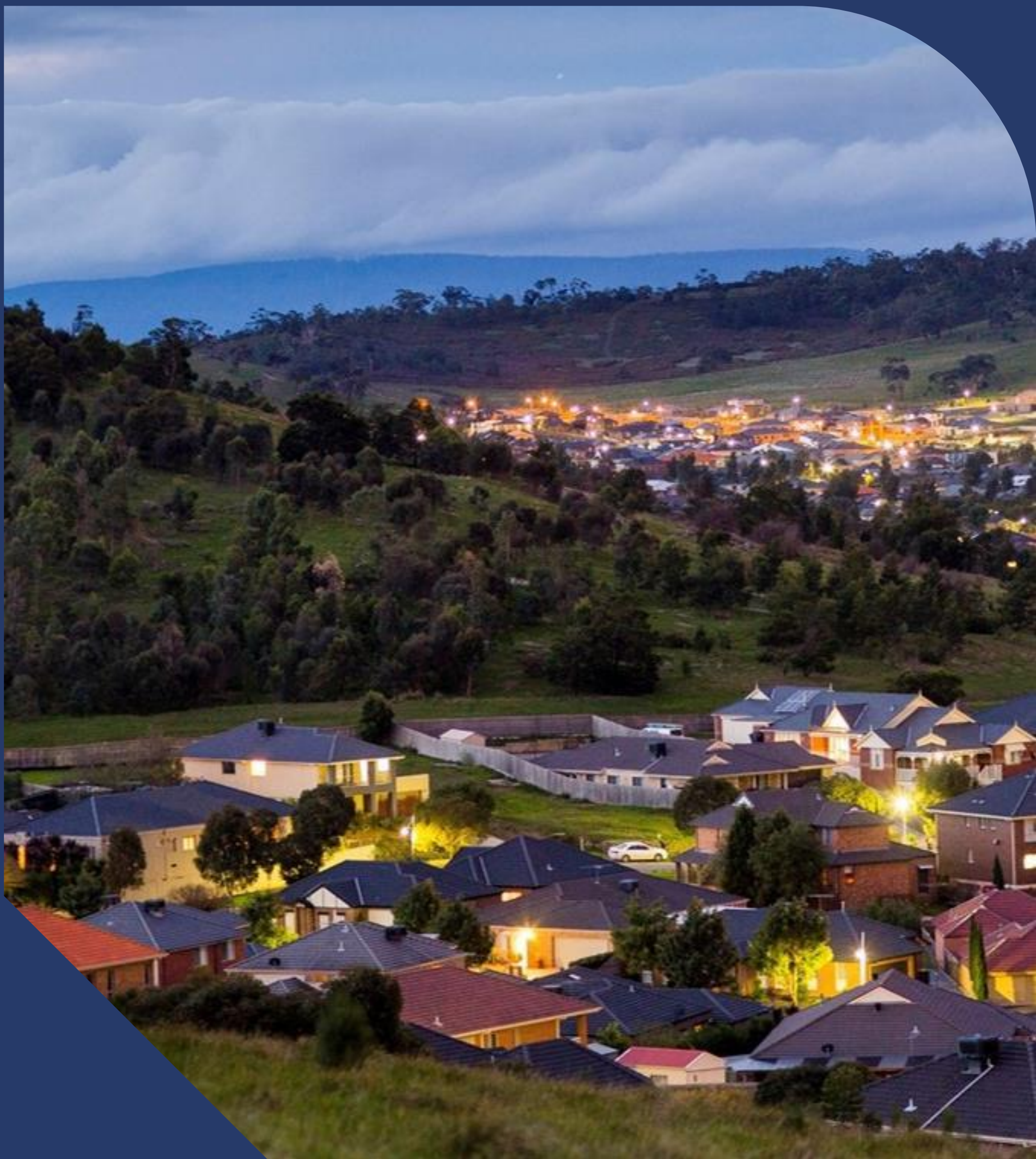
AusNet

Auxiliary Power Systems

AMS – Electricity Distribution Network



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AusNet

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1. Executive Summary

This document is part of the suite of Asset Management Strategies relating to AusNet's electricity distribution network. The purpose of this document is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of Auxiliary Power Systems.

This strategy applies to Auxiliary Power Systems, that is the DC and AC supply systems installed in electricity distribution network zone substations to allow network equipment to operate as required. There are 71 sites which contain Auxiliary Power Systems, with a total of 114 medium voltage station service transformers installed providing 415V AC supply, that range in size from 25kVA to 750kVA. There are also 153 battery banks and associated DC chargers providing the DC supply at the sites. Battery sizes range up to 400Ah capacity and up to 250V DC.

