Circuit Breakers & Recloser Replacements

Business Case

19 January 2024

Part of Energy Queensland

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DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
Draft v0.1	Draft	28/04/2023	Asset Strategy Engineer
Draft v0.2	Initial Release	31/05/2023	Asset Strategy Engineer
Draft v0.3	Finalised Draft – Formatted	02/11/2023	Manager Asset Strategy
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RELATED DOCUMENTS

Document Date	Document Name	Document Type
JAN 2024	Asset Management Plan – Circuit Breakers and Reclosers	PDF
NOV 2023	Circuit Breakers and Reclosers CBRM/CNAIM Model	Excel
JUN 2023	RIN 2.2 Compare 2021-22 (Rosetta)	Excel
NOV 2023	Energex 2022-23 - Category Analysis - RIN Response - Consolidated - 24 November 2023 – PUBLIC (16063386.1)	Excel
JUL 2023	Network Risk Framework ID2877290	PDF
JUN 2023	Maintenance Acceptance Criteria (MAC) – Release 11	PDF
OCT 2023	Lines Defect Classification Manual	PDF
V3	Substation Defect Classification Manual	Manual
MAR 2023	Electrical Safety Act 2002 (Qld)	PDF

1 SUMMARY

Title	Circuit Breaker and Recloser Replacements
DNSP	Energy Queensland (EQL) – Energex Ltd
Expenditure category	☒ Replacement ☐ Augmentation ☒ Connections ☐ Tools and Equipment ☐ ICT ☐ Property ☐ Fleet
Identified need	The objective of this Business Case report is to outline the projected limitations pertaining to Circuit Breaker (CB) and Recloser (RE) assets in alignment with the lifecycle management approaches specified in the Asset Management Plan. Additionally, this Business Case provides the summary of interventions, both in terms of volume and financial allocations during the regulatory period 2025-30, as informed by the results of CNAIM/CBRM modelling. Energex has the obligation as a Distribution Network Service Provider to ensure safe and reliable network. Energex employs all reasonable measures to ensure it does not exceed minimum reliability service standards, assessed as: • System Average Interruption Duration Index (SAIDI) • System Average Interruption Frequency Index (SAIFI).
Optimal Timing and NPV Analysis	Within the framework of the Network Planning Process, an assessment is conducted for the limitations associated with each Circuit Breaker or Recloser. Subsequently, individual projects are initiated, and an assessment undertaken to determine the optimal timing for their replacement. This procedure involves performing Net Present Value (NPV) analysis, risk assessment, and consolidating activities with other network assets in suboptimal condition at a designated timing. Energex ensures prudency and efficiency, ultimately curbing the financial impact on our customers and the broader community. Attachment 5.2.01 SCS Capex model – January 2024 outlines our overall investments for the 2025-2030 period, which will include circuit breakers and reclosers. Business cases for those investments are available on request.
Volume and Expenditure Summary	see table below

Year	2025/26	2026/27	2027/28	2028/29	2029/30	Total
$M direct 2022-23	6.9	10.9	10.7	11.4	9.1	**49.0**
Quantity	11	35	64	19	151	**280**

2 PURPOSE AND SCOPE

This document outlining the projected replacement and expenditure volumes for the replacement of our Circuit Breakers & Reclosers during the Regulatory Control Period 2025-2030 and should be read this document in conjunction with the Circuit Breaker & Recloser Asset Management Plan.

3 BACKGROUND

Circuit Breakers and Reclosers play a critical role in ensuring the safe operational control of our network. They prevent or minimize asset damage and reduce the likelihood of public safety issues to the extent reasonably practicable (SFAIRP).

Energex employs a regime of periodic inspections and intrusive maintenance practices in alignment with our maintenance strategy to efficiently uphold the Circuit Breaker and Recloser assets. The CBRM/CNAIM model used by Energex leverages these observed and measured conditions to predict the assets' end-of-life scenarios.

3.1 Asset Population

Energex manages 7,169 Circuit Breakers and Reclosers for both indoor and outdoor applications.

Energex's Circuit Breaker and Recloser asset class quantities are detailed in Figure 1. The age profile indicates that 463 CBs/REs will be over 50 years old by 2030, with 157 CBs/REs over 60 years old.

