DC Supply Replacements

Business Case

23 January 2024

CONTENTS

List of Tables

List of Figures

DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
Draft v0.1	Draft	22/09/2023	Snr Asset Engineer
Draft v0.2	Initial Release	15/11/2023	Snr Asset Strategy Engineer
V1.0	Finalised	25/11/2023	Manager Asset Strategy

RELATED DOCUMENTS

Document Date	Document Name	Document Type
JAN 2024	Asset Management Plan - DC Supply Systems	PDF
V3	Substation Defect Classification Manual	PDF

1 SUMMARY

<table>
<tr><th>Title</th><th>DC Supply Replacements</th></tr>
<tr><td>DNSP</td><td>Energy Queensland (EQL) - Ergon Energy</td></tr>
<tr><td>Expenditure category</td><td>☒ Replacement ☐ Augmentation ☐ Connections ☐ Tools and Equipment
☐ ICT ☐ Property ☐ Fleet</td></tr>
<tr><td>Identified need</td><td>☒ Legislation ☐ Regulatory compliance ☒ Reliability ☐ CECV ☒ Safety
☐ Environment ☒ Financial ☐ Other

The objective of this business case is to outline the proposed volumes of replacement and expenditure associated with DC supply systems owned by Ergon during the regulatory period 2025-30, in accordance with the lifecycle management strategies detailed in the Asset Management Plan

To meet the challenges of Ergon retiring its end-of-life DC Supply Systems population, replacements will be an ongoing endeavour. Around 38% (3 approx. 160 units) of battery chargers in the DC Supply System in Ergon have exceeded their engineering life in the 2025-2030 regulatory period. With limited spares capability, the cost of DC Supply System replacement after failure will be significant and prolong Ergon's exposure to network safety, reliability, and financial risks.</td></tr>
<tr><td>Replacement Volume</td><td>Replace 20 chargers a year for the 5-year regulatory period (2025-2030) thereby reducing the overall age profile and ensuring existing assets are still supported by both manufacturer and available spare components. Battery banks are replaced routinely at 7 years.
<table>
<tr><th></th><th>2025-26</th><th>2026-27</th><th>2027-28</th><th>2028-29</th><th>2029-30</th><th>2025-30</th></tr>
<tr><td>Substation Projects ($m, direct 2022-23)</td><td>0.67</td><td>0.59</td><td>0.56</td><td>0.55</td><td>0.54</td><td>2.81</td></tr>
<tr><td>Battery Replacement Program ($m, direct 2022-23)</td><td>0.18</td><td>0.27</td><td>0.28</td><td>0.43</td><td>0.28</td><td>1.44</td></tr>
<tr><td>Total Expenditure ($m, direct 2022-23)</td><td>0.75</td><td>0.86</td><td>0.84</td><td>0.98</td><td>0.82</td><td>4.25</td></tr>
<tr><td>Battery Charger</td><td>20</td><td>20</td><td>20</td><td>20</td><td>20</td><td>100</td></tr>
<tr><td>Battery Bank</td><td>31</td><td>48</td><td>49</td><td>76</td><td>49</td><td>253</td></tr>
</table></td></tr>
<tr><td>Benefits</td><td>Enhances safety of the public and work crews, improves network reliability, reduces DC Supply System defect management resource requirements and costs. Proactive battery charger replacements improve battery life through ensuring charging profiles remain correct and suitable.</td></tr>
</table>

2 PURPOSE AND SCOPE

The purpose of this document is to outline the forecast volumes of replacement and expenditure associated with DC supply systems in accordance with the lifecycle management strategies detailed in the Asset Management Plan – DC Systems.

This document is to be read in conjunction with the Asset Management Plan – DC Systems which contains detailed information on the asset class, populations, risks, performance history, influencing factors, asset management objectives and the lifecycle strategy.

3 BACKGROUND

In a substation, the DC Supply System is responsible for providing reliable and stable DC voltage to various devices and equipment such as protective relays, control circuits, and communication systems. This system typically consists of a battery bank, charger, and associated control and monitoring equipment.

