised into three separate groups based on their technology type as described below. These categories are based on how units are constructed and also give an indication of expected lifespan of the asset, as the unique components within each type have differing degradation characteristics.

Based on industry best practice and past observations, below are the associated life expectancies of the different relay types:

- Electromechanical relays – 45 years
- Static or Analogue relays – 25 years
- Microprocessor relays – 20 years.

2.1.1 Electromechanical Relays

Electromechanical relays are considered first generation protection devices installed on power systems and operate via physical phenomena such as magnetic induction; and are often identified by the fact that their functionality is implemented by components that physically move in operation.

These relays typically do not contain electronic components or DC power supplies. Typically, they consist of turning discs, current and/or voltage coils, attracted armature output relays and mechanical dials to achieve the desired settings.

Electromechanical relays were the earliest model type to be installed within EQL’s network and are considered highly reliable as evident from their historical performance. EQL continues to purchase a small number of electromechanical auxiliary relays for use as follower relays and CB tripping.

2.1.2 Analogue or Static Relays

Static/analogue relays have been typically installed since the mid-1970s. Electronically controlled with no moving parts except for attracted armature output relays, this type of relay offered improved accuracy, faster operation and quicker resetting times compared to electromechanical relays. These relays typically utilise analogue electronics circuitry to measure and compare currents and voltages, establish timing, and generate outputs for their protection functions. As such, they have PCBs featuring power supplies, transistors, small to medium scale integrated circuits along with other electronic components that electromechanical relays do not have. Often static relays feature analogue dials on their front faceplate to set and display relay settings. Analogue/Static relays may be capable of performing some binary logic but do not have inbuilt microprocessors or numerical processing capability and typically do not have self-diagnostics capability.

2.1.3 Microprocessor Relays

Microprocessor relays are the latest generation of relays installed since the early 1990s. They are predominantly identified by their microcontroller component and intelligent auxiliary functions. These relays typically operate by digitising and interpreting input signals from instrument transformers and other devices via the microcontroller and perform calculations digitally.

These relays require power supplies to operate and have a self-diagnosing health indicator capable of generating alarms as necessary. Additionally, these devices have more complex PCBs than their analogue counterparts.

Currently, microprocessor relays are the most popular type of AC Relay in the EQL network due to their high accuracy, fast response, availability, flexibility, repeatable performance, and additional functions which contribute towards safe and secure network operation.

2.2 Asset Quantity in DNSP by Technology type

EQL currently has over 25,000 protection relays in-service within its network. The breakdown of the different types of technologies for each DNSP is shown in Table 3.

Asset Type	Ergon	Energex	Total
Electromechanical	2989	4443	7432
Static or Analogue	971	1602	2573
Microprocessor	3946	11429	15375
Total	7906	17474	25380

Table 3: Asset Quantities across EQL

2.3 Asset Age Distribution

Because of the widely varying components and physical constructions that each technology type covers, the age distribution, failure modes and life expectancy of these relay types also vary significantly, impacting the associated asset management methodology for each technology type.

Below is a discussion on each classification and age profiles to detail the distinct age differences between the relay model categories. Age distribution is for in-service relays only and has been estimated where data gaps exist, however, there are many relays with unknown installation year, year of manufacture or technology type.

Age thresh holds in section 2.1 are applied to graphs below for each technology type as shaded areas which indicate the volume and age of relays exceeding age thresholds.

2.3.1 Electromechanical Relays

EQL has approximately 7400 electromechanical relays in service inclusive of AC protection relays and auxiliary tripping relays. The age profiles of electromechanical relays for each DNSP are shown in Figures 3 & 4.

While microprocessor relays have increased in numbers significantly over the last 20 years, there is still a large presence of electromechanical relays throughout EQL's network. A significant population of a.c. electromechanical relays remain in the medium voltage distribution network. These relays also have the highest expected operational life compared to their counterparts due to their simple and robust construction. As mentioned above, electromechanical relays are still procured to provide auxiliary tripping functions on new installations, however, there has also been a reduction in the procurement of these relays in recent years as more auxiliary functions are now being integrated in a.c. microprocessor relays. The population of electromechanical relays remains second behind microprocessor relays.

Both DNSPs have a small number of electromechanical relays exceeding the age thresh hold of 45 years, however, the volume of these relays is larger in Ergon compared to Energex. Electromechanical relays are subject to drifts on timing and pick up and therefore require special focus in both Ergon and Energex relay replacement strategies.

Approximate quantities of electromechanical relays currently exceeding 45 years in age are:-

- Energex: 300
- Ergon: 700.

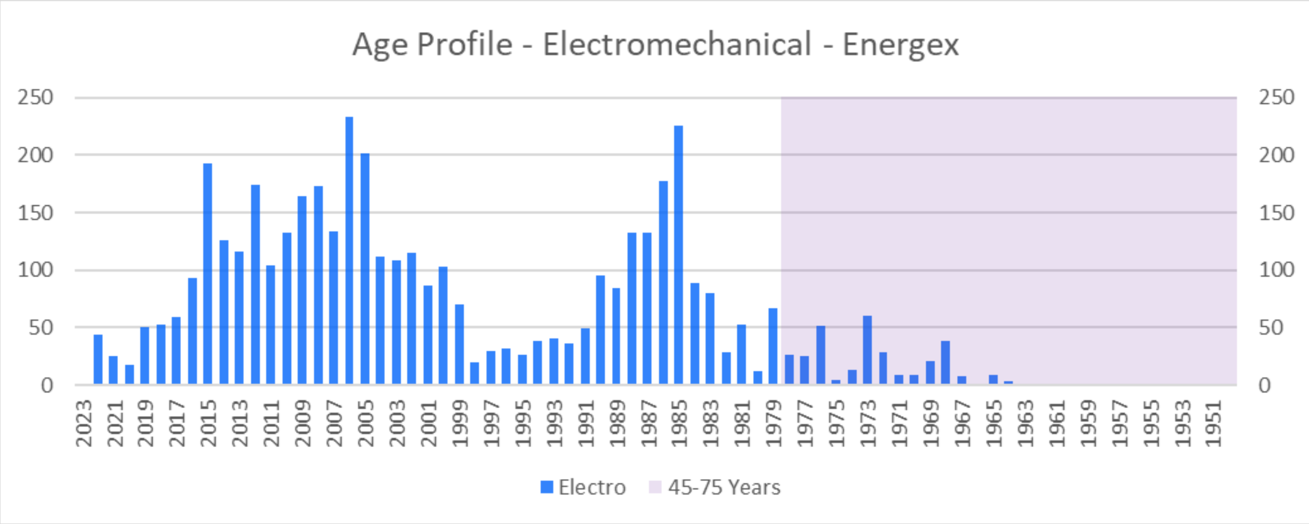


Figure 3: Energex Electromechanical relay age profile

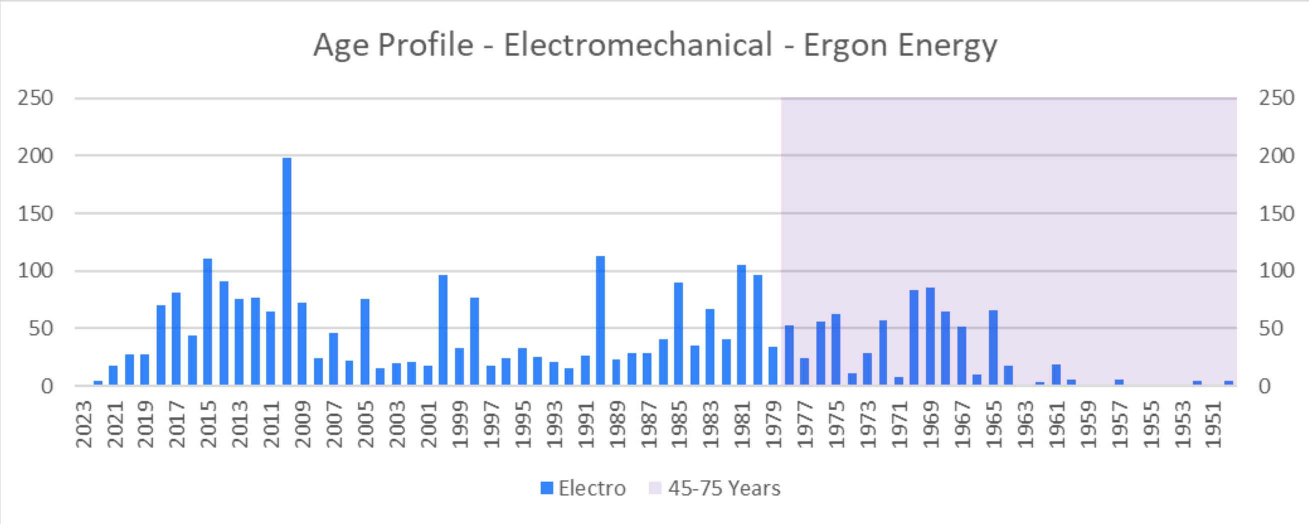


Figure 4: Ergon Electromechanical relay age profile

2.3.2 Static or Analogue Relays

EQL has approximately 2500 static/analogue relays in service with the age profiles as shown in figures 5 & 6. EQL. Energex have a larger and younger fleet of Static or Analogue relays primarily for pilot wire and inter-tripping functions in many underground cable feeders whereas Ergon has a significant population of legacy a.c. Static or Analogue relays, mostly on distribution feeders and a small quantity on transmission feeders.

It should be noted that whilst Energex has a small volume of Static or Analogue relays exceeding age thresh hold, Ergon has a much larger volume which is of concern and requires special focus in Ergon Energy relay replacement strategy.

Approximately quantities of Static or Analogue relays currently exceeding 25 years in age are: -

- Energex: 140
- Ergon: 880.