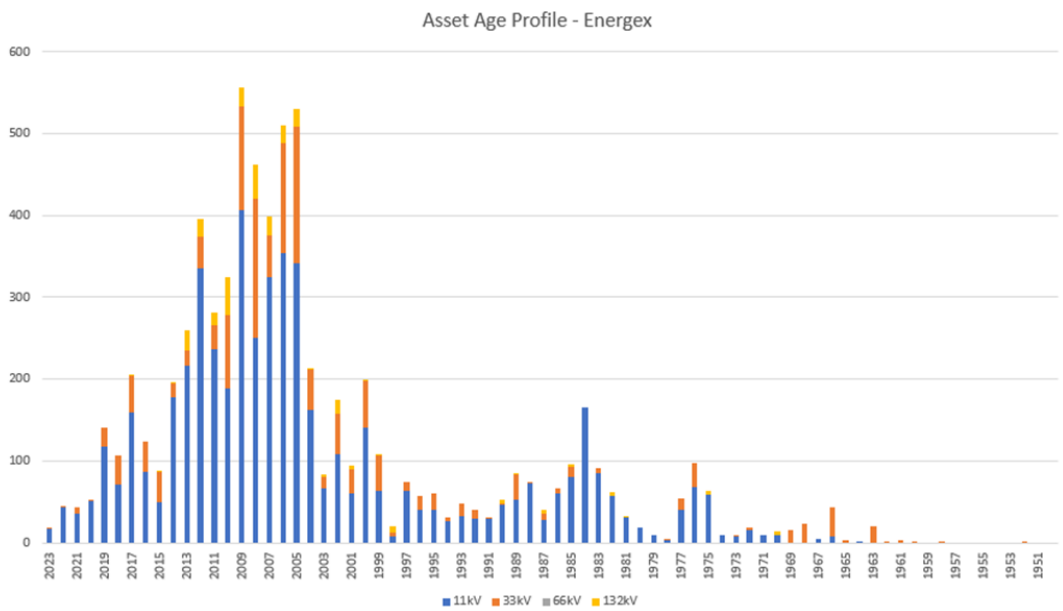

Figure 1: Asset Age Profile

3.2 Asset Management Overview

Energex adopts a number of strategies in managing our circuit breaker and recloser assets. These include:

- **Preventative maintenance** – performed in accordance with the inspection and intrusive Maintenance Standard Tasks with maintenance intervals outlined in the Maintenance Activity Frequency.
- **Corrective Maintenance** – undertaken when inspection and condition monitoring classify defects as outlined in the Lines Defect Classification Manual and Substation Defect Classification Manuals.
- **Proactive Replacement** – is the management strategy used in conjunction with Condition Based Risk Management to replace problematic and poor condition assets.
- **Reactive Replacement** – occurs when the asset has failed and this is to be avoided as it has negative safety, reliability and reputational impact.

3.3 Asset Performance

Two main failure modes have been considered in this business case as per the following description:

- **Unassisted Failures:** Functional failure of a Circuit Breaker and Recloser asset or component under normal operating circumstances and not caused by any external intervention such as abnormal weather or human.
- **Defects:** Circuit Breaker, Recloser asset or component deemed defective based on prescribed classifications and if not rectified in a prescribed time scale (P0/P1/P2) could result in an unassisted failure.

Identified defects are scheduled for repair according to a risk-based priority scheme (P0/P1/P2). The P0, P1 and P2 defect categories relate to priority of repair, which effectively dictates whether normal planning processes are employed (P2), or more urgent repair works are initiated (P1 and P0).

Historical unassisted failure and defect data has been provided in Figure 2 and Figure 3. The asset failures in the last 5 years have been relatively stable, demonstrating the effectiveness of our current replacement program and condition monitoring process. Defects data shown in Figure 3 shows a consistently high rate of around 500 defects per year pre 2021-22, with numbers peaking at 563 in 2020-21. However, from 2021-22, the improvement in asset performance indicate that our defect identification and rectification processes are working as expected to maintain the current level of service.