Batteries are analysed using only asset service life data for likelihood assessment. A Weibull distribution is then used to determine parameters for calculating probability of failure (PoF) and its remaining life.

Using the probability of failure and consequence of failure and unserved energy at risk, a risk assessment for Auxiliary Power System is performed to establish an economically prudent replacement program.

Proactive management of Auxiliary Power System inspection, condition monitoring and replacement practice is required to ensure that stakeholder expectations of cost, safety, reliability and environmental performance are met.

1.1. New Assets

All new DC Systems shall be installed with:

- 125V DC X and Y batteries (10 hour rating), chargers fully duplicated and segregated;
- Isolation boards, distribution cubicles as per appropriate Australian Standard and AusNet Station Design Manual;
- DC / DC converters where other voltage levels are required;
- Individual battery cell monitoring systems (voltage and impedance);
- SCADA alarm monitoring and control; and
- Battery room / container / kiosk which comply with Australian Standard and AusNet Station Design Manual.

All new AC Systems will be installed with a new switchboard fitted with Auto-changeover and wired in compliancy with AS/NZS 3000.

1.2. Inspections and Monitoring

Continue existing inspections and monitoring activities in line with PGI 02-01-04 and SMI 32-01-01

1.3. Maintenance

- Continue existing maintenance activities in line with PGI 02-01-04 and SMI 32-01-01
- Investigate and acquire (if feasible) the use of spare battery trailer or other methods to keep spare batteries for individual cell replacement or emergency full battery bank replacement.

1.4. Refurbishment

- Refurbishment of battery room to comply with Australian Standard and Ausnet Station Design Manual must be carried out during battery replacement work
- Installation of AC and DC system failure alarms and DC system earth fault alarms where applicable.

1.5. Replacement

- Replace single, aging and poor health battery banks at critical Zone Substations as per new Auxiliary Power System asset and perform DC segregation.
- Replace single, aging and poor heath battery bank for non-critical Zone Substations as per new, battery asset Duplication of battery bank and charger may not be required.
- Replace aging DC supply cables which cause earth fault problems.
- Replacement of aging and high risk AC Auxiliary Power System as part of replacement of battery bank as per new asset.

1.6. Research and Development

- Continue to monitor the performance of new emerging battery technology and installation.
- Investigate technique of battery condition trending to improve battery condition for replacement and maintenance regime.
- Continue to monitor new development in maintenance-free and long-life battery type.

2. Introduction

2.1. Purpose

The purpose of this document is to outline the inspection, maintenance, replacement, and monitoring activities identified for economic life cycle management of Auxiliary Power System. This document is intended to inform asset management decisions and communicate the basis for activities.

In addition, this document forms part of our Asset Management System for compliance with relevant standards and regulatory requirements. It is intended to demonstrate responsible asset management practices by outlining economically justified outcomes.

2.2. Scope

Included in this strategy is Auxiliary Power System, both DC and AC supply systems installed in the electricity distribution network zone substation, 66kV regulator sites and various other smaller MV sites.

Excluded from this strategy is Auxiliary Power System associated with Lines Assets such as radio towers or pole top devices, BESS and SAPS.

2.3. Asset Management Objectives

The high-level asset management objectives are outlined in *AMS 01-01 Asset Management System Overview*.

The electricity distribution network objectives are stated in *AMS 20-01 Electricity Distribution Network Asset Management Strategy*.

3. Abbreviations and definitions

TERM	DEFINITION
OLTC	On Load Tap Changers
SCADA	System Control and Data Acquisition
CB	Circuit Breaker
DC	Direct Current
AC	Alternating Current
BESS	Battery Energy Storage System
SAPS	Standalone Power System
SDM	Station Design Manual
REFCL	Rapid Earth Fault Current Limiter
DIC	Digital Interface Cubicles
SRC	Scheme Replacement Cost
EDDAM	Enhanced Data-Driven Asset Management
CoF	Cost of Failure
PoF	Probability of Failure
LoC	Likelihood of Consequence
ESV	Energy Safe Victoria
NBN	Australia's National Broadband Network
4G / 5G	Fourth and Fifth generation wireless network
ZSS	Zone Substation
EPA	Environment Protection Authority Victoria
PGI	Plant Guidance and Information
SMI	Standard Maintenance Instruction
S/S Tx	Station Service Transformer

4. Asset Description

4.1. Asset Functions

Auxiliary Power Systems are essential for the safe and reliable operation of zone substation equipment.

Each zone substation contains two components of Auxiliary Power System:

(1) AC Systems; and

(2) DC Systems.