The battery bank is the primary source of DC power, which is charged by the charger when the AC supply is available. The charger regulates the charging current to maintain the battery voltage at the desired level. The control and monitoring equipment ensure that the battery bank is always in good condition and that the charger operates correctly.

The DC supply systems is critical to the integrity of the Ergon network as many devices and equipment rely on it for their operation in a substation. In case of a power outage or a fault, the battery bank provides backup power to keep the protection and control systems operational, allowing the continued safe and efficient management of the power grid. Without a reliable DC supply system, protection relays will not be able to operate, leading to damage to plant and equipment, power outages, injuries or even fatalities. Therefore, it is essential to maintain and monitor the DC supply systems to ensure its reliability and prevent any failures.

3.1 Asset Population

In many substations in the Ergon network there are multiple DC supply systems from duplicate/backup systems to multi voltage systems depending on equipment requirements in the substation. Energy Queensland Limited (EQL) manages approximately 400 DC supply systems in the Ergon network and are typically managed based on asset condition and risk.

The age profile for the battery chargers in the DC supply systems shows a growing population of units beginning to reach end of life with which Ergon has deemed to be 25 years based on manufacturer specifications and industry standard and our maintenance programs as per Figure 1 and. Due to errornous records of the manufactured dates associated with battery chargers and banks, the age profile produced significant numbers of unknowns as per Figure 2.