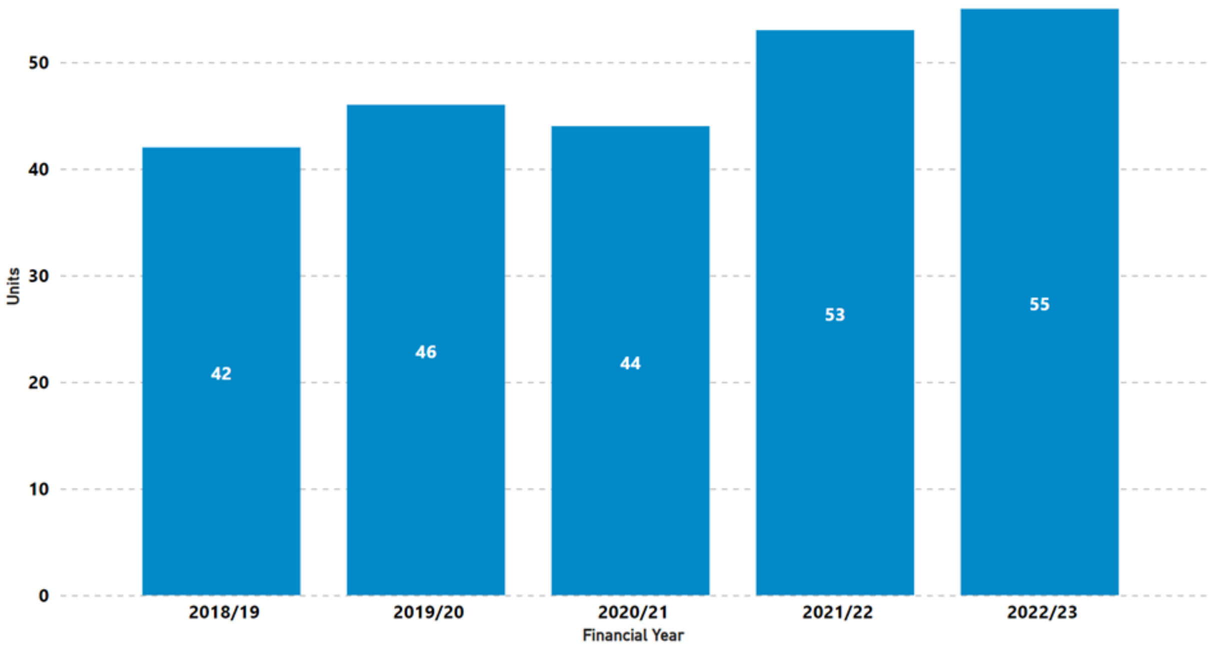

Figure 2: Unassisted CB & RE Failures

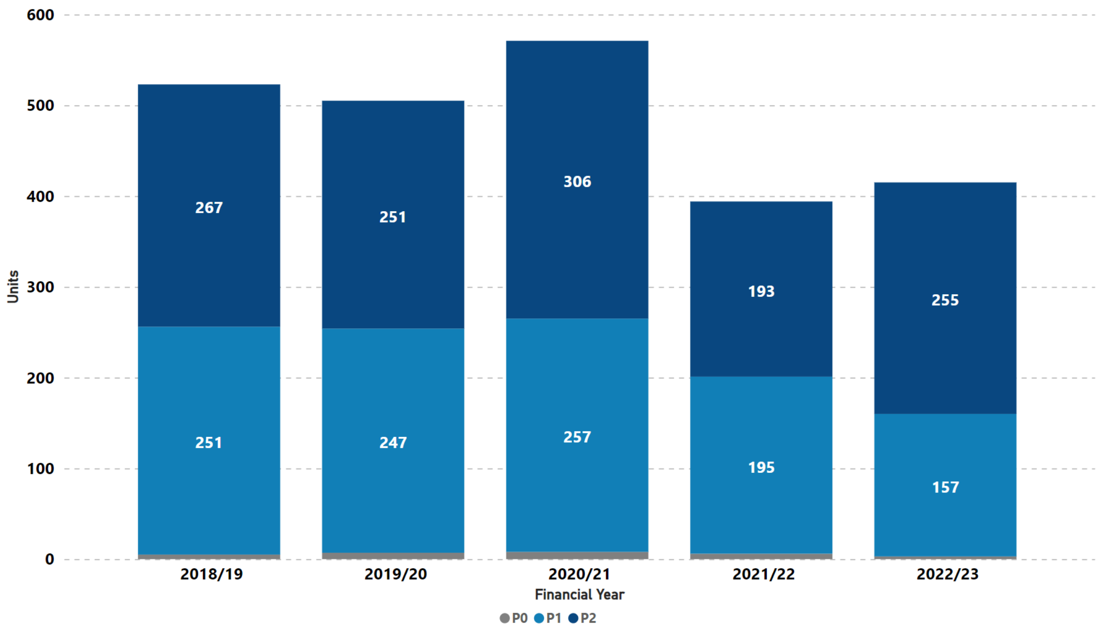

Figure 3: CB & RE Defects

3.4 Risk Evaluation

The risk is calculated as per equation in Figure 4.