4.1.1. AC Systems

AC systems supply energy for transformer cooling, battery chargers for the DC Systems, transformer OLTCs, station lighting, air compressors, air conditioning and general purpose/maintenance outlets at 415V.

Station AC systems include auxiliary/service transformers, switchboards and all wiring associated with the AC supply circuits.

ZSS have their AC supplied from within the station, usually via a station service transformer from a supply feeder or externally from a street supply.

4.1.2. DC Systems

DC systems supply energy for protection and control systems, SCADA, instrumentation, metering, communications equipment, alarm systems, circuit breaker (CB) controls and CB auxiliary power.

These loads are critical for the safe and reliable operation of the substation and require an uninterrupted power supply, even when the power supply into the substation is interrupted.

Station DC systems include batteries, battery chargers, DC isolation and distribution boards, DC / DC converters, monitoring and alarm system and all wiring associated with the DC supply circuits.

4.2. Population

4.2.1. Population Considerations

The population profile for Auxiliary Power System is crucial for effective lifecycle management. This profile includes detailed data on the quantity, types, locations, and specifications of these assets within the electrical distribution network.

A comprehensive understanding of the population profile allows asset managers to:

- Identify critical assets: Determine which Auxiliary Power Systems are essential for maintaining the integrity and reliability of the network.
- Allocate resources efficiently: Plan and allocate maintenance / replacement resources effectively by knowing the exact number and location of assets. For instance, knowing that certain stations with single battery bank can help in prioritising replacement program.
- Risk management: Assess and manage risks associated with different assets. For example, if the population profile indicates that certain sites with Auxiliary Power System are in bushfire-prone area, battery banks must be maintained at a regular intervals as per schedules.
- Optimise maintenance schedules: Develop optimised maintenance schedules based on the distribution and condition of assets. For instance, single auxiliary power systems that are critical for SCADA and protection

systems might be scheduled for more frequent inspections and maintenance or on-line monitoring retrofitted to prevent any potential failures.
- Enhance reliability and safety: Ensure that all components, including AC and DC Auxiliary Power Systems, meet the required standards for reliability and safety. For example, if the profile reveals that certain battery chargers are aged, outdated and no longer meet safety standards, these can be prioritised for replacement.
- Support strategic planning: Inform long-term strategic planning and investment decisions.

4.2.2. Geographic Impact Areas

The AusNet electrical distribution network covers a significant portion of Victoria, including Melbourne's northern and eastern suburbs, and extends across eastern and north-eastern Victoria. This region encompasses a diverse range of geographic locations, each with specific environmental impacts on auxiliary power systems. Understanding these impacts is essential for effective asset management within the AusNet electrical distribution network.

Notable examples include:

- Corrosive Areas: Coastal areas and industrial regions where salt and pollutants are prevalent can cause corrosion of metallic components in Auxiliary Power System. Example: Auxiliary Power Systems in coastal towns like Wonthaggi require regular inspections and maintenance to identify early corrosion of battery posts.
- Bushfire Areas: Bushfire-prone areas, common in many parts of Victoria, pose a risk of fire damage to community. Example: In the bushfire-prone regions, Auxiliary Power Systems must be maintained before summer season to ensure the operation of REFCL equipment.
- Seismic Zones: Though less common, areas with potential seismic activity may require Auxiliary Power Systems to be constructed with flexibility and resilience to absorb and dissipate seismic forces, reducing the risk of structural failure.

4.2.3. Population by Type

Asset Type: Auxiliary Power System

AusNet has a range of Auxiliary Power Systems on the distribution network, including both AC and DC supply systems installed in zone substations, 66kV regulator sites, and various other smaller MV sites.

AC Systems

- Summary Explanation of Form and Function: AC systems supply energy for transformer cooling, battery chargers for the DC Systems, transformer on load tap changers (OLTCs), station lighting, air compressors, air conditioning, and general purpose/maintenance outlets at 415V. Station AC systems include auxiliary/service transformers, switchboards, and all wiring associated with the AC supply circuits.
- Purpose within the Asset Class: The AC systems are crucial for ensuring the proper functioning of various substation equipment, providing the necessary power for cooling, lighting, and other auxiliary needs.
- Purpose within the Network Design: In the network design, AC systems ensure the operational efficiency of substations by supplying power for essential equipment and maintenance activities. They are usually supplied from within the station, via a station service transformer from a supply feeder or externally from a street supply.
- Process Function: The AC system continuously supplies power to essential equipment and services within the substation, ensuring uninterrupted operation and maintenance.