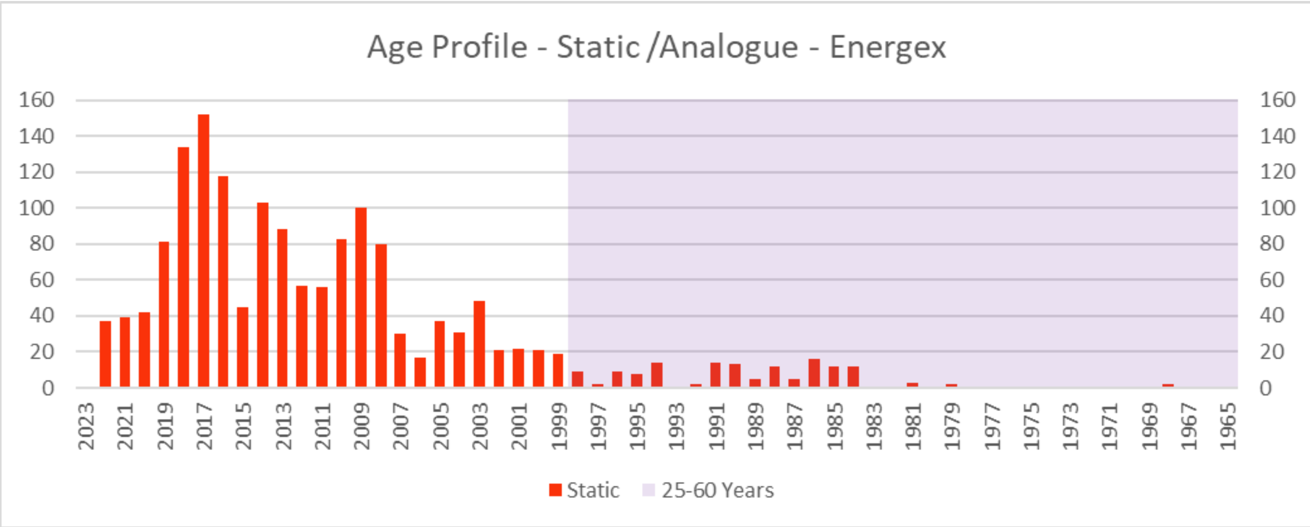
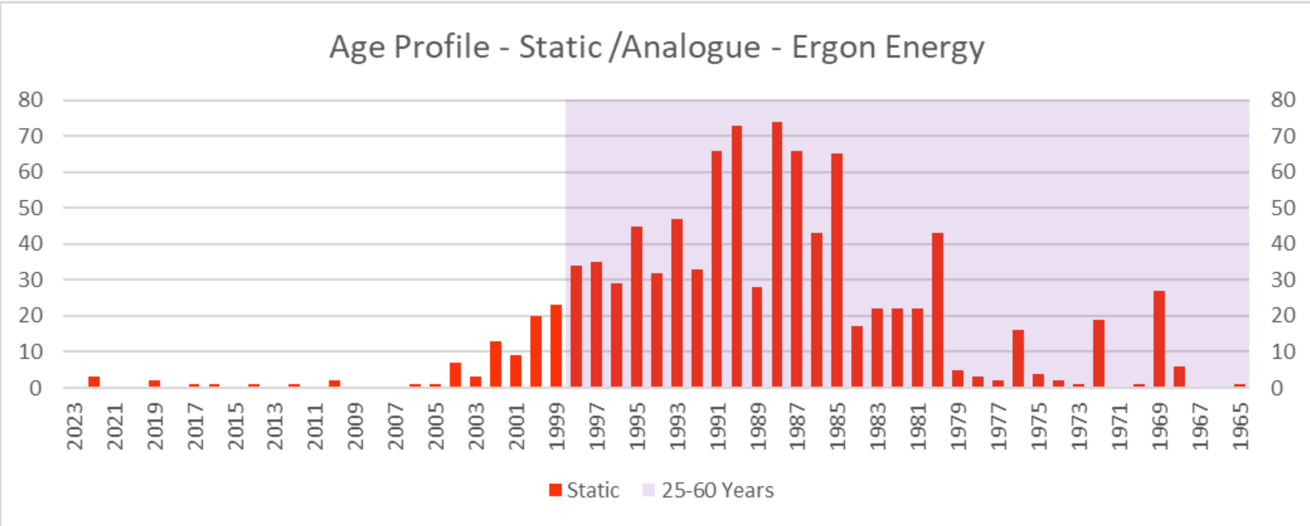


Figure 5: Energex Static or Analogue relay age profile



Note: There are data accuracy issues for older relays in the Ergon graph given Static or Analogue relays were mostly manufactured after mid-1970s

Figure 6: Ergon Static or Analogue age profile

2.3.3 Microprocessor Relays

EQL has approximately 15,000 microprocessor relays in service with the age profiles as shown in figures 7 & 8. Most microprocessor relays were installed within the past 25 years and given they have an expected lifespan of 20 years and their fast-growing population; this is expected to become an emerging issue with an anticipated increase in failures and replacement quantities in the near future. Early generation microprocessor relays were manufactured soon after 1990 and are approaching 30 years, however, majority were manufactured after 2000 and are approaching 20 years in age. There is a growing concern regarding the longevity of microprocessor relays. Based on the graphs below, Energex has installed significantly more microprocessor relays in recent years compared to Ergon and this trend expected to continue in future. This also implies that Ergon needs to accelerate relay replacements in its network.

Energex has a younger population of microprocessor relays with a very small volume of these relays exceeding the age thresh hold. The age profile of Ergon microprocessor relays is spread out with significantly more relays exceeding the age threshold. The early generation microprocessor relays are not only aged, but some models are becoming obsolete or no longer manufactured. *First generation microprocessor relays and relays exceeding the 20 years in age in both Ergon and Energex will also require special focus in EQLs relay replacement strategy. This is a more significant issue in Ergon.*

Approximately quantities of microprocessor relays currently exceeding 20 years in age are:-

- Energex: 450
- Ergon: 920.

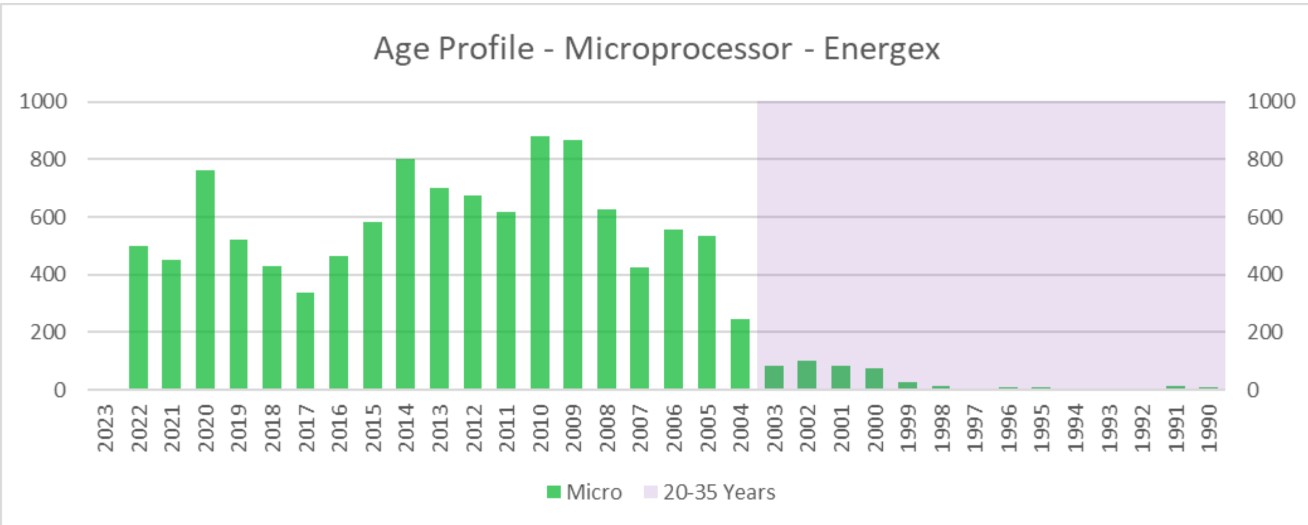


Figure 7: Energex microprocessor relay age profile

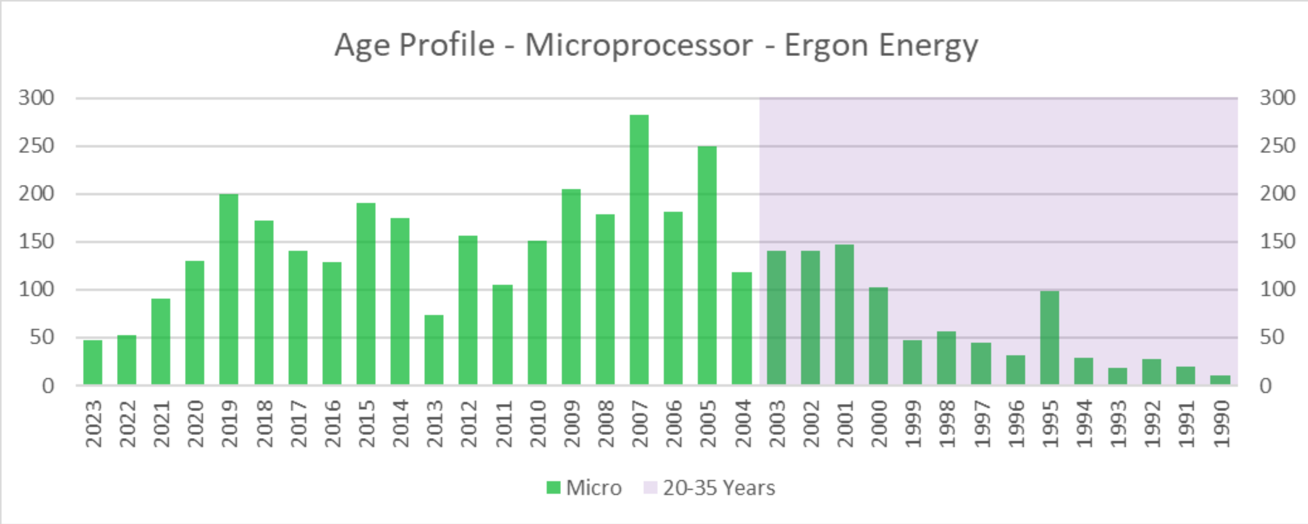


Figure 8: Ergon microprocessor age profile

2.4 Population Profile

The total population of microprocessor relays in each DNSP has been increasing over the last 25 years combined with some reduction in the total population of electromechanical and static/analogue AC relays. It is noted that majority of the relays purchased over the last 25 years were of the microprocessor type. The total population of auxiliary relays may have increased slightly over recent years if more relays have been added via new schemes compared to legacy auxiliary relays replaced by inbuilt functions of new microprocessor relays, however, this is difficult to verify at this stage due to significant gaps in relay data.

