DC Supply 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	6/4/2023	Asset Strategy Engineer
Draft v0.2	Initial Release	31/05/2023	Asset Strategy Engineer
V1.0	Finalised	22/11/2023	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

Title	DC Supply Replacements
DNSP	Energex
Expenditure category	☒ Replacement ☐ Augmentation ☐ Connections ☐ Tools and Equipment ☐ ICT ☐ Property ☐ Fleet
Identified need	☐ 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 Energex during the regulatory period 2025-30, in accordance with the lifecycle management strategies detailed in the Asset Management Plan To meet the challenges of Energex's DC supply system population condition; system replacements will be an ongoing endeavour. Around 9% (approx. 72) of battery chargers in the DC Supply Systems in Energex will exceed 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 Energex's exposure to network safety, reliability, and financial risks.
Expenditure	We are proposing to replace an average of 10 chargers per year for the 5-year regulatory period (2025-2030) thereby reducing the overall age profile and ensuring existing assets are still supported by the manufacturer and spare components are available. Battery banks are proposed to be replaced routinely at 6 years.
Benefits	This program enhances the safety of the public and our work crews, improves network reliability, reduces DC Supply System defect management resource requirements and costs. Proactive battery charger replacements will also improve battery life through ensuring charging profiles remain correct and suitable.

Expenditure table:

Year	2025-26	2026-27	2027-28	2028-29	2029-30	2025-30
$m, direct 2022-23	0.80	0.86	0.43	0.27	0.32	**2.68**

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 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 system is critical to the integrity of the Energex network as many devices and equipment rely on it for their operation in a substation. In the event 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 in the case of a fault in the associated network covered by the protection system. 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 Energex 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 900 DC supply systems in the Energex network and are typically managed based on asset condition and risk.

The age profile for the battery chargers in the DC supply systems shows in Figure 1 a growing population of units beginning to reach end of life with which EQL has deemed to be 25 years based on manufacturer specifications and industry standard and our maintenance programs.