Figure 4: Monetised Risk Calculations

Each consequence category follows the same calculations in Figure 4 to obtain the total monetised risk is as per Figure 5. Energex broadly considers five value streams for investment justifications regarding replacement of widespread assets. In Figure 5, only four of the value streams are considered; the 'Export' is not material to CB/RE.

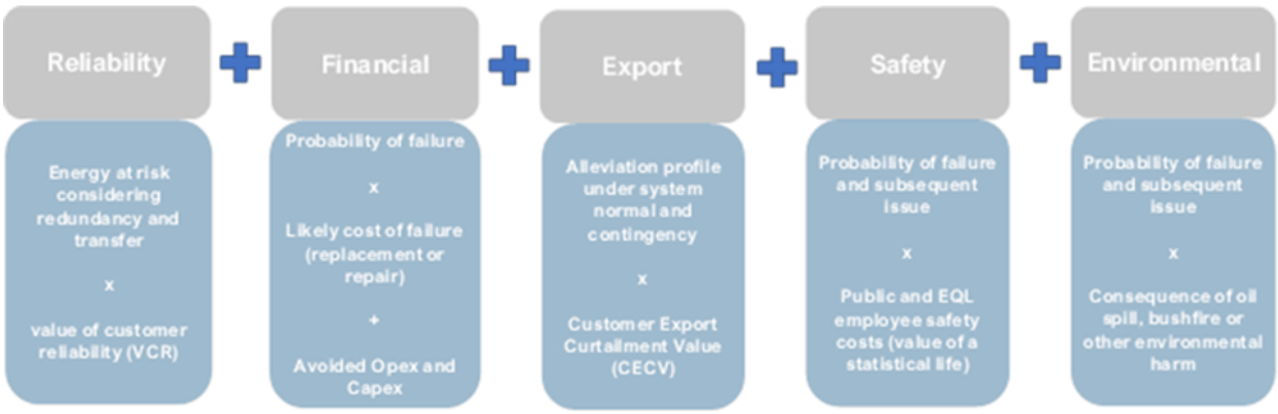

Figure 5: Total Risk Cost Calculations

3.4.1 Probability of Failure (PoF)

In order to determine the assets condition realistically several contributing factors have been considered including appropriate probabilistic impact scales in line with Condition Based Risk Management (CBRM) and Common Network Asset Indices Methodology (CNAIM) principles. Both observed external deterioration (oil/gas leaks, rust, corrosion etc) and measured condition data from oil samples, mechanism condition and bushings condition assessment. Also, electrical testing and operation times (closing and opening) are measured and recorded to monitor the conditions and Health Index (HI) for all CBs/REs to calculate the future probability of failure.

The PoF is calculated based on a well-established equation set out in CBRM/CNAIM modelling after analysing worldwide data about the relationship between health index and PoF for different assets.

3.4.2 Consequence of Failure (CoF)

Consequences of an in-service failure has been assessed across four value streams are relevant to this business case:

- **Reliability:** There will be unserved energy following the in-service failure of a CB/RE. The network performance is also monitored through SAIDI and SAIFI performance of the distribution network – a key performance indicator for the business and community.
- **Financial:** There will be a financial cost associated with responding to a failed CB/RE as well as replacing the CB/RE under emergency. The unplanned cost could vary significantly from a couple of thousands to hundreds of thousands depending on the scale of failure and damage.
- **Safety:** There is a risk of multiple serious injuries or a fatality following a failure of a CB/RE, specifically asset with porcelain housing/bushings, dependent on the failure mode and proximity of the employee/contractor during the event. Considering that these CBs are installed, exceptions to Reclosers – could be both outside and inside, within security fences public injuries are very rare and therefore has not been considered in the risk assessment.
- **Environmental:** There is a risk of minor environmental impact/contamination under right conditions in case of failure of a CB/RE or some nuisance impact due to a small fire in the CB/RE. Bushfire is highly unlikely.