Figures 9 & 10 show the population profile of protection relays inclusive of technology types across the Energex and Ergon regions respectively.

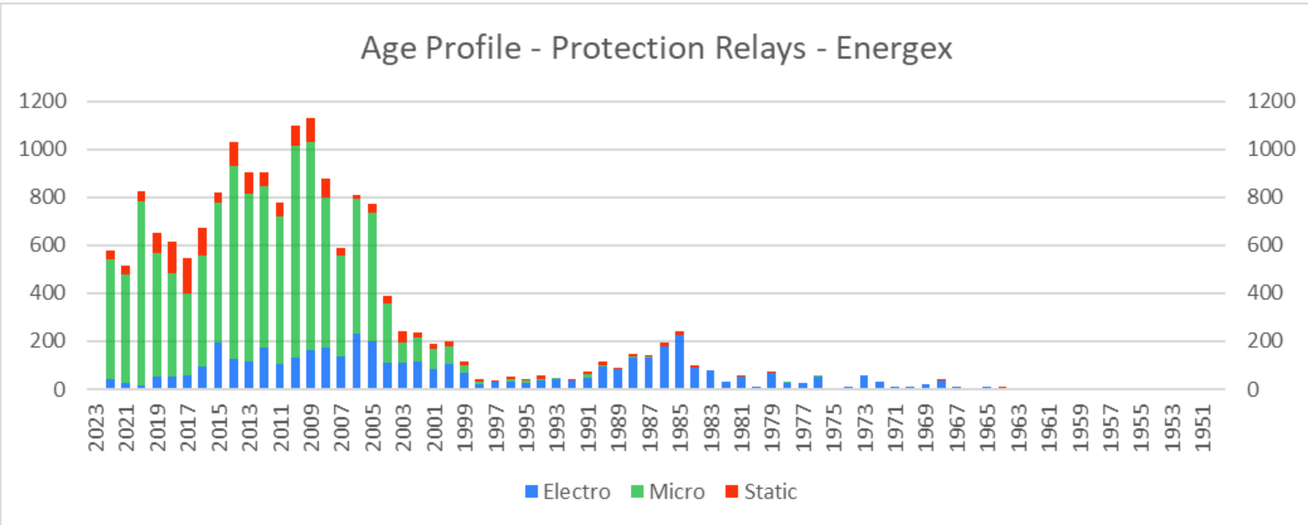


Figure 9: Energex relay age profile by technology type

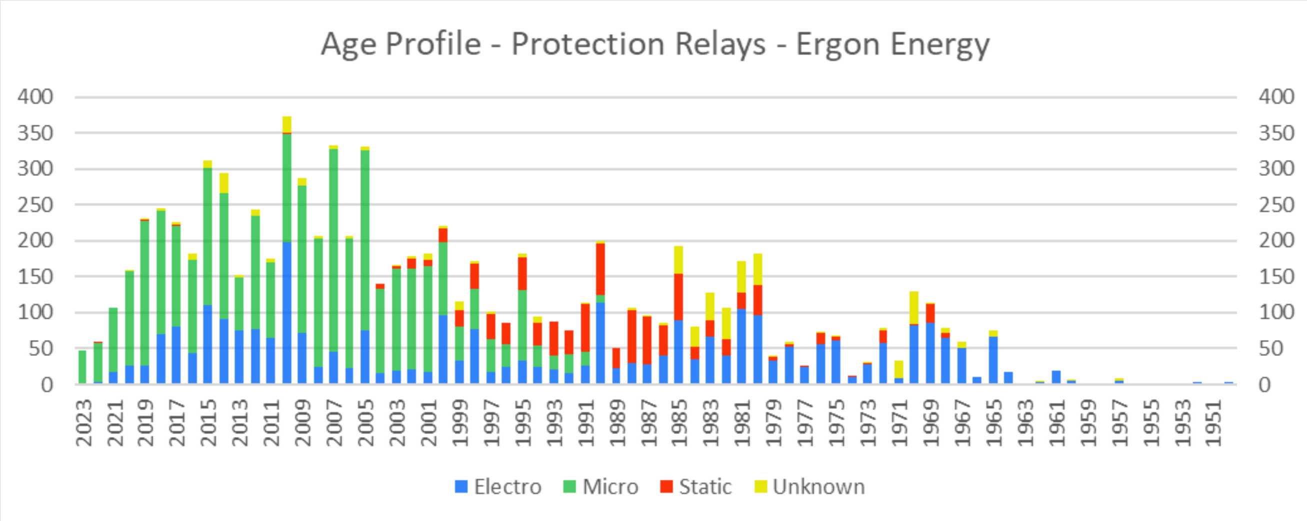


Figure 10: Ergon relay age profile by technology type

2.5 Asset Life Limiting Factors

Table 4 describes the key factors that influence the operational life of protection relays and drivers for replacement/renewal which contributes towards the lifecycle management of protection relays.

Factor	Influence	Impact
Age	Deterioration of asset components over time due to natural processes; mechanical wear, capacitors drying, heat cycling, corrosion, etc.	Gradual decrease in asset performance and reliability, ultimately resulting in device malfunction and failure; potential loss of network protection.
Number of Operations	Deterioration of asset components over time due to mechanical wear of bearings, contacts, attracted armatures, etc	Gradual decrease in asset performance and reliability, ultimately resulting in device malfunction and failure; potential loss of network protection.
Abnormal Weathering or Other External Damage	Deterioration or destruction of asset components due to abnormal atmospheric conditions or third-party, unexpected events.	Increased deterioration or sudden failure of asset performance and reliability.
Obsolescence	From time to time, particular relay models may have firmware upgrades; model upgrades, obsolete software or hardware to communicate with relay. The predecessor relay may no longer be produced and available for purchase.	Due to the inability to purchase obsolescent relays, spares and replacement strategies needs to be revised. Relay models may require proactive replacement and existing in-service population may need to be pulled from service to enter strategic spares inventory. New relay applications required for current contract replacement relays.

Factor	Influence	Impact
Problematic	These relays are known for their inherent problems or failures in-service. They are high risk and unreliable which requires replacement as soon as possible	Use of relays in this category may result in mal operation such as a through fault event. Furthermore, these relays may not operate during a fault scenario within its setting; or operate unnecessarily under normal system conditions.
Network impacts of relay failure	High risk relaying applications such as those on transmission lines, power transformers, busbars, SEF for safety, auto-reclose for reliability	Reduced network safety and reliability if a like for like replacement is not found in time which will then require a defect management plan, protection design and therefore delays. Some relay models in high-risk applications may require proactive replacement.
Manufacturer Defects	Unexpected component defects due to errors within the manufacturing process or the use of poor components identified post installation	Relays may fail earlier than the expected. End of life defects may be detected within the service life via manufacturer notices or asset failure, resulting in the need to replace the relay or consider if the defect or failure warrants action.
Obsolete Firmware/End of Firmware Support	The risk of security and operability of the relay may be increased due to outdated firmware. Some functionalities may not be available with existing firmware.	The relay may be exposed to security breaches or mal-operations. Required protection functionality is unavailable.
Augmentation Requirements	Changing network requirements to accommodate new and emerging applications such as reverse power flow detection, anti-islanding protection, etc	Existing relays may be incompatible with changes in the network and require replacement.
Primary Systems Upgrade	Replacement of primary plant such as circuit breakers, transformers, or even complete switchboards	Existing relays may need to be upgraded to the current protection standard. Additional or replacement functionality may be required as part of this standard.
Secondary Systems Upgrade	Replacement of secondary plant such as batteries or communication systems.	Existing relays may be incompatible with the new technology or standards and require replacement.
Protection Standard	Protection standards evolve and recommend the implementation of different protection schemes.	Existing relays may no longer meet the latest standards and require replacement.
Risk Assessments	Risk assessments performed may identify particular relays to be of high risk of failure.	Particular refurbishment projects may target relays for replacement if they have been identified as at risk.
Replacement Prioritisation Analysis	Particular relays will be identified as being high priority for replacement as a result of the prioritisation analysis system.	As a result of a number of characteristics for a particular relay, it may be flagged as being of a high priority for replacement and removed from service.

Factor	Influence	Impact
Project Bundling	In order to improve project macro-efficiency, specific projects at the same substation location may be bundled in order to reduce time and cost expenditures.	Particular in-service relays may be chosen to have their replacement brought forward to align with the earlier project required by date.
Strategic Spares	Relays in the strategic spares holding are obsolescent. Once strategic spares holding drops below a certain level, stock can no longer be replenished.	In a scenario where a relay fails in-service and there are no spare relays, it is possible the substation may experience loss of customers while design is done on a replacement relay.
Population (and Strategic Spares)	Low population (20 units or less in the network) on its own does not influence the reliability of a relay. However, when taken account with strategic spares holding, it can become critical should there be no spares.	In a scenario where a relay fails in-service and there are no spares, it is possible the substation may experience loss of customers while design is done on a replacement relay.

Table 4: Protection Relay Life Limiting Factors

3 Current and Desired Levels of Service

The in-service failure of protection relays can create temporary shortfalls in the required performance of the electric network, with the potential to impact on service levels. EQL actively manages and maintains the protection relay fleet to ensure that the following are met:

- Safety of personnel, the general public, plant and equipment, public areas, and the environment
- High network reliability through supply quality and security of the network
- Minimised costs through efficient programs and prudent spending.