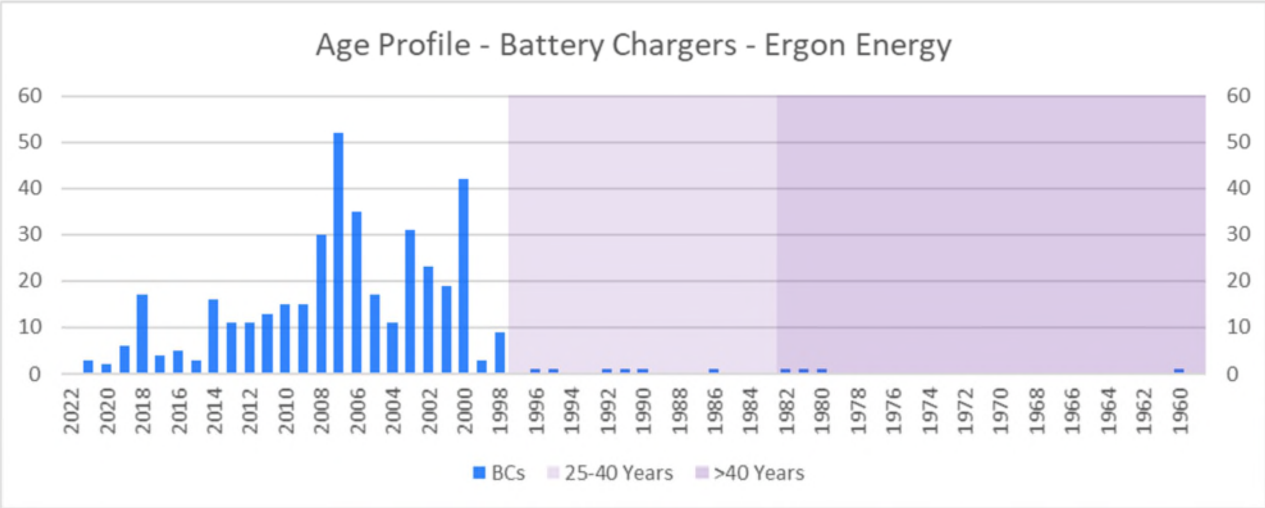

Figure 1: Battery Charger Age Profile

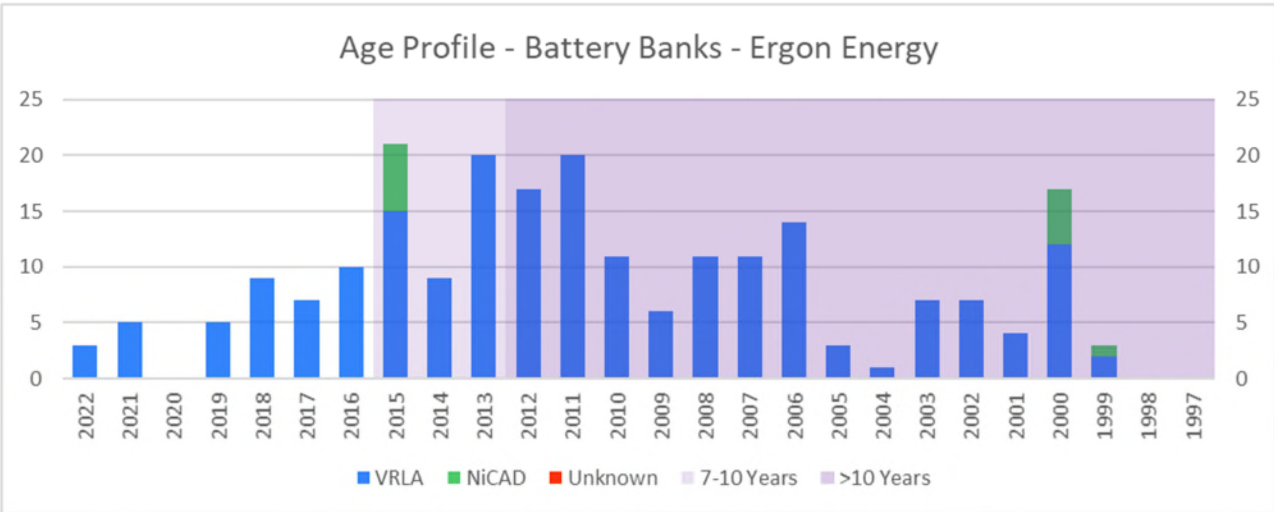

Figure 2: Battery Bank Age Profile

The battery banks for the DC supply systems are replaced routinely at 7 years. This timeframe is based upon installation conditions and historical knowledge of battery cell failures in the substations.

3.2 Asset Management Overview

All substations are inspected six monthly as part of routine hazard inspections, the DC supply system is inspected as part of this task with specific in-service condition assessments. The DC supply system is routinely tested every 12 months, which includes a basic loading test of the battery banks and battery charger function testing.

Loading tests typically reveal individual battery cells that are unable to discharge stored energy as intended. Individual battery monoblocs (a series of battery cells connected in series as a single purchased unit) are replaced if they do not perform as intended.

Battery chargers are tested to ensure the supply to the battery banks is consistent and charging settings are correct.

Corrective maintenance occurs following detection of battery bank or battery cell or charger failure in accordance with the Substation Defect Classification Manual.

Battery chargers are replaced proactively for when the condition deteriorates to a point where it is at end of life.

3.3 Asset Performance

Two main functional failure modes considered in the business case and modelling are defined as:

- **Unassisted Failures:** Functional failure of a DC supply system under normal operating conditions and not caused by any external intervention such as abnormal weather or human.
- **Defects:** A DC supply system 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.

The historical failures for chargers and battery banks are shown in Figure 3 and Figure 4 respectively. The failures indicate a low profile except one year in both charger and battery banks.

Additionally, the annual numbers of P1 and P2 level defects for chargers and battery bank are shown in Figure 4 and Figure 6 respectively. 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).

Battery charger defects have been decreasing over time, while battery banks defects are on the rise.