Sub-assets of AC Systems:

1. Auxiliary/Service Transformers
    - Form and Function: These transformers step down the high voltage from the main supply to a lower voltage suitable for use by the substation’s auxiliary systems.
    - Purpose: Provide a stable AC power supply for various substation operations.
    - Network Design: Integrated into the substation to ensure a reliable power supply for auxiliary equipment.

   - Process Function: Step down voltage and distribute it to different auxiliary systems.
2. Switchboards
   - Form and Function: Switchboards control and distribute the AC power to various substation auxiliary equipment.
   - Purpose: Ensure the safe, efficient and redundant distribution of AC power within the substation.
   - Network Design: Central point for managing the distribution of AC power to auxiliary systems.
   - Process Function: Control, protect, and distribute AC power to various substation components.
3. Wiring and Circuits
   - Form and Function: Includes all wiring and circuit components associated with AC supply circuits.
   - Purpose: Facilitate the distribution of AC power from the auxiliary transformers to the substation equipment.
   - Network Design: Ensures the safe and efficient transmission of AC power within the substation.
   - Process Function: Transmit AC power to different auxiliary systems and components.

DC Systems

- Summary Explanation of Form and Function: DC systems supply energy for protection systems, SCADA, instrumentation, metering, communications equipment, alarm systems, CB controls, and CB auxiliary power. These systems are critical for the safe and reliable operation of the substation.
- Purpose within the Asset Class: The DC systems provide a reliable power supply for critical control and protection equipment, ensuring these systems remain operational even during power interruptions.
- Purpose within the Network Design: In the network design, DC systems are essential for maintaining the functionality of protection and control equipment. This includes providing power to SCADA, CB controls, and other critical infrastructure.
- Process Function: The DC system continuously supplies power to critical protection and control equipment, with batteries providing backup power in case of AC supply failure. This ensures the reliability and safety of substation operations.

Sub-assets of DC Systems:

1. Batteries
   - Form and Function: Batteries store energy to supply the DC system during power interruptions.
   - Purpose: Provide an uninterrupted power supply for critical control and protection systems.
   - Network Design: Essential for ensuring the continuous operation of substation control and protection equipment.
   - Process Function: Store and supply energy to the DC system during outages or AC supply failures.
2. Battery Chargers
   - Form and Function: Battery chargers maintain the charge of the batteries and supply power to the DC system during normal operations.
   - Purpose: Ensure batteries are charged and ready to supply power when needed.
   - Network Design: Integral part of the DC system, ensuring batteries are always fully charged and operational.
   - Process Function: Charge the batteries and supply power to the DC system during regular operations.
3. DC Isolation and Distribution Boards
   - Form and Function: These boards isolate and distribute the DC power to various substation equipment.
   - Purpose: Safely manage the distribution of DC power to different control and protection systems.
   - Network Design: Key component in distributing DC power within the substation.
   - Process Function: Isolate and distribute DC power to various substation control and protection systems.
4. Wiring and Circuits
   - Form and Function: Includes all wiring and circuit components associated with DC supply circuits.
   - Purpose: Facilitate the distribution of DC power from the batteries and chargers to the substation equipment.
   - Network Design: Ensures the safe and efficient transmission of DC power within the substation.
   - Process Function: Transmit DC power to different control and protection systems.

4.2.4. Population Profile

There are 71 sites on the distribution network which contain Auxiliary Power Systems.

The majority of these are ZSSs, however, some of these sites are simpler, having a single piece of equipment which requires only single Auxiliary Power System such as a 66kV regulator site or some MV switchboards sites.

4.2.4.1 AC Systems

There is a total of 114 station service transformers (S/S Tx) installed within the distribution network with most ZSSs having redundant station services transformers.

The rating of individual station service transformers ranges from 25kVA and can be as high as 750kVA and shown in figure 1 below as a percentage of the total population.