The following sections define the level of performance required from the asset class, measures used to determine the effectiveness of delivering corporate objectives, and any known or likely future changes in requirements.

3.1 Asset Failures and Defects

Refer to the definitions of failure and defect for this asset class in Appendix 2. Asset failures and defects have been monitored via dashboards for both DNSPs since July 2021 and presented in the graphs below.

3.1.1 Energex relay failure and defects

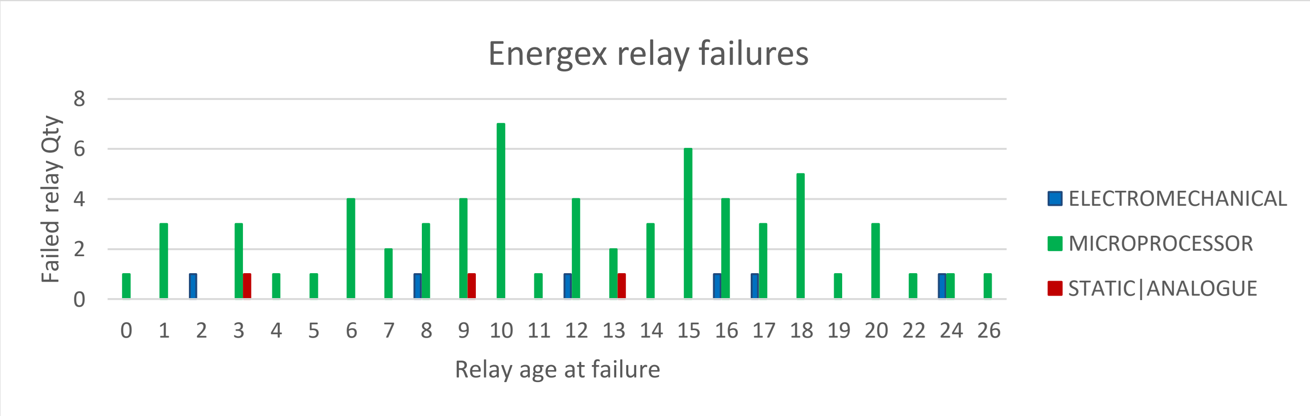


Figure 11: Energex relays failures since July 2021

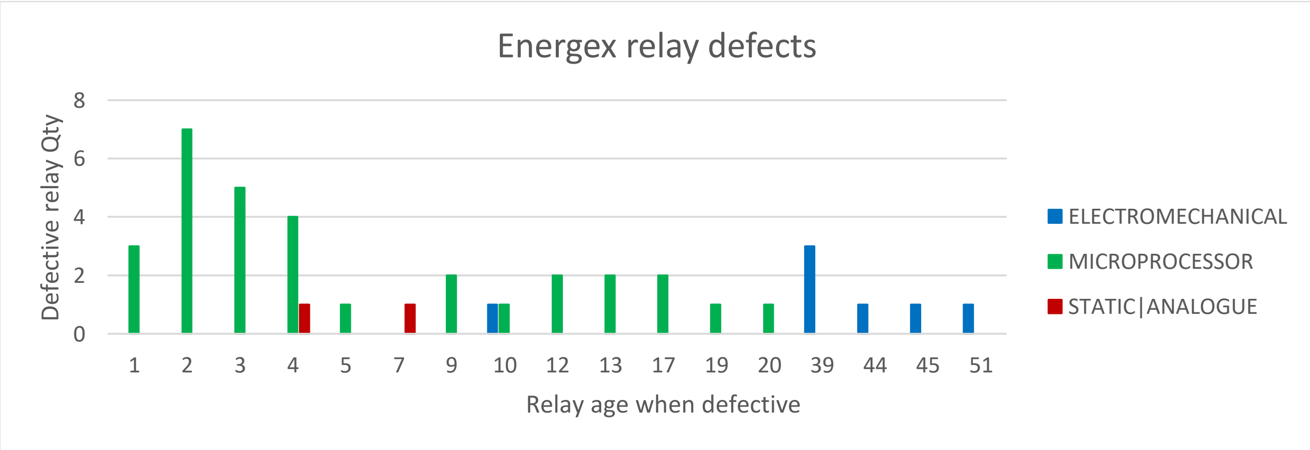


Figure 12: Energex relay defects since July 2021

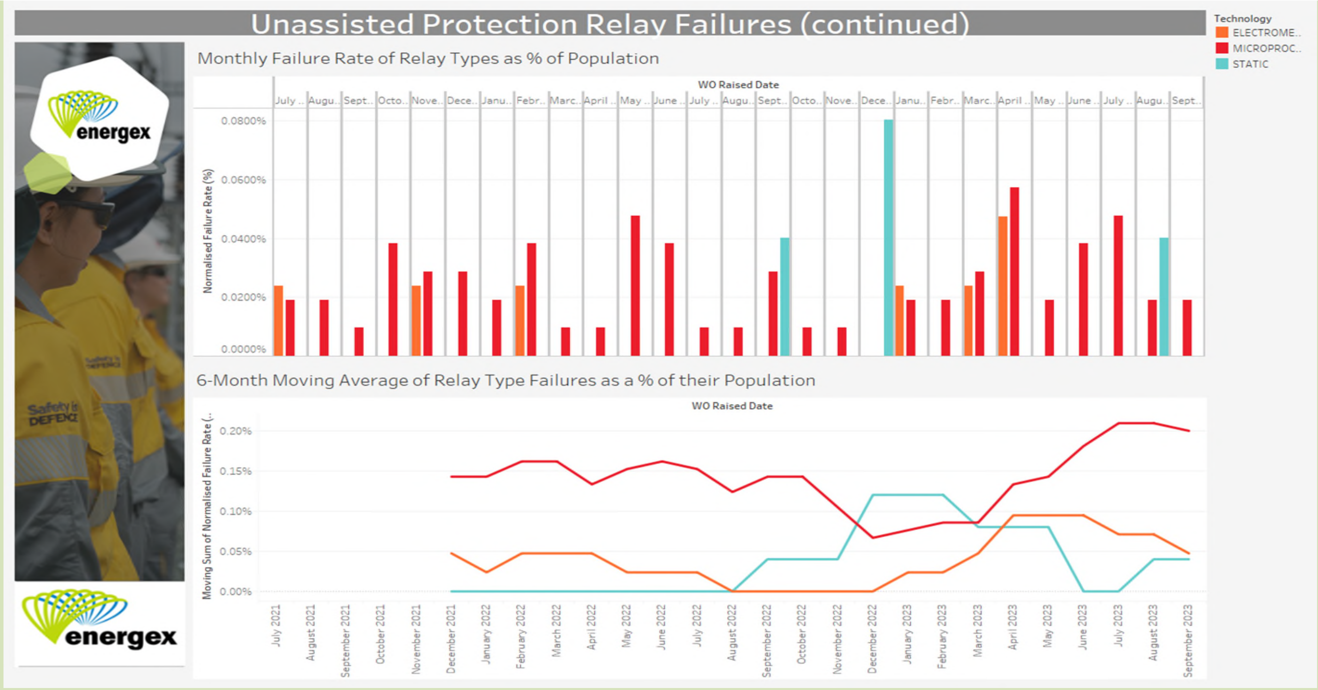


Figure 13: Energex relay dashboard failure trend since July 2021

Figures 11 and 13 show quantities of Energex relay failures and Figure 12 shows defects since July 2021 including the age at which the failure or defect occurred.

The graphs show that although Energex microprocessor relay failures are not significant to be a concern at this stage given their large population base. Failures have occurred under the age of 26 years, with a lower in-service life compared to legacy electromechanical and Static or Analogue relays. Microprocessor relays tend to either operate correctly or fail, a condition which is usually detected via a watchdog alarm contact wired to the SCADA system. A high prevalence of recent defects on microprocessor relays is attributed to issues with DNP communications hardware on a particular make of relays, however, this is expected to be resolved in the near future.

Energex has fewer failed, or defective electromechanical and Static or Analogue relays compared to microprocessor relays with a much lower failure count. Electromechanical and Static or Analogue relays have a longer life expectancy. Like electromechanical relays, static/analogue relays can drift with regards to pick up and timing performance and therefore classified as defective, however unlike electromechanical relays, static relays have the added risk of age-related failures and therefore pose additional risks typically due to the absence of self-health monitoring capability. It is unusual for an electromechanical relay to fail to operate. However, defects and failures on these relays are only detected during maintenance testing or after a protection incident. For this reason, Static or Analogue relays in high-risk applications are considered a higher priority for replacement.

Figure 13 shows a reasonably consistent moving average with higher normalised failure rate for microprocessor relays compared to Electromechanical and Static or Analogue relays albeit a slight increase in recent months. Based on the dashboard data, at this stage, failure rates in Energex for all technology types are low.