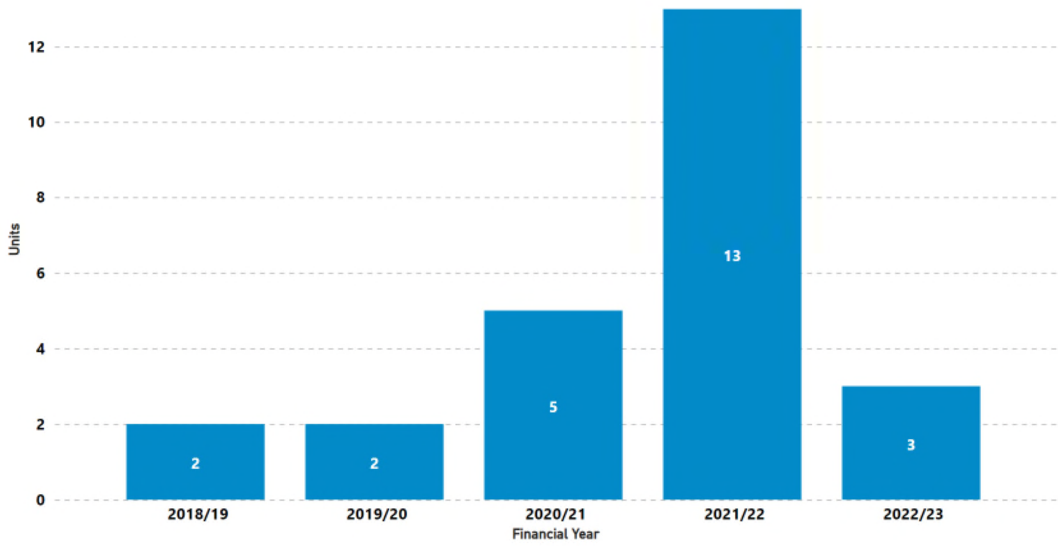

Figure 3: DC Supply Battery Charger Failures

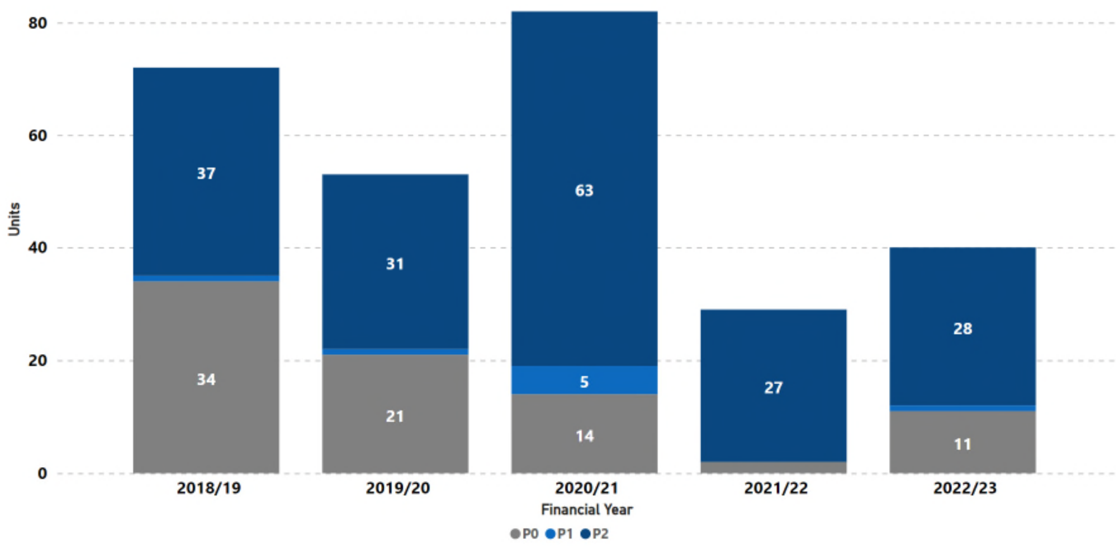

Figure 4: DC Supply Battery Charger Defects

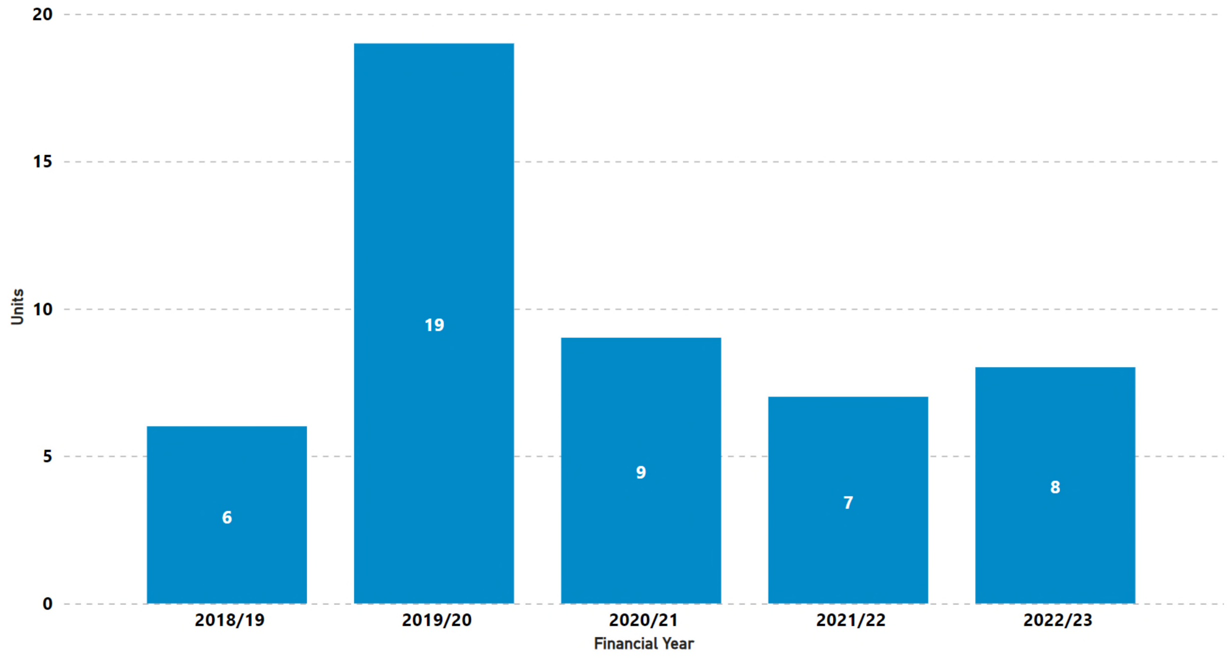

Figure 5: Battery Bank Failures

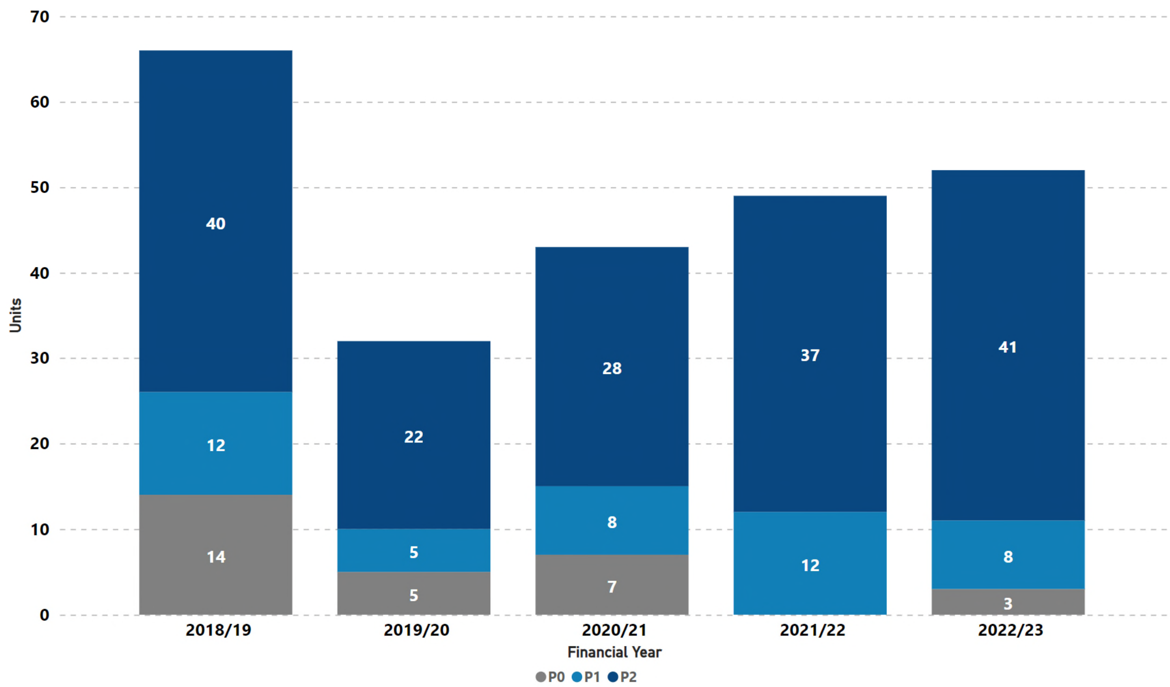

Figure 6: Battery Bank Defects

3.3.1 Consequence of Failure (CoF)

The key attributes of the battery charger modelling approach in determining the consequence of failure are:

- **Reliability:** Reliability represents the unserved energy cost to customers of network outages and is based on an assessment of the amount of Load at Risk in circumstances where the battery charger fails, and loss of DC supply occurs when the battery bank is depleted.
- **Financial:** The financial cost of failure is derived from an assessment of the likely replacement costs incurred by the failure of the asset.
- **Safety:** There is a risk of multiple serious injuries or fatality following a failure of a battery bank. The safety risk is also a derivative of the full loss of supply scenario where the DC supply system has insufficient capacity to operate circuit breaker trip circuitry.

3.3.2 Likelihood of Failure (LoF)

The likelihood of failure refers to the probability of a particular outcome or result occurring as a result of a given event or action. To estimate the likelihood of consequence, Ergon has utilised a combination of historical performances and researched results. Ergon 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, Ergon also has conducted extensive research to gather relevant information and data related to the respective risk criteria.