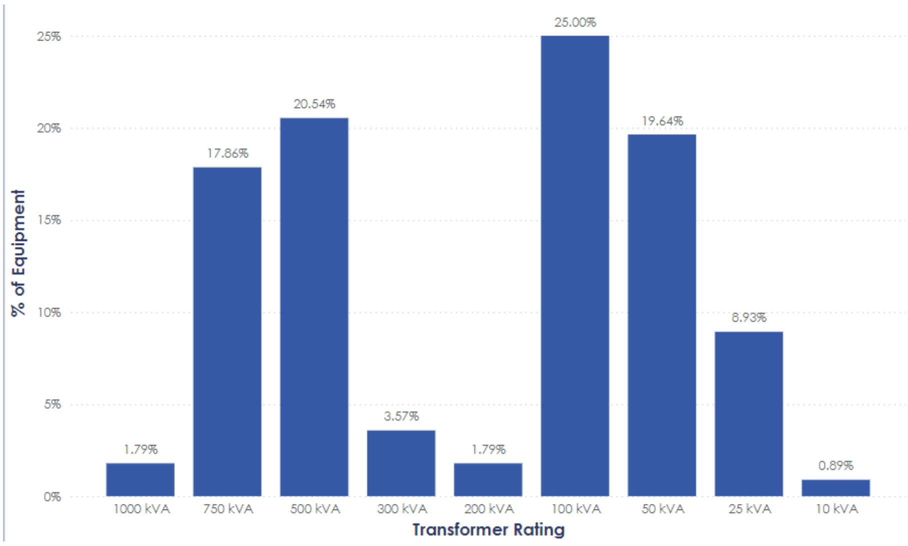

Figure 1: Rating Profile of Station Service Transformers

4.2.4.2 DC Systems

The main components of a DC system are batteries and battery chargers. The current standard for DC Systems is for fully duplicated DC Systems. In this arrangement each DC System is fully segregated from the other system (i.e. separate batteries and battery chargers). Control and communication equipment or other equipment which requires different voltage is supplied by via DC / DC converters. Older ZSSs have dedicated single control, alarm and communication batteries separate from the main DC systems.

4.2.4.2.1 Batteries

There are 162 battery banks providing power. This count is the number of individual battery banks, for example a duplicated system has two battery banks. Battery bank voltages range from 6V DC to 250V DC, with 125V DC the most common bank size as shown in Figure 2. Capacities range in size up to 400Ah.

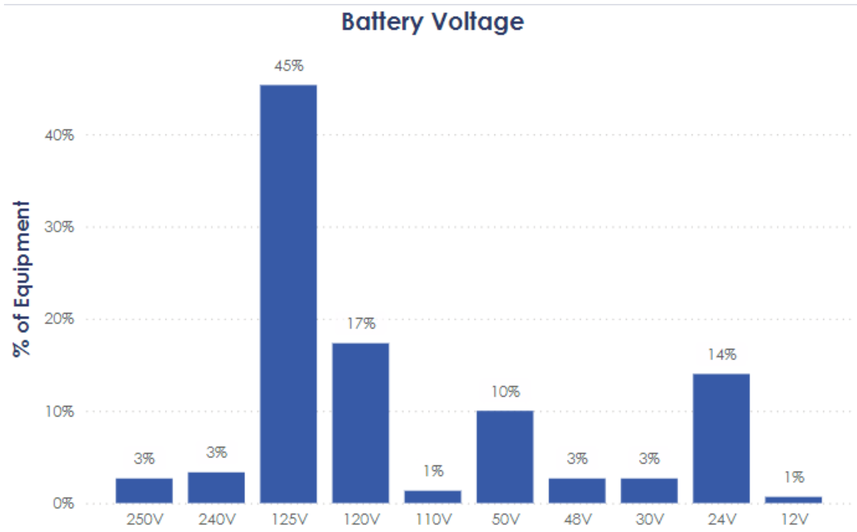

Figure 2: DC Battery Voltages

The vast majority are valve regulated lead acid batteries. The remainder are flooded lead acid batteries, which are being phased out as they are obsolete and more hazardous such as acid spill and fire risk.

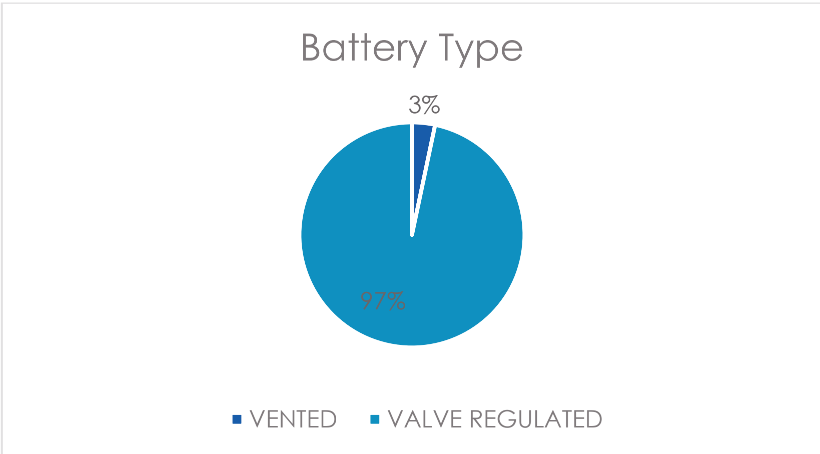

Figure 3: Battery Type

4.2.4.2.2 Battery Chargers

The number of battery chargers in service is equal to the number of battery banks on the network, that is 162 battery chargers. The battery chargers supply the DC panels and provide float charge to the batteries. In the event the AC systems fail, the batteries will supply the DC panels.