3.1.2 Ergon relay failure and defects

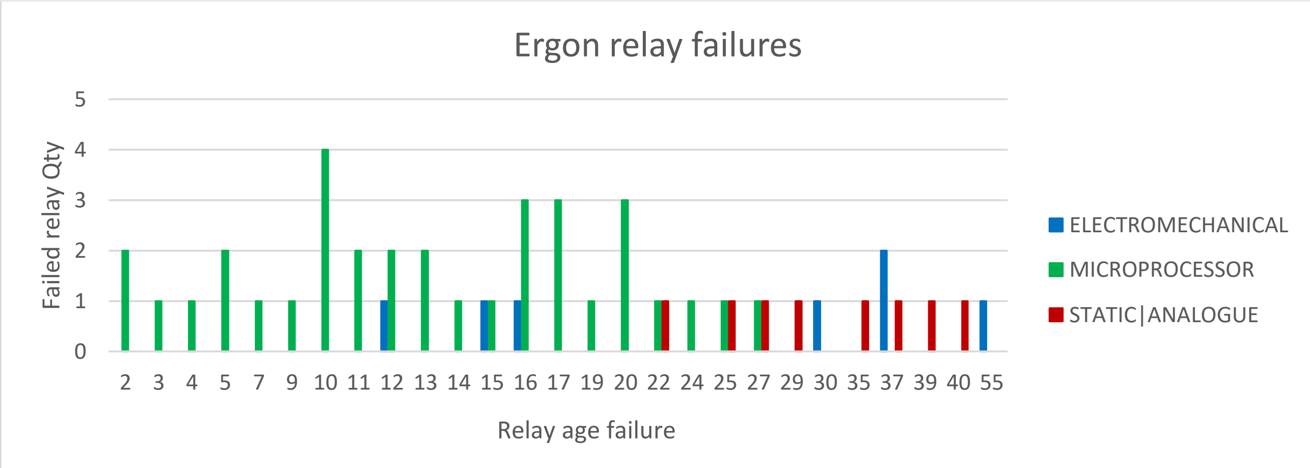


Figure 14: Ergon relay failures since July 2021

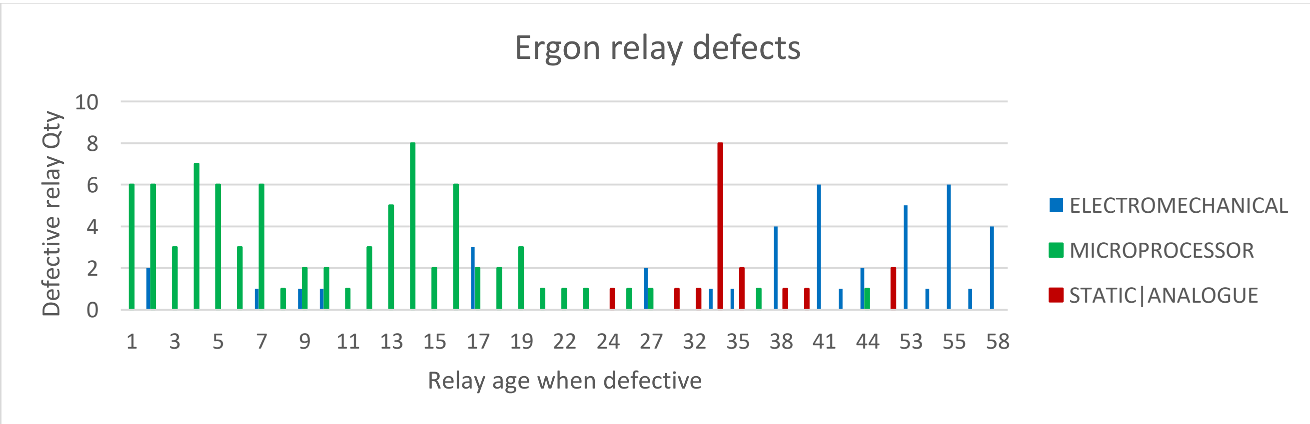


Figure 15: Ergon relay defects since July 2021

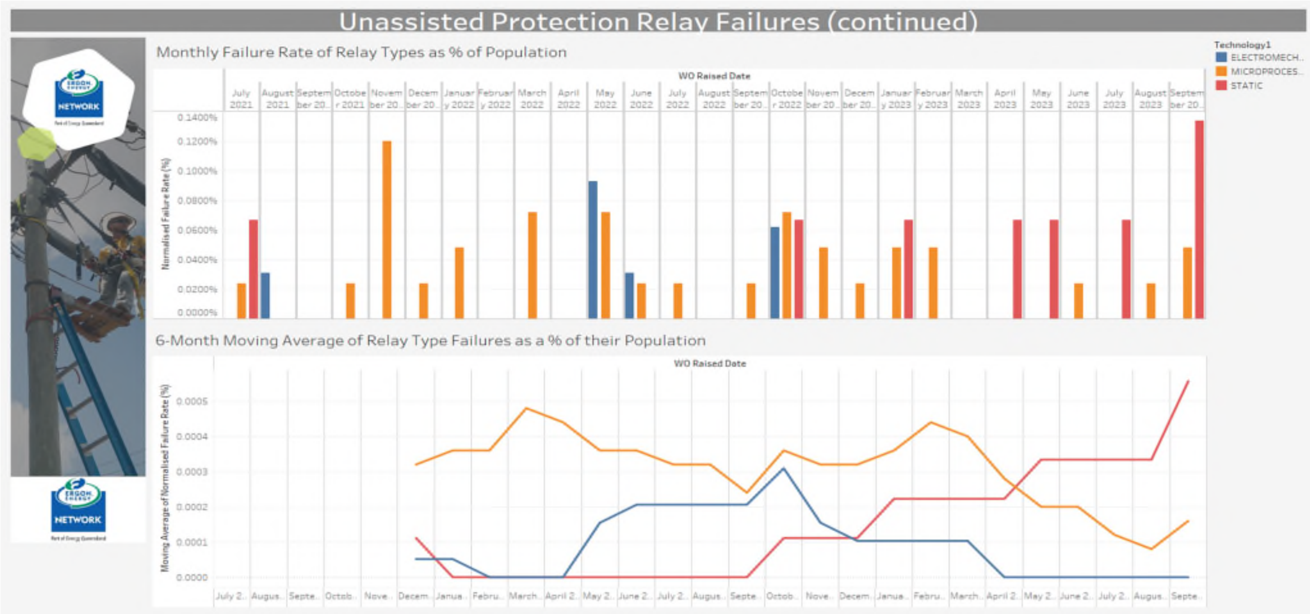


Figure 16: Ergon relay dashboard failure trend since July 2021

Figures 14 and 16 show quantities of Ergon relay failures and Figure 15 shows defects since July 2021 including the age at which the failure or defect occurred.

The graphs show that although Ergon microprocessor relay failures is not high at this stage given their moderate population base. Failures have occurred under the age of 27 years, with a lower in-service life compared to legacy electromechanical and Static or Analogue relays. This is consistent with the age at failure observed on Energex microprocessor relays. A high prevalence of recent defects on microprocessor relays is attributed to issues with DNP communications hardware on a particular make of relays, however, this is expected to be resolved in the near future.

Ergon has fewer failed, or defective electromechanical and Static or Analogue relays compared to microprocessor relays; however, these relays were aged with some electromechanical relays approaching 60 years and Static or Analogue relays approaching 40 years at failure. Electromechanical and Static or Analogue relays have a longer life expectancy, however, Static or Analogue relays in high-risk applications are considered a higher priority for replacement due to their age and absence of self-supervision.

Figure 16 shows a consistent moving average with higher normalised failure rate for microprocessor relays until May 2023. However, there has been an increase in failure counts for Static or Analogue relays in recent months due to routine 6 yearly testing of some legacy substations. There is an increasing level of concern in the Ergon network regarding the condition of Static or Analogue relays.

3.2 Current Levels of Service

Asset failures occur where the programs in place to manage the assets do not identify and rectify an issue prior to it failing in-service. Failures typically result in or expose the organisation to risk and represent the point at which asset related risk changes from being proactively managed to retrospectively mitigated. The following table shows the asset failures and defects for protection relays by region for the last five years. Refer to appendix 2 for definitions of relay failures and relay defects which represent two different conditions of relays.

Technology Type	FY2019/20[1]		FY2020/21[1]		FY2021/22		FY2022/23		FY2023/24[2]	
	Energex	Ergon	Energex	Ergon	Energex	Ergon	Energex	Ergon	Energex	Ergon
Electromechanical	4	2	3	1	3	5	4	13	0	0
Static or Analogue	0	3	0	4	0	1	3	4	1	3
Microprocessor	22	28	13	18	32	17	26	2	9	3
Total	26	33	16	23	35	23	33	19	10[2]	6[2]

Notes:

1. Failure data for FY2019/20 and 2020/21 are estimated for both DNSP.
2. Failure data for FY2023/24 only covers the first quarter of the financial year.

Table 5: Failure History

3.3 Desired Levels of Service

This asset class will be managed, consistent with corporate asset management policy, to achieve all legislated obligations and any specifically defined corporate key performance indicators, and to support all associated key result areas as reported in the Statement of Corporate Intent (SCI).

Safety risks associated with this asset class will be eliminated “so far as is reasonably practicable” (SFAIRP), and if not able to be eliminated, mitigated SFAIRP. All other risks associated with this asset class will be managed “as low as reasonable practicable” (ALARP).

This asset class consists of a functionally alike population differing in age, brand, technology, application, material, construction design, technical performance, purchase price, and maintenance requirements. The population will be managed consistently based on generic performance outcomes, with an implicit aim to achieve the intended and optimised life cycle costs contemplated for the asset class and application.

All inspection and maintenance activities will be performed consistent with manufacturers’ advice, good engineering operating practice, and historical performance, with intent to achieve longest practical asset life overall.

Life extension techniques will be applied where practical, consistent with overall legislative, risk, reliability, and financial expectations. Problematic assets such as very high maintenance or high safety or reliability risk assets in the population will be considered for early retirement.

Assets of this class will be managed by age, failure rate, criticality of application, population trends, defects, and regular maintenance, and where possible, will be allowed to operate as close to and prior to calculated end of life. Once the asset is obsolete or deemed problematic, assets will be managed or replaced as appropriate to achieve the desired risk appetite.

3.4 Legislative Requirements

Regulatory performance outcomes for this asset include compliance with all legislative and regulatory standards, including the *Electrical Safety Act 2002 (Qld)*, the *Electrical Safety Regulation 2013 (Qld)*, and the *Queensland Electrical Safety Codes of Practice*.

The *Electrical Safety Act 2002 (Qld)* s29 imposes a specific duty of care for EQL, which is a prescribed Electrical Entity under that Act:

1) An electricity entity has a duty to ensure that its works:
    a. are electrically safe; and

b. are operated in a way that is electrically safe.

2) Without limiting subsection (1), the duty includes the requirement that the electricity entity inspect, test and maintain the works.

The NER imposes DNSP obligations on power system protection requirements and its impact on network security and connection access which EQL must comply with.