4 IDENTIFIED NEED

4.1 Problem Statement

The DC supply systems for Ergon substations provides a critical backup supply for the communication and protection devices when a fault occurs. The components of the DC supply systems require constant maintenance, testing and replacement to ensure this backup supply is readily available and operates as needed.

Ergon has an aging population of DC battery chargers that are nearing or have exceeded expected end of life with several manufacturers no longer operating. While life extension of these chargers is desirable, the lack of spare parts/manufacturer support and a proportion of assets that have exceed their expected life presents a risk that needs to be monitored and managed in order to meet asset management objectives.

With replacement of specific chargers that have exceeded the stated end of life and are still serviceable but no longer have spare parts or manufacturer support, these units would provide support for existing installed similar chargers. Allowing the business to extend the life of aging and unsupported chargers and reducing the overall age of the fleet.

The records pertaining to battery chargers and banks are often inaccurate and incomplete, hindering effective reporting.

4.2 Compliance

The management of DC supply systems is guided by the following legislation, regulations, rules and codes:

- National Electricity Rules (NER)
- Electricity Act 1994 (Qld)
- Electrical Safety Act 2002 (Qld)
- Electrical Safety Regulation 2013 (Qld)
- Electrical Safety Code of Practice 2010 – Works (ESCOP)
- Work Health & Safety Act 2014
- Work Health & Safety Regulation 2011
- Ergon Corporation Limited Distribution Authority No D01/99.

5 ASSET LIMITATION FORECAST SUMMARY

5.1 Asset Condition Limitations

Several known battery chargers have exceeded their expected service life with no spares or manufacturer support. These assets require replacement to ensure ongoing reliable service and support to other units that are still in service.

5.2 Age Based Battery Charger Replacement

With around 38% (approx. 160) of battery chargers exceeding their expected life by the end of the regulatory period 2030, it is expected there will be an increase in battery charger failures with less spare parts available. The proposal is to replace 20 chargers a year for the five-year regulatory period (2025-2030) thereby reducing the overall age profile and ensuring existing assets are still supported by both manufacturer and available spare components. The routine replacement program volume for battery banks is also shown in Table 1.

Replacement Volumes	2025/26	2026/27	2027/28	2028/29	2029/30	Total
Battery Chargers	20	20	20	20	20	100
Battery Banks	31	48	49	76	49	253

Table 1: DC System Replacement Volume Forecast

6 RECOMMENDATION

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