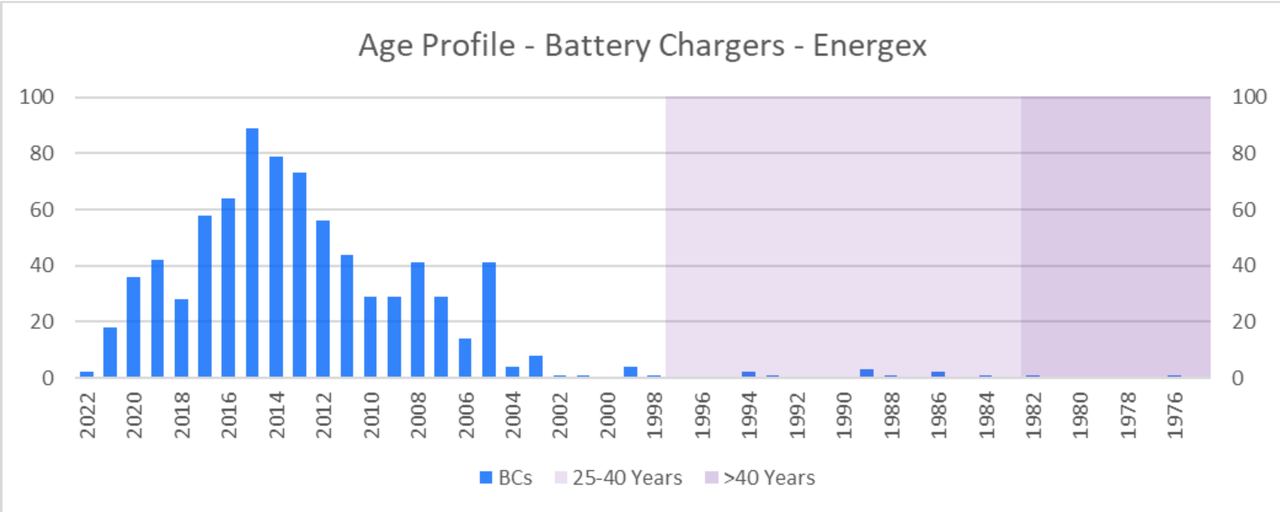

Figure 1: Battery Charger Age Profile

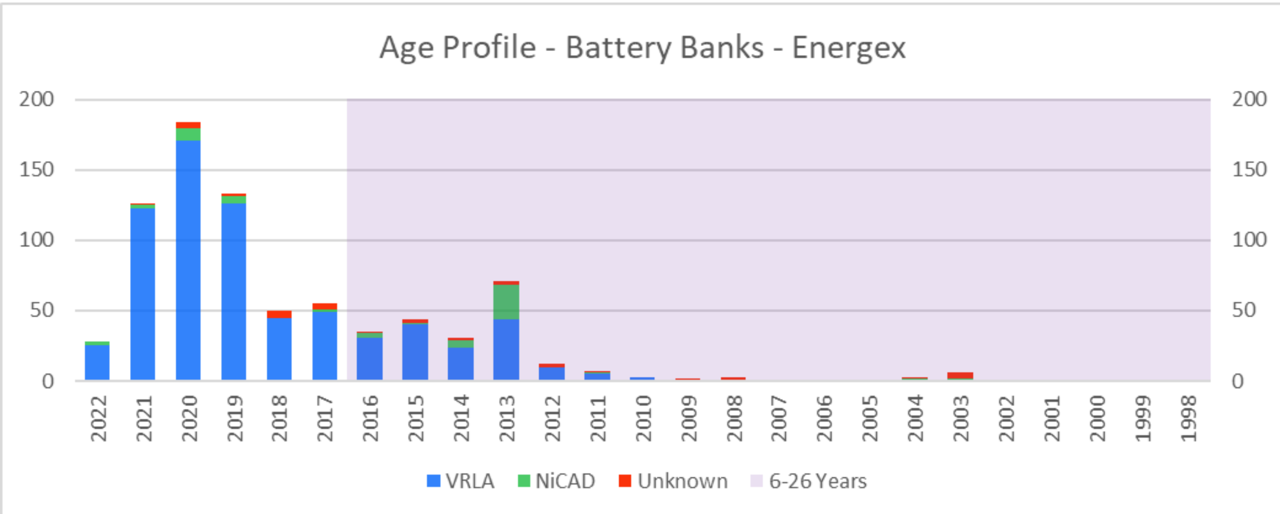

Figure 2: Battery Bank Age Profile

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 the 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.

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 (1 and P0).

The historical failures for chargers and battery banks are shown in Figure 3 and Figure 5 respectively. Additionally, the annual numbers of P1 and P2 level defects for chargers and battery bank are shown in Figure 4 and Figure 6 respectively. Both the failure and defect graphs showing a declining trend reflecting the improvement in management of these DC system equipment (Battery Bank and Battery Chargers).