3.4.3 Likelihood of Consequence (LoC)

Likelihood of consequence refers to the probability of a particular outcome or result occurring because of a given event or action. To estimate the likelihood of consequence, Energex has utilised a combination of historical performances and researched results. Energex has analysed past events, incidents, and data to identify patterns and trends that can provide insights into the likelihood of similar outcomes occurring in the future. Additionally, Energex also has conducted extensive research to gather relevant information and data related to the respective risk criteria.

4 IDENTIFIED NEED

4.1 Problem

The impact of a Circuit Breaker or Recloser failure or maloperation is the potential of causing a significant safety risk and unnecessary long electricity outages. To avoid this, it is important Energex ensures the safe and reliable operation of our Circuit Breaker and Recloser assets by prudently investing in the maintenance of these assets and to replace these assets at the end of life before a catastrophic failure incident occurs.

Key challenges for the management of the Circuit Breaker and Reclose asset class include:

- Ensuring continuous improvement in asset data quality, recording of accurate failure information, condition assessments, and commissioning / decommissioning data to support asset management objectives.
- Improving maintenance practices to avoid recurring incidents and to achieve optimum asset life.

- Managing the reduced asset design life of modern circuit breakers and reclosers compared to their older and more conventionally designed models, to ensure minimal impact on the economic viability of future investment of capital and operating expenditure.

4.2 Compliance

The assets described in this business case are not specifically referenced in the legislation, and therefore we are expected to achieve general obligations surrounding asset safety and performance and service delivery in relation to them. These obligations include compliance with all legislative and regulatory standards, including the Queensland Electrical Safety Act 2002 and the Queensland Electrical Safety Regulation 2013 (ESR).

The Queensland Electrical Safety Act 2002 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
   b. are operated in a way that is electrically safe.
2. Without limiting subsection (1), the duty includes the requirement that the electricity entity inspects, test and maintain the works.

Under its distribution licences, Energex/EQL is expected to operate with an ‘economic’ customer value-based approach to reliability, with “Safety Net measures” aimed at managing low probability high consequence outage risks. Energex/EQL is expected to employ all reasonable measures to ensure it does not exceed minimum service standards (MSS), assessed by feeder type, as:

- System Average Interruption Duration Index (SAIDI)
- System Average Interruption Frequency Index (SAIFI).

Safety Net targets are described in terms of the number of times a benchmark volume of energy is undelivered for more than a specific time period.

An outage of substation circuit breakers or reclosers is usually a significant event and may require Safety Net contingency plans to be exercised.

An outage of a distribution recloser will typically only impact the downstream customers on that feeder having a reduced reliability impact. Both Safety Net and MSS performance information is publicly reported annually in the Distribution Annual Planning Reports (DAPR).

5 ASSET LIMITATION FORECAST SUMMARY

5.1 Asset Condition Limitations – HI Summary

Energex uses Condition-Based Risk Management (CBRM) to predict the end of life of CBs/RE's. CBRM uses age, location, duty, and condition to predict the health of the asset as an index (Health Index – HI) that has a range of 0 – 10. A higher HI value represents a more degraded asset as illustrated in Figure 6.

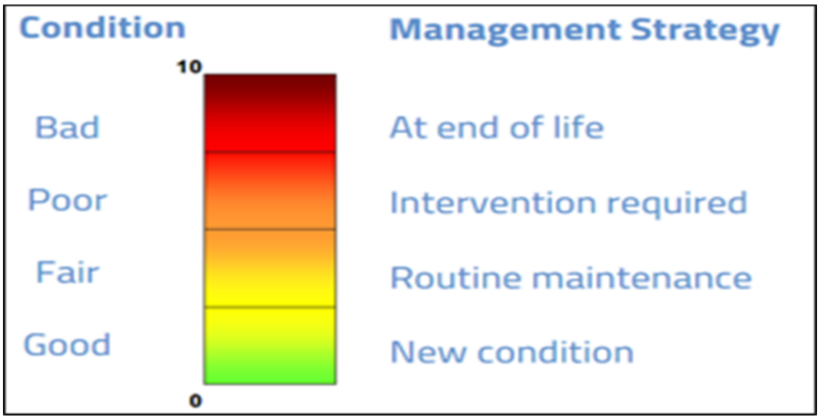

Figure 6: Health Index and Condition Summary

Energex employs a structured approach to asset replacement, utilizing a Health Index (HI) threshold of 7.5 as the trigger point for consideration. The CBRM documentation details the methodology for assessing asset condition and determining the HI. After the derivation of asset limitation from CBRM, we utilise the Network Risk Framework to prioritise asset replacement, accounting for financial and resource constraints.