3.5 Performance Requirements

EQL does not have any specific business targets relating to protection relay asset failures or defects. Instead, relays are prioritised for replacement predominately based on a number of factors including failure rate, age, primary assets protected, remaining population, consequences of failure and complexity of replacement under RTS. Relays that are obsolete or obsolescent with low population or inadequate strategic spares are also considered for replacement. Routine inspection and testing of relays may result in relays being classified with defects of differing severities and may result in their retirement and replacement.

EQL monitors the performance of protection relays through monthly publishing of dashboard reports on failures and defects including trends.

3.6 Risk Valuation

Valuing the consequences of risk supports understanding and comparison of asset management risks. Valuing the consequences of safety related risks is also an essential part of confirming EQL's compliance obligations for the Queensland Electrical Safety Act.

4 Asset Related Corporate Risk

As detailed in Section 3.2, Queensland legislation details that EQL has a duty to ensure its works are electrically safe. This safety duty requires that EQL take action SFAIRP to eliminate safety related risks, and where it is not possible to eliminate these risks, to mitigate them SFAIRP.

Figure 17 provides a threat-barrier diagram for EQL protection relay assets. Many threats cannot be controlled (e.g., third-party damage), although EQL undertakes a number of actions to mitigate them SFAIRP. Failure of a Service risks public and staff safety in several ways, most notably:

- Damage to equipment and/or plant resulting in dangerous exposure to fire hazards or shrapnel.
- Circuit failure leading to potential shock and electrocution within the substation, public vicinity and/or customer premises.
- Loss of supply to customer premises.

EQL's safety duty results in most inspection, maintenance, replacement works and expenditure related to protection relays being entirely focused upon preventing and mitigating protection relays failure.

The asset performance standards described in Section 3 detail EQL's achievements to date in respect of this safety duty. The following sections detail the ongoing asset management journey necessary to continue to achieve high performance standards into the future.

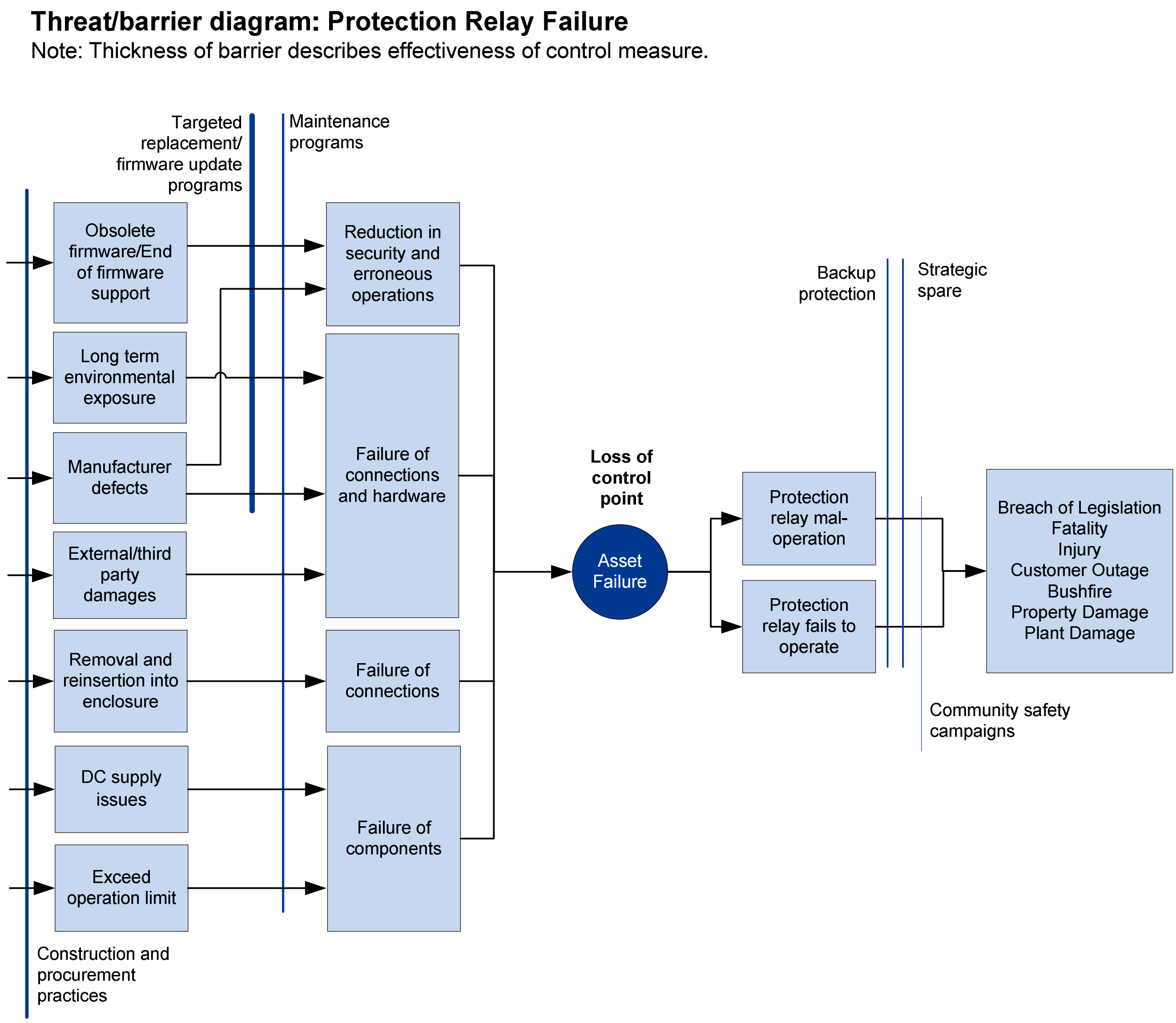


Figure 17: Threat/barrier diagram for protection relay failure

5 Health, Safety & Environment

Health, safety, and the environment are a focus for EQL as a business and in its network operations across all regions. Therefore, maintaining the serviceability of the protection relay asset class is vital for the safety of the community, staff, environment, and the network, due to the important functions performed by the protection relay asset class in addressing the detrimental effects of faults on the network.

6 Current Issues

The following sections outline the pertinent issues currently facing the asset management EQLs protection relay population.

6.1 Asset Data Quality

Ellipse is the asset register for Ergon relays and IPS is the equivalent register for Energex relays. Many missing or incorrect relay attributes in both Ergon and Energex asset registers require review, estimating and updating to produce more accurate age profiles, complete part numbers, technology types and models of relays which will require significant effort to complete and maintain. For this reason, finding matching spare relays for non-stores held in-service relays can be challenging unless photos are available with detailed part numbers, or a site visit is performed to determine full part number for the failed or defective relay. It can also be difficult to report failed or defective relays which are not sufficiently described in asset registers or identified in defect work orders. As a consequence, it often requires significant manual effort to identify relays whether it is for spares, RIN reporting, defect/dashboard reporting or condition reporting for replacement purposes. A significant amount of missing or incorrect relay attribute data results in much reduced efficiency of any data analytics involving relays. However, it may be possible to correct some existing data and infer some missing data from other attributes of other assets in the substation.

Assumptions are made in order to assign the year of manufacture for relays where this data is missing or incorrect. The year of manufacture is estimated by either inferring from the installation date of neighbouring assets installed in the same panel (or bay); or by referring to the assets commissioning date if available. With this methodology, the relays could be targeted for replacement before their end of operational life or alternatively result in protection relay failures if the relay was not correctly identified and assigned for an appropriate future replacement date.

Appropriate defect and failure codes are also required under the MSSS reporting system to help assess and better understand protection relay defects, failures and causes where possible.

EQL is currently:

- Reviewing protection relay attributes in conjunction with Engineering Data group to improve relay data quality in Ergon and Energex asset registers. This requires desktop validation and/or estimation of relay year of manufacture, part numbers and technology types using serial numbers and other sources of information to improve consistency and repeatability of data extraction process for the annual RIN submission, dashboard reporting and other purposes.
- Conducting on site protection relay data audit to compare and validate existing relay data in asset registers each time a Substation Condition Report (SCAR) is requested by the Planning Team. This will help develop more accurate project scopes involving relay replacements.
- Integrating relay data collection in the relay routine maintenance process via job cards to ensure compliance with the Protection and Control Maintenance Standard to progressively improve data accuracy through routine relay maintenance.

6.2 Spares Holdings

Obsolescent relays are categorised as no longer on current contracts and can no longer be procured. If an obsolescent relay fails in-service and an available in project/general spares have been depleted, engineering redesign and rewiring are required as the replacement relay will be a different make or model. This process is especially difficult if the existing panel does not have sufficient space to house the new relay.

EQL keeps some strategic relay spares at a number of warehouses around the state. Release of these strategic spares relays requires the approval of the relevant Assets Team associated with their custody. The temporary solution is removal of in-service relays for use as strategic spares via incorporated replacement into upcoming projects. Relays with low populations may therefore be considered for replacement even if they are in a healthy state.

Stores held relays including strategic spares may either be procured under current or legacy contracts if available from the manufacturer. A review of relay inventory including minimum and maximum control parameters and stock on hand was completed recently which triggered new orders in line with updated stock control parameters. This will reduce risks associated with longer delivery items as well as delays. A further review is planned in the next two years to ensure the inventory control parameters adequately cater for relays required for new projects as well as in for any in-service failures.

In addition to the above spares management initiatives, the following relay spares initiatives have also been completed: -

- A relay spares App has been developed and rolled out EQL wide for registering recovered grey stock relay spares for storage in local depots which facilitates visibility and shared use of recovered relays under RTS scenarios. This App allows quick and efficient tracking of available grey stock spares including relay part numbers for EQL wide access. It is expected that depot held grey stocks will be audited each year to ensure ongoing accuracy of relay spares data supporting the App.
- Relay failures, warranty returns and repairs management process utilises a relay failures App which has been developed and deployed in the Energex region at this point in time. It is expected that deployment of this App will be extended to the Ergon region.