The current battery charger standard requires chargers to be installed with temperature control functionality. Temperature control functionality regulates the charge voltage in line with battery specification maximising the life span of individual battery cells. Figure 4 illustrates the battery charger population by whether the battery charger has temperature control.

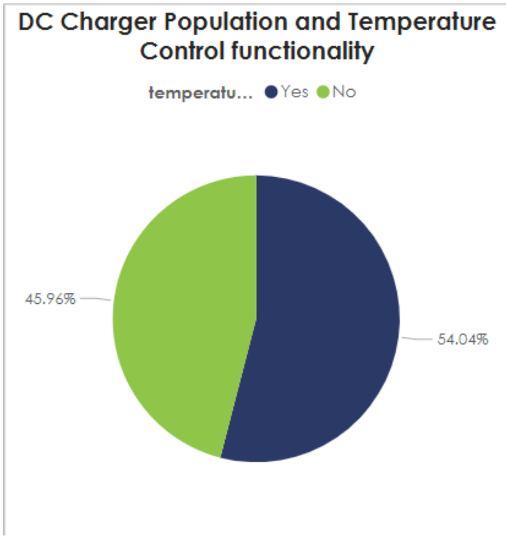

Figure 4: Battery Charger Population and Temperature Control functionality

4.3 Age Profile

Understanding the age profile of Auxiliary Power System is crucial for effective asset management and lifecycle planning. Knowing the age distribution of these assets helps in predicting their remaining useful life and planning maintenance, upgrades, or replacements accordingly.

- AC Systems: The age profile of AC systems, including station service transformers and switchboards, can indicate potential issues related to component ageing and degradation. Older systems may require more frequent inspections and condition assessments to ensure they continue to operate safely and efficiently. For example, proactive testing and monitoring of transformer insulation resistance in older AC systems can prevent unexpected failures and extend their service life.
- DC Systems: The age profile of DC systems, including batteries and battery chargers, can reveal areas where performance may decline over time. By analysing the age profile, asset managers can identify systems at higher risk of failure and prioritise them for maintenance or replacement especially with single battery bank ZSSs. For instance, replacing aging battery banks and chargers or performing discharge testing of aging battery banks can prevent costly outages and enhance network reliability.

4.3.1 AC System Age Profile

AC systems will usually be the same age as the station they supply but may have been augmented as the station has grown. They are normally replaced and upgraded when a station is rebuilt.

Figure 5 illustrates the age profile of Station Service Transformer fleet as a percentage of the total population.

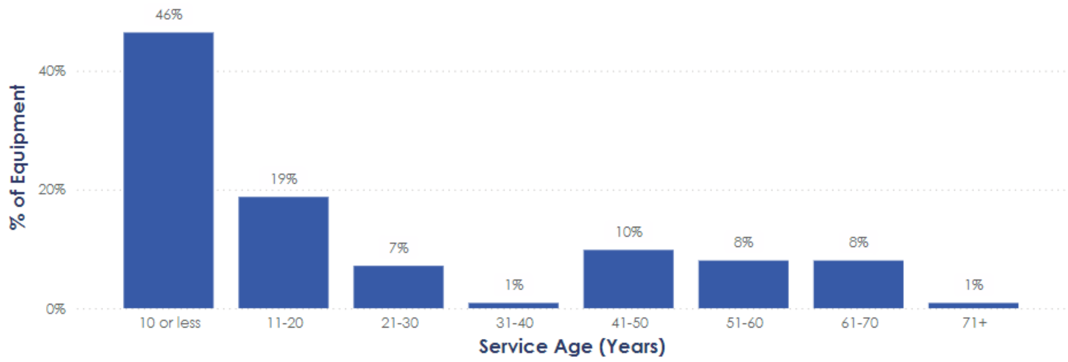

Figure 5: Station Services Transformer Age Profile

4.3.2 DC System Age Profile

Batteries

As shown in Figure 6, the oldest battery is recorded as 24 years. The useful life of a battery is typically 12 years where it can maintain its rated capacity above 80%. If the environment in which the battery is installed is not temperature controlled, the battery life may be substantially less than the warranty life and can be based on experience as low as 10 years life.