To identify assets in the poorest condition, Energex utilises CBRM modelling. Additionally, older Circuit Breakers and Reclosers (CBs/REs) that have surpassed their technical life are earmarked for potential replacement to prevent the accumulation of aging assets. Replacement decisions for these candidate assets are made in conjunction with network requirements and other factors, such as augmentation and customer-requested projects, ensuring the most cost-effective solution from a holistic network perspective. The Network Risk Framework is applied at the individual project level to further guide replacement decisions within the defined constraints.

Additionally, replacement of entire switchboard is considered economical compared to replacement of individual CB in the switchboard necessitating replacement of several additional CBs along with some poor condition CBs in the switchboard.

Figure 7 presents the latest HI data for CBs/REs, with an HI of 7.5 signifying poor asset condition requiring intervention within a specified timeframe. Notably, this figure indicates that approximately 13 assets currently have an HI exceeding 7.5, necessitating intervention in the next few years.

Furthermore, Figure 8 provides an estimated forecast of the HI summary for CBs/REs at the end of the modelling period (year 2030), as determined by CBRM. It highlights that 103 assets are projected to exceed the HI threshold of 7.5, underscoring the need for a proactive replacement program over the next few years, including within the current regulatory period, to effectively manage this risk.

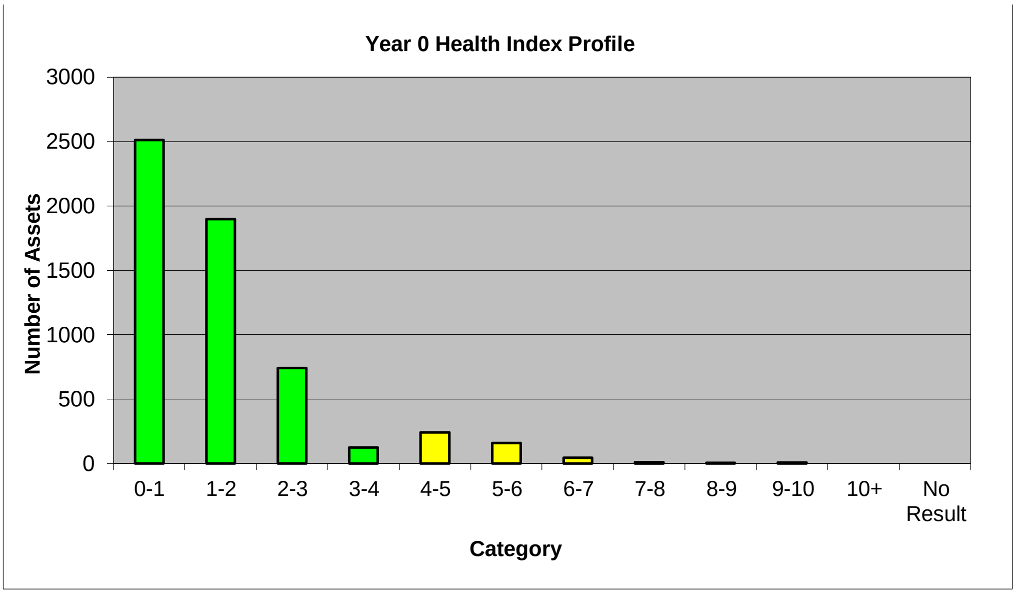

Figure 7: Current Health Index Summary – CB and RE

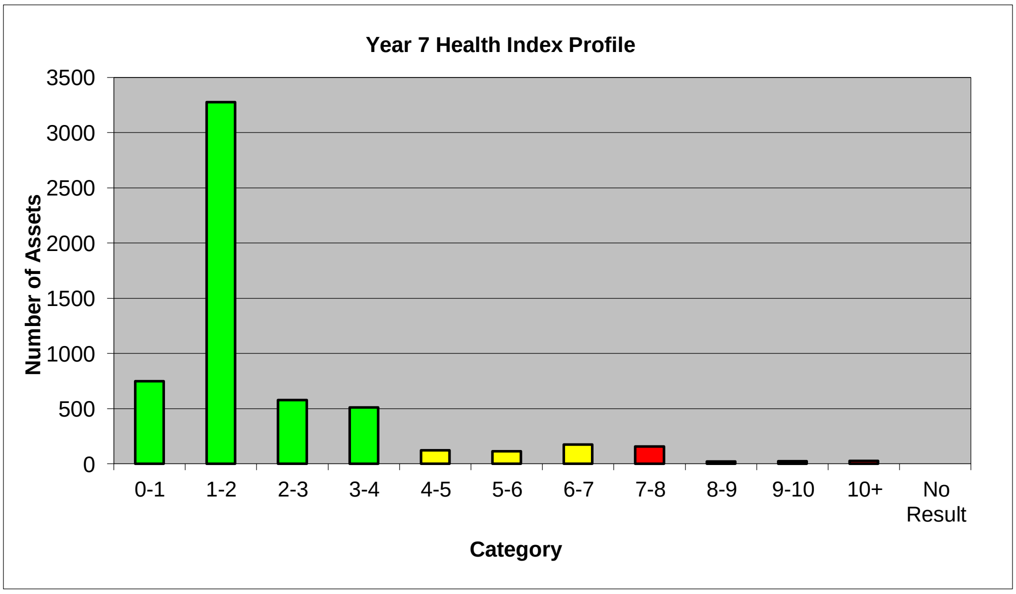

Figure 8: Future Year 7 Health Index Summary - CB and RE

5.2 Optimal Timing and NPV Analysis

This Business Case presents asset limitations in terms of CBRM modelling outcomes as per descriptions in Section 5.

However, the optimal timing of replacement of an asset, NPV analysis, risk evaluation and bundling of works with other poor condition network assets at a specific time shall be carried out in a case-by-case basis under each individual project based on overall prudency and efficiency to minimise the cost impact on customers and the community.