Currently, EQL is:

- Extending the deployment of the relay failures App and the warranty returns and repairs management process to Ergon.
- Auditing grey stock spares held in all depots to ensure suitable relay spares are correctly registered in the Relay spares App.
- Reviewing inventory min/max control parameters and SOH for stores held relays including strategic spares.

6.3 Maintenance of Protection Relays

Analysis suggests that protection relays have a defined lifecycle exhibiting increased but different defect and failure rates depending on technology type as the asset approaches end of its operational life (EOL). Dashboard reports indicate that failure counts on microprocessor relays exceed other technology types in Energex whereas defects in Ergon primarily occur on Static or Analogue and electromechanical relays. This is due to Energex having a significant population of microprocessor relays which have a shorter life span; whereas Ergon still has a significant population of Static or Analogue and electromechanical relays which have a longer life span and tend to become defective instead of failing completely. Although there is a significant population of relays approaching or exceeding their life expectancy within the next five to ten years, at this stage, dashboard performance statistics do not suggest that current failures and defect rates are of any significant concern; or suggest that the current 6 yearly MAF cycle for routine inspection and maintenance should be changed.

Although protection maintenance in both Energex and Ergon are based on a common Maintenance Standard, there are differences in the way maintenance is implemented in each DNSP. Ergon protection asset hierarchy is set up in Ellipse with maintenance scheduled at a protection scheme level whereas Energex does not have a similar set up in Ellipse. This limitation in Energex is currently overcome by scheduling protection maintenance linked to primary plant assets. It is envisaged that any future common asset management system will incorporate a common approach towards scheduling maintenance with the ability to uniquely identify each physical asset (relay) for Work Order assignments, MSSS coding and tracking of defects and failures at a physical asset (relay) level.

EQL maintenance practice on microprocessor relays is currently no different to Static or Analogue and electromechanical relays and based on the repeatability of timing and pickup performance and the existence of watch dog supervision on microprocessor relays, it is recommended that the scope of routine testing on microprocessor relays is reduced to proportionally reduce maintenance costs and gain efficiencies without undertaking additional risks. This is expected to be reflected in EQL protection maintenance job cards in future.

Currently, EQL is:

- Reviewing Ergon Cards for EQL wide implementation to ensure uniform maintenance practices.
- Reviewing testing practices to reduce the extent of routine testing of microprocessor relays with regards to pick up and timing performance.

6.4 Protection Relay Test Records Management

Both Energex and Ergon maintain test records through proprietary relay testing software using Doble and Omicron software. Test records are currently stored in separate shared folders; however, it is expected that in future, Field Operations will use a common repository for such records which can be readily retrieved if required.

6.5 Energex Region and Ergon Standards Alignment

There are differences between DNSPs with regards to the procurement and application of current standard protection relays with opportunities for further alignment in the following key areas: -

- Relay Inventory – Majority of stores held relays are different between the DNSPs, with only a few common stock codes having the same relay part number due to legacy protection design and installation practices. It is expected that relays will be further standardised across EQL in future reducing stores inventory, number of relay spares and required application standards.
- Standards and Specifications – There are separate contracts in place for procurement of relays due to differences in product specifications, design, and application guides between DNSPs. Future alignment is expected in due course for the above reasons.
- Although there is a common EQL Protection Maintenance Standard, some aspects of implementation including Standard jobs and job cards still require alignment between the DNSPs.

7 Emerging Issues

The following sections outline some of the emerging issues associated with managing EQL's protection assets.

7.1 Technology Requirements and Advancement

Existing substations with aged legacy assets will eventually be required to be replaced. Due to vastly changing technological environment, 'like for like' model replacement will not be an option due to unavailability of legacy relays resulting in replacements with current contract relays which may not be compatible with other equipment on site. This may lead to replacement of some relays that may not be at the end of life at a much higher cost.

7.1.1 DNP3

There has been a requirement for all new substations to utilise the latest set of communications protocol, allowing relays to communicate directly with one another, bypassing the in-house designed IEDs. This requirement results in relays using the older protocols becoming obsolete due to inherent incompatibility issues. This reduces flexibility in the choice of relay models and forces protection upgrade to current standards.

7.1.2 Communications

As communications systems within substations are refurbished and upgraded to utilise fibre optic cabling over the existing copper-based pilot cable technology, existing relays may be incompatible and require replacement. This imposes design constraints and causes particular relay models to become unsuitable for use. The situation is also somewhat exacerbated with aged and failing pilot cable cores.

7.1.3 Firmware Management

Microprocessor relays are highly sophisticated devices with integral firmware. Both Ergon and Energex currently manage relay firmware in IPS which is the relay settings data base, however, this will remain an ongoing challenge given the large variety of legacy relay makes and models and firmware upgrades over the last 20 years or so and in future. Multiple firmware upgrades over the life of a make/model will also require a larger number of specific relay types from a spares management perspective.

7.1.4 Obsolescence

Modern relays have a short life cycle with some makes and models now approaching end of production after some 20 years, with failed relays now requiring equivalent current standard relay replacements with different form factors and design specifications with significantly increased costs compared to a like to like replacement scenario.

7.2 Ergon and Energex alignment of asset management practices

Energex and Ergon regions have a number of differences in engineering processes, data capture, and management strategies which will need to be aligned in due course. Ergon also has a larger population of high-risk legacy relays whereas Energex already has a large and growing population of microprocessor relays. Relay replacement strategies needs to be tailored for each DNSP based on the relay population types, their life cycle stages, and should be risk based rather than being primarily age based.

8 Improvements and Innovation

The following sections outline any improvements or innovations to asset management strategies relevant to this asset class, being investigated by EQL.

8.1 Data Quality Improvements

Asset data in the context of this AMP refers to data in asset registers (IPS & Ellipse) as well as condition data obtained from the relay maintenance processes. In addition to the information in section 6.1 to improve asset data, asset condition data reported via preventive and corrective maintenance processes is currently not always a clear representation of the defect or failure and it sometimes difficult to identify the relay in question for reporting purposes. It is expected that the new asset management system will enable use of MSSS codes and unique equipment identifiers to improve data quality for failure and defect reporting, and asset identification.

8.2 Health Index and Risk Monetisation

To support / justify the increased replacement volumes and resolve the economic limitation of Ergon Energy, EQL has:

- Developed a Weibull distribution-based analysis to establish optimum replacement volumes.
- Committed to adopt an economic, customer value-based approach when it comes to ensuring the safety and reliability of the network. To substantiate the advantages of this approach for the community and businesses over the modelling period, we have employed Net Present Value (NPV) modelling. This commitment is in line with their efforts to minimize the impact on customer prices.
    - A cost benefit analysis has been conducted to confirm that the protection relay replacements are prudent capital investments.

9 Lifecycle Strategies

The following sections outline the planned approach of EQL to the lifecycle asset management of this asset class.

9.1 Philosophy of Approach

Protection relays in the EQL electricity network are managed with the goal of conducting relay replacements as quickly and efficiently as possible to minimise network downtime. Considering that in-service repairs or maintenance on protection relays are difficult or impossible to carry out, the best method of asset management is to have an ample supply of spares on hand and to accurately identify the at-risk relays before they fail.

In order to identify at-risk relays, there are a number of systems utilised. The first is a predictive analysis-based system, used to predict the relays that are close to the end of their service life by incorporating information on specific failure rates, age, and availability of spares. In addition, some relay models are monitored for faults and logged for observation. All systems result in the ability to send maintenance crews to the targeted relays to verify their condition with physical diagnostic testing.

If a relay fails diagnostic testing and is removed from service, an assessment process is carried out to determine whether to scrap the relay or send it away for repair and/or storage.

The overall approach to the management of protection relays is to prioritise the proactive replacement of these assets before they fail in-service. This strategy improves the efficiency of the electric network, through both improved protection, decreased downtime, and lowered operational costs to the organisation.

9.2 Supporting Data Requirements

Refer to sections 6.1 and 8.1 for existing data issues and recommended improvements.

9.3 Acquisition and Procurement

EQL has a regular review process for the selection of standard protection relays for its network in addition to preparing for planned phase out of relays which are no longer available from manufacturers.

Period contracts are renewed with a focus on the needs of the distribution network and contract relay models are determined for procurement and purchased into stores. The quantity of relays kept in stock are based on their usage, in-service population of grey stock spares (if available), estimated in-service population and failure rate of the particular model and type. Relay stores stock holdings are reviewed, and min/max levels adjusted to not only to cater for new installations but also to support for RTS and planned projects. A new process has also been rolled out to repair failed relays under manufacturer warranty including relays which are critical or strategic spares but no longer manufactured.

9.4 Maintenance

EQL employs both preventive and corrective maintenance on protection relays depending on the serviceability.

Routine preventive maintenance is the typical method of inspecting and testing relays in the EQL network. This may generate corrective maintenance work including like for like replacements. In the absence of a like for like spare relay, a capital project is created and issued to replace the failed or defective relay. A defect management process is concurrently activated for managing risks associated with the failed or defective relay.

Currently, EQL is reviewing the Protection and Control Maintenance Standard in line with business document review timelines.

9.4.1 Preventive Maintenance

The policies for preventative maintenance are outlined below:

- Ergon relays are visually checked every 36 months (3 years). This is purely a condition assessment without taking the relay out of service. This maintenance is yet to be implemented in Energex.
- Relays are tested and maintained every 72 months (6 years) in both Ergon and Energex. This maintenance is non-intrusive and involves injection testing of relays to verify their performance and requires relays to be taken out of service.
- Relay defect classifications for corrective work are based on the current version of the EQLs MAC criteria. MAC stipulates relay tolerances which are referenced to classify failed and defective relays.

9.4.2 Corrective Maintenance

EQL reacts to corrective and forced maintenance issues as they arise. These are usually addressed by an immediate replacement with the same make and model relay if available, sourced from the strategic spares inventory or grey stock spares inventory depending on obsolescence status. If the relevant spares inventory is depleted, then the current standard contract relay will be installed instead, but at a significantly higher cost.