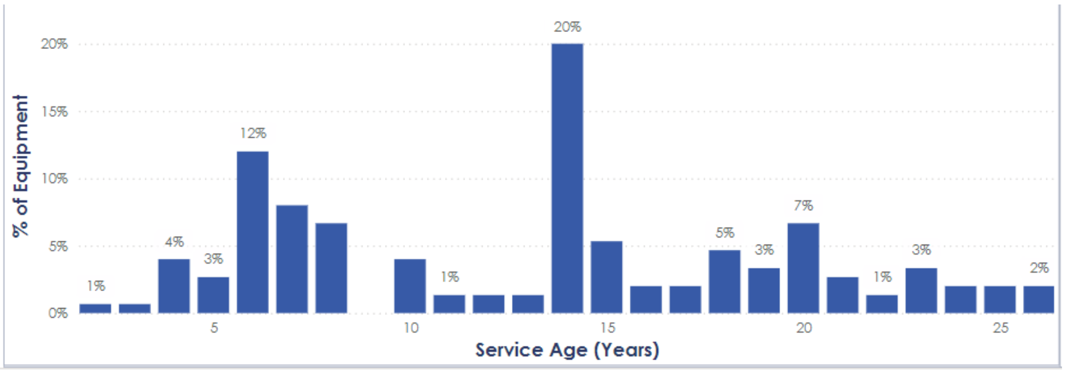

Figure 6: DC Battery Age Profile

Over a 40% of the battery population is 10 years old or greater.

Battery Charger

Figure 7 shows the age profile of battery charger. The recorded age of the oldest battery chargers are 45 years.

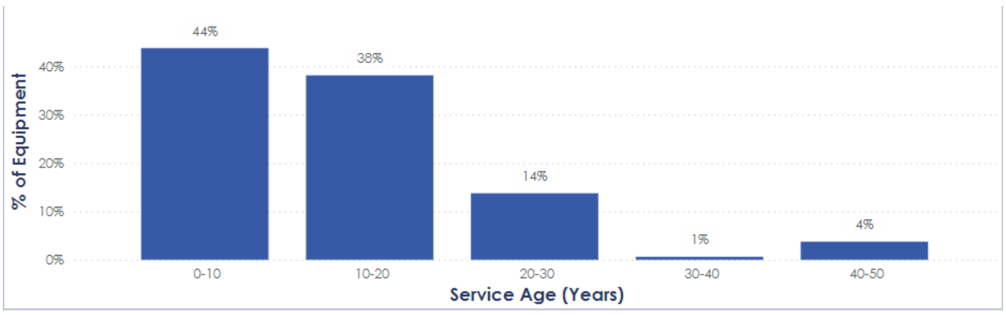

Figure 7: Battery Charger Age Profile

5 Asset Risk

AusNet maintains a risk management system designed in accordance with AS ISO 31000 Risk Management – Guidelines to ensure risks are effectively managed to provide greater certainty for the owners, employees, customers and the communities in which we operate. The risk of each asset is calculated as the multiplication of probability of failure (PoF) of the asset and the consequence of failure (CoF). The risk is then extrapolated into the future accounting for forecast changes in PoF and CoF.

In the distribution network, AusNet aims to maintain risk. Risk treatments required to achieve this over time include replacement, refurbishment, and maintenance activities, and are developed based on current risk and extrapolated risk. The overall approach to quantified asset risk management is detailed in AMS 01-09. Section 5.1, 5.2 and 5.3 of this document describe the considerations and methodologies to determine PoF, CoF and risk treatment that are unique to Auxiliary Power System asset.

5.1 Probability of Failure

Refer to *AMS 01-09 Asset Risk Assessment Overview*, section 2.3.2.2 for likelihood methodology. The analysis of each asset should include four categories: asset service life, asset utilisation/duty factor, location, and the measured or observed physical condition of the asset. However, auxiliary power system likelihood of failure is only based on asset service life due to the lack of data on other factors.

5.1.1 Failure Modes

Understanding failure modes is an important tool that supports measuring the criticality of assets, especially when assessing the risk of potential failures and their potential impact on the overall system. By identifying and analysing the various ways in which an asset can fail (including the root causes and mechanisms of failure), asset managers can better predict and mitigate risks. This understanding allows for a more accurate assessment of the probability of failure (PoF) and the consequence of failure (CoF), which, as noted above, is a core aspect of how AusNet approaches determining asset criticality.

Failure Modes by Asset Class

Assessing failure modes and utilising the detailed information about each mode plays a crucial role in various aspects of Asset Management Planning. Understanding failure modes enhances the effectiveness of risk management efforts and ensures the optimal performance and reliability of assets within the electrical distribution network. Some notable failure modes for auxiliary power systems are detailed below.