Individual project business cases are then created to evaluate project timing, risk evaluation and cost benefit outcomes.

5.3 Asset Replacement Limitation Forecast

Based on CBRM modelling and HI calculations a total of 21 CB/RE per annum are forecast to be replaced during the period 2025-30 as per Table 1.

Year	2025/26	2026/27	2027/28	2028/29	2029/30	Total
Quantity	20	20	21	21	21	**103**

Table 1: CB and RE Replacement Volume Summary – AER 2025-30 – CBRM Modelling

After conducting the risk evaluation, optimal timing and NPV analysis for individual projects to optimise the cost/benefits for the community by bundling of works including several additional CB/RE the proposed Replacement Program (volume and expenditures) has been provided in Table 2.

Year	2025/26	2026/27	2027/28	2028/29	2029/30	Total
$M direct 2022-23	6.9	10.9	10.7	11.4	9.1	49.0
Quantity	11	35	64	19	151	280

Table 2: CB/RE Proposed Replacement Program – RIN Forecast

Of the 280 circuit breaker replacements, over half are made up of 8 individual projects:

- West End Switchgear Replacement and Additional Transformer
- Makerston St Switchgear Replacement
- Stafford Zone Substation Transformer and Circuit Breaker Replacement
- Kirra Zone Substation Transformer and Circuit Breaker Replacement
- Capalaba Zone Substation Transformer and Switchgear Replacement
- Loganholme Zone Substation Transformer and Circuit Breaker Replacement
- Maleny Zone Substation Rebuild (expenditure over this period and next period)
- Nudgee Substation Switchgear Replacement

6 RECOMMENDATION

The proposed volume provides the best balance of benefits and risks for the organisation. As such, the decision has been made to continue with the counterfactual replacement strategy, with a focus on optimising existing processes and enhancing efficiencies where possible.

7 APPENDIX –– RESET RIN RECONCILIATION

RE	2025/26	2026/27	2027/28	2028/29	2029/30	Total
	Expenditure	Expenditure	Expenditure	Expenditure	Expenditure	Expenditure
$, direct 2022-23	6.9	10.9	10.7	11.4	9.1	**49.00**
$, direct 2024-25	7.8	12.4	12.2	13.1	10.5	**56.09**

Table 3: RESET RIN Reconciliation Table