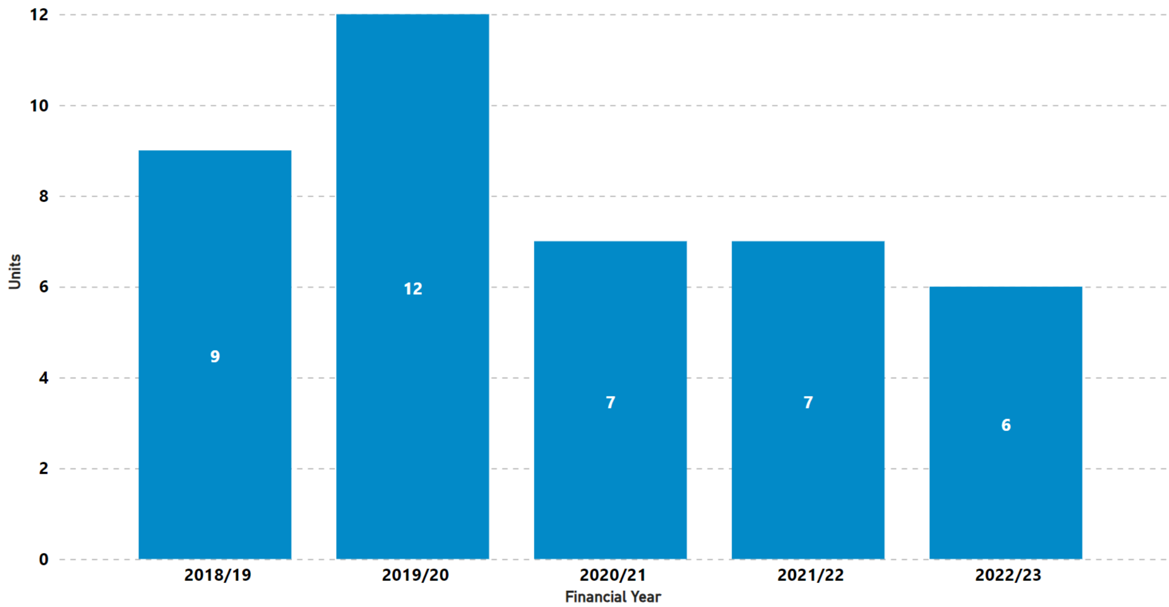

Figure 3: Battery Charger Unassisted Failures

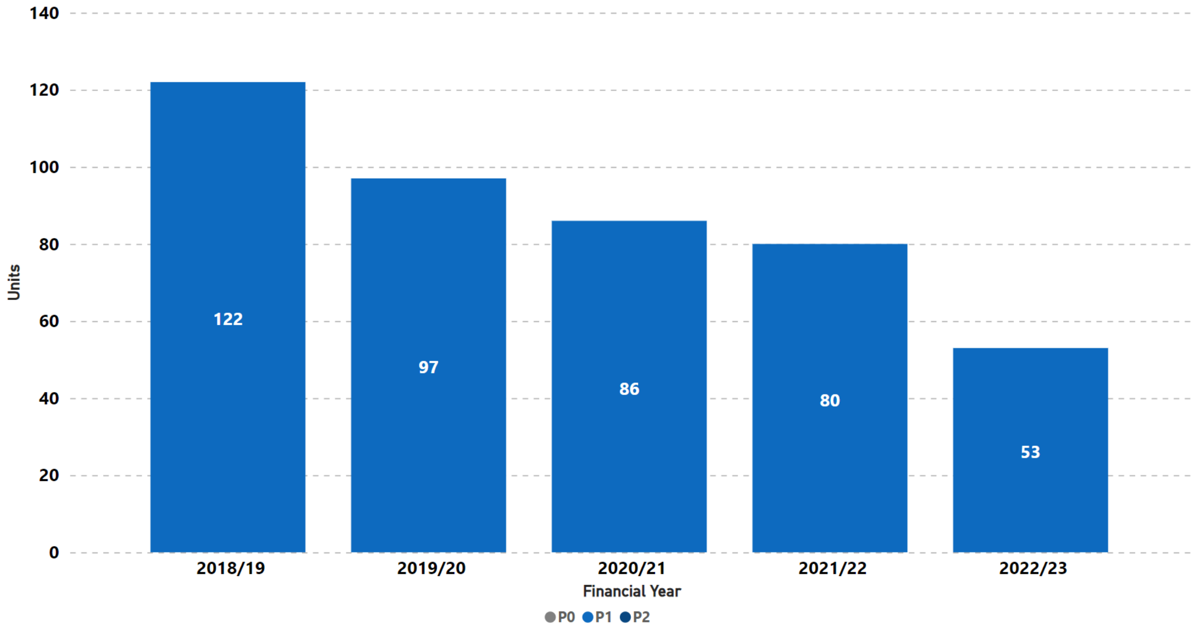

Figure 4: Battery Charger Defects

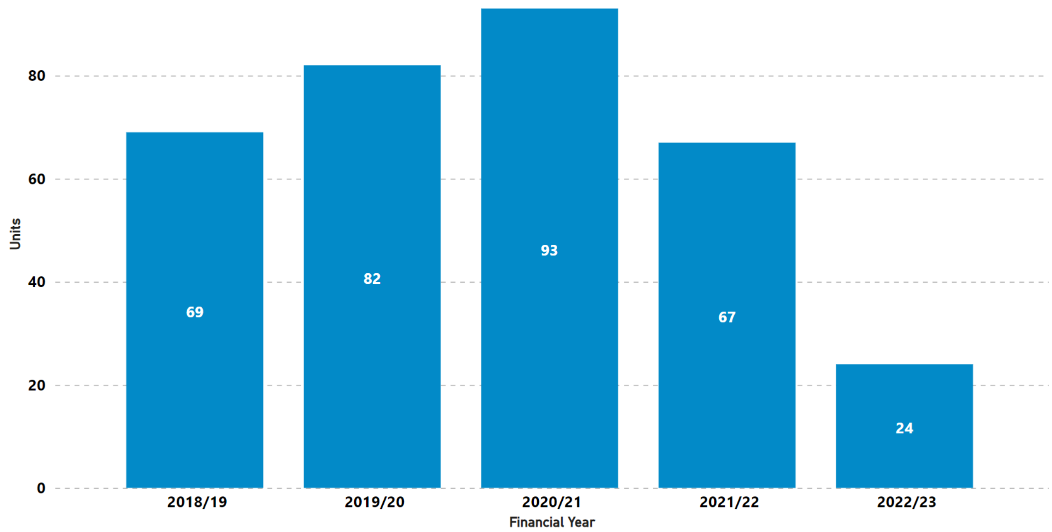

Figure 5: Battery Bank Unassisted Failures

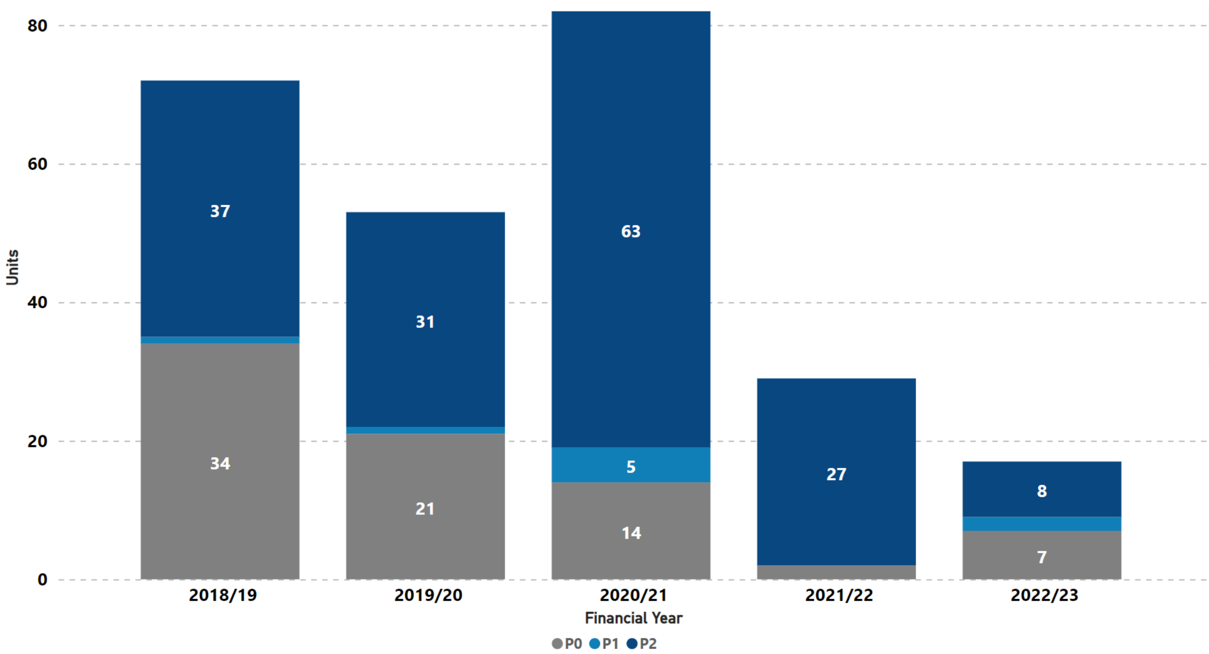

Figure 6: Battery Bank Defects

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. This is a very low likelihood scenario as crews will be on site and secure DC supply before the battery bank lose capacity.
- **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 also is 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 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

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

The 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, would allow the replaced unit to provide support for existing installed similar chargers by utilising their spare parts. This would allow us to extend the life of ageing and unsupported chargers and reducing the overall age of the fleet.

There is also an opportunity to ensure that end of life for many of our DC supply assets is reached with improved installation conditions. Several systems are installed in control rooms without air-conditioning and therefore operate in environments that are above the operating temperature of both the battery and the charger and Energex has seen a premature end of life of several battery systems. Through improving the installation conditions Energex should see an extended life of the battery bank to at least the expected/planned end of life.

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
- Energex Limited Distribution Authority No. D07/98

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 9% (approx. 72) 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 10 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. The routine replacement program volume for battery bank is also shown in Table 1.

Replacement Expenditure	2025/26	2026/27	2027/28	2028/29	2029/30	Total
$m, direct 2022-23	0.80	0.86	0.43	0.27	0.32	**2.68**
Volume	15	16	8	5	6	**50**

Table 1: DC System Replacement Expenditure 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 continue with proactive replacement volume for battery chargers and routine battery bank replacement, with a focus on optimising existing processes and enhancing efficiencies where possible.