9.4.3 Spares

Spares are managed in two different sets – general and strategic. The general spares are accessible by any part of the EQL business as required. These relays are typically current standard contract relays that can still be procured through normal channels.

Strategic spares, on the other hand, are held for the purpose of minimising network downtime and as such are controlled through restricted access. Approval is required from Asset Maintenance before the relay is released. Relays in these categories are transferred from the general inventory to the strategic spares inventory.

Minimum and maximum stock levels and stock on hand for relays held in the inventory systems including strategic spares are reviewed adjusted based on in-service population, failure rates, defect rates and lead times.

There are situations where a necessary number of spares are not at hand and EQL is unable to source any additional spares through the vendor. In such instances, some in-service relays of that particular model can be proactively removed and held as spares, being replaced by a different current contract relay model. It is quicker and more convenient for EQL to replace a relay like-for-like in the event of an unexpected failure than it is to source a new current contract model, which typically has a far longer lead time to procure.

9.5 Refurbishment and Replacement

Any relays deemed faulty during routine maintenance and testing will be removed and replaced with a like-for-like replacement relay where available. In the Energex Region, any faulty relay removed will either be sent for repairs or disposed of as per the ‘Policy for Treatment of Decommissioned Protection Relays’ document. The Ergon Region do not currently have a formal policy document for decommissioned protection relays. Any failed relays will be immediately disposed of.

Currently, EQL is developing a policy document for decommissioned protection relays.

9.5.1 Refurbishment

Refurbishment generally only occurs if relays are still under warranty, or if the relays are strategic or critical spares and potentially repairable. Repairable relays are sent to the manufacturer. Sometimes the repair issues are simple such as replacing an LCD display or the power supply unit on a microprocessor relay, and in these instances, an in-service repair is performed, with the manufacturer providing the replacement parts if available.

9.5.2 Replacement

In general, relays in EQL are replaced as per the following conditions.

- Any relays that fail in-service or during maintenance are managed following the corrective maintenance process outlined under Section 9.4.2.
- Relays are replaced either with a like-for like model or by a current contract relay having the required protection functions. Refer to the Guidelines for Maintenance driven relay replacements in EQL. An additional consideration is to determine whether there is an existing project at the target substation site to bundle the relays into the project scope to achieve cost efficiencies.

Currently, EQL is reviewing to update the guideline “Maintenance driven Relay replacement Priorities and Spares Strategy” incorporating updated failure and defect data from dash boards, high risk relaying applications as well as the population of relays exceeding the age thresholds for each technology type.

9.5.3 Program Requirements and Delivery

Discuss various programs of work by OPEX and CAPEX NAMP Line categories. Include nominal annual budget expectations for this and next few fin years. Notionally presents NAMP line budgets derived after the AER final decisions and EQL decides what those are.

An example of what this might look like is shown in document “Asset Management Plan – Substation Transformers – Stage 2 ideas”.

9.6 Disposal

Assets are disposed of as e-waste in accordance with standard EQL corporate process for materials handling and disposal.

10 Program Requirements and Delivery

The programs of maintenance, refurbishment and replacement required to outwork the strategies of this AMP are documented in Network Program Documents and reflected in corporate management systems. Programs are typically coordinated to address the requirements of multiple asset classes at a higher level such as a substation site or feeder to provide delivery efficiency and reduce travel costs and overheads. The Network Program Documents provide a description of works included in the respective programs as well as the forecast units.

Program budgets are approved in accordance with Corporate Financial Policy. The physical and financial performance of programs is monitored and reported on a monthly basis to manage variations in delivery and resulting network risk.

Appendix 1. References

This table details all documents authorised/approved for use in EQL which supports this Asset Management Plan.

Legacy organisation	ECM Document Number	Title	Type
Energex & Ergon Energy	3055925	Maintenance Standard for Protection and Control Systems	Standard
Energex & Ergon Energy	2928929	Standard for Maintenance Acceptance Criteria	Standard
Energex & Ergon Energy	2357714	Network Schedule of Maintenance Activity Frequency Master.	Standard

The following supporting documents have also been produced to help provide further direction for managing this asset class since the merger of the legacy organisations. Documents in the list below relate to spares review, failed relay management process, and guidelines for maintenance driven relay replacements.

Title	Type
EQL Maintenance driven Relay replacement Priorities and Spares Strategy	Guideline
EQL Protection relay & recloser controller Stores Inventory review	Business Case & Spreadsheet Analysis
EQL Guidelines for managing failed relays	Briefing Note & process flowchart.

Appendix 2. Definitions

Term	Definition
AC Protection Relay	An alternating current and/or voltage sensing relay which operates to isolate network faults and also during abnormal network operating conditions
Static or Analogue Relay	An a.c. protection relay designed primarily with analogue electronics using discrete components and attracted armature direct current (d.c.) output relay coils. These relays may have some integrated circuits to execute basic binary logic but are not equipped with microprocessors for software based numerical processing. These relays were typically manufactured between 1975 and 1985 in the era of analogue and first-generation digital electronics.
Auxiliary Relay	Secondary relay that operates in response to the opening or closing of its operating circuit to assist another relay (typically an a.c. relay) or device in performing its function. Auxiliary relays are typically d.c. operated electromechanical or static relays. Auxiliary relays have been used on protection systems since power systems were first built and will continue to be used in the near future.
Condition Based Risk Management	A formal methodology used to define current condition of assets in terms of health indices and to model future condition of assets, network performance, and risk based on age, different maintenance, asset refurbishment, or asset replacement strategies.
Corrective maintenance	This type of maintenance involves planned repair, replacement, or restoration work that is conducted to repair an identified asset defect or failure occurrence, in order to bring the network to at least its minimum acceptable and safe operating condition. An annual estimate of the volume of corrective maintenance is provided for the PoW against the appropriate category and resource type.
Current Contract	The latest agreed contractual specifications of specific equipment, e.g. protection relays, between Energex and the manufacturer that has not expired
Current transformer (CT)	Current transformers are used to provide/transform currents suitable for metering and protection circuits where current measurement is required.
Distribution	LV and up to 22kV (and some 33kV) networks, all SWER networks
Electromechanical relay	An a.c. protection relay which is primarily constructed using mechanical components including moving discs, current and/or voltage input coils and attracted armature d.c. output relay coils. These relays were typically manufactured before 1990.
Forced maintenance	This type of maintenance involves urgent, unplanned repair, replacement, or restoration work that is carried out as quickly as possible after the occurrence of an unexpected event or failure; in order to bring the network to at least its minimum acceptable and safe operating condition. Although unplanned, an annual estimate is provided for the PoW against the appropriate category and resource type.
In-service	The state of plant or equipment that is considered operating within the network.
Instrument transformers	Refers to Current Transformers (CTs), Voltage Transformers (VTs) including CTs and VTs inside Metering Units (MUs)
Like for Like	Refers to the exact same make and model relay

Term	Definition
Microprocessor Relay	An a.c. protection relay capable of digitizing and numerical processing of a.c. currents, voltages and binary inputs/outputs, and equipped with attracted armature d.c. output coils, software-based logic and firmware accessible via manufacturers proprietary software to manage settings and retrieve historical event logs. These relays have been typically manufactured after 1990.
Metering Units	A unit that includes a combination of both Current Transformers and Voltage Transformers for the purpose of statistical or revenue metering
Obsolescent	Can no longer be purchased from the manufacturer but can still be requisition or checked back into stores
Obsolete	Can no longer be purchased from the manufacturer or supported with spare parts
Preventative Maintenance	This type of maintenance involves routine planned/scheduled work, including systematic inspections, detection, and correction of incipient failures, testing of condition and routine parts replacement designed to keep the asset in an ongoing continued serviceable condition, capable of delivering its intended service
Protection Relay Failure	A protection relay is classified as failed if it can no longer perform its basic function of detecting and/or tripping to isolate faults
Protection Relay Defect	A protection relay is classified as defective if one or more components are not performing as expected but the relay can still perform its basic function of detecting and/or tripping to isolate faults to an acceptable level
Distribution Voltage	33kV and below
Sub Transmission Voltage	33kV and 66kV
Transmission Voltage	Above 66kV
Voltage Transformers (VT)	Voltage or potential transformers are used to provide/transform voltages suitable for metering and protection circuits where voltage measurement is required.

Appendix 3. Acronyms and Abbreviations

The following abbreviations and acronyms may appear in this asset management plan.

Abbreviation or acronym	Definition
AC	Alternating current
ALARP	As Low As Reasonably Practicable
AMP	Asset Management Plan
AUGEX	Augmentation Expenditure
CB	Circuit Breaker
CT	Current Transformer
CVT	Capacitor Voltage Transformer
DC	Direct Current
DEE	Dangerous Electrical Event

Abbreviation or acronym	Definition
DNSP	Distribution Network Service Provider
EQL	Energy Queensland Limited
ESCOP	Electricity Safety Code of Practice
ESR	Queensland Electrical Safety Regulation (2013)
HV	High Voltage
IED	Intelligent Electronic Device
ISCA	In-Service Condition Assessment
LDCM	Lines Defect Classification Manual
LV	Low Voltage
MAC	Maintenance Acceptance Criteria
MSS	Minimum Service Standard
MSSS	Maintenance Strategy Support System
MU	Metering Unit
MVAr	Mega-VAr, unit of reactive power
NEF	Neutral Earth Fault
NER	National Electricity Rules
NIM	Non-Intrusive Maintenance
OCC	Operations Control Centre
OTI	Oil Temperature Indicators
PCB	Printed Circuit Board
POC	Point of Connection (between EQL assets and customer assets)
PoW	Program of Work
PRD	Pressure Relief Device
REPEX	Renewal Expenditure
RIN	Regulatory Information Notice
RTS	Return To Service
SCAR	Substation Condition Assessment Report
SEF	Sensitive Earth Fault
SCADA	Supervisory Control and Data Acquisition
SCI	Statement of Corporate Intent
SDCM	Substation Defect Classification Manual
SFAIRP	So Far As Is Reasonably Practicable.