AC Systems:

- Auxiliary/Station Service Transformers
  - Insulation Degradation: The insulation material can degrade over time due to thermal ageing and environmental exposure, leading to reduced efficiency and potential electrical faults. Example: high temperatures can accelerate the decomposition of insulation material, compromising its ability to handle electrical stress effectively.
  - Mechanical Wear: Components such as windings and core laminations can suffer from wear and fatigue, affecting the transformer's ability to operate correctly. Example: Frequent load cycles may wear down the mechanical components, leading to slower or incomplete voltage regulation.
  - Moisture Ingress: Over time, moisture ingress can cause the internal components to corrode and reduce insulation effectiveness. Example: In high humidity areas, moisture ingress can corrode the internal components of transformers, compromising reliability.
- Switchboards

  - Component Fatigue: Repeated electrical switching can cause fatigue in the switchgear components, reducing their effectiveness over time. Example: Regular exposure to high current loads can wear out the internal components, making them less reliable for future operations.
  - Environmental Degradation: Exposure to harsh environments can lead to corrosion of metal components and degradation of insulation. Example: Salt spray in coastal regions can accelerate the corrosion of switchboard parts, leading to premature failure.
  - Thermal Overload: Excessive current flow can cause the switchgear to overheat, leading to thermal degradation and potential failure. Example: Sustained high current can cause switchgear components to overheat, leading to melting and failure.
- Wiring and Circuits
  - Insulation Breakdown: The insulation material can degrade over time due to thermal ageing and environmental exposure, leading to potential electrical faults. Example: High temperatures can accelerate the decomposition of insulation material, compromising its ability to handle electrical stress effectively.
  - Mechanical Damage: The wiring can suffer from mechanical damage during handling, transport, and installation. Example: Improper handling during installation can damage the insulation, leading to electrical faults.
  - Moisture Ingress: Over time, moisture ingress can cause the wiring to corrode and reduce insulation effectiveness. Example: In high humidity areas, moisture ingress can corrode the wiring, compromising reliability.

DC Systems:

- Batteries
  - Capacity Loss: Batteries can lose capacity over time due to chemical degradation, repeated charge-discharge cycles or constant over-charge.
  - Component Fatigue: over-charging battery can cause the decomposition of electrolytes within the battery which leads to cracked case or post growth problem.
  - Thermal Runaway: Excessive charging can cause the batteries to overheat, leading to thermal runaway and potential failure. Example: High charging currents can cause batteries to overheat, leading to a thermal runaway condition.
  - Moisture Ingress: Over time, moisture ingress can cause the batteries to corrode and reduce their effectiveness which leads to battery terminal corrosion.
- Battery Chargers
  - Component Fatigue: Charger's rectifier module can degrade overtime due its high duty cycle requirement, reducing their effectiveness.
  - Thermal Overload: Excessive current flow can cause the charger to overheat, leading to thermal degradation and potential failure. Example: Sustained high current can cause charger components to overheat, leading to failure.
  - Environmental Degradation: Exposure to harsh environments can lead to degradation and failure of charger's electronic devices. Example: failure of charger mimic panel which displays measurement value of auxiliary system.
- DC Isolation and Distribution Boards
  - Component Fatigue: Repeated electrical switching can cause fatigue in the switchgear components, reducing their effectiveness over time. Example: Regular exposure to high current loads can wear out the internal components, making them less reliable for future operations.

- Environmental Degradation: Exposure to harsh environments can lead to corrosion of metal components and degradation of insulation. Example: Salt spray in coastal regions can accelerate the corrosion of switchboard parts, leading to premature failure.
- Moisture Ingress: Over time, moisture ingress can cause the internal components to corrode and reduce insulation effectiveness. Example: In high humidity areas, moisture ingress can corrode the internal components, compromising reliability.

- Wiring and Circuits
  - Insulation Breakdown: The insulation material can degrade over time due to thermal ageing and environmental exposure, leading to potential electrical faults. Example: High temperatures can accelerate the decomposition of insulation material, compromising its ability to handle electrical stress effectively.
  - Mechanical Damage: The wiring can suffer from mechanical damage during handling, transport, and installation. Example: Improper handling during installation can damage the insulation, leading to electrical faults.
  - Moisture Ingress: Over time, moisture ingress can cause the wiring to corrode and reduce insulation effectiveness. Example: In high humidity areas, moisture ingress can corrode the wiring, compromising reliability.

5.1.2 Likelihood Assessment

Refer to *AMS 01-09 Asset Risk Assessment Overview,* section 2.3.2.2 for methodology of likelihood assessment.

Auxiliary power system is analysed using only asset service life data for likelihood assessment. Weibull distribution is then used to determine parameters for calculating probability of failure (PoF) and its remaining life.

5.1.3 Likelihood Profile

Figure 9 illustrates the likelihood of failure of Battery Systems as percentage of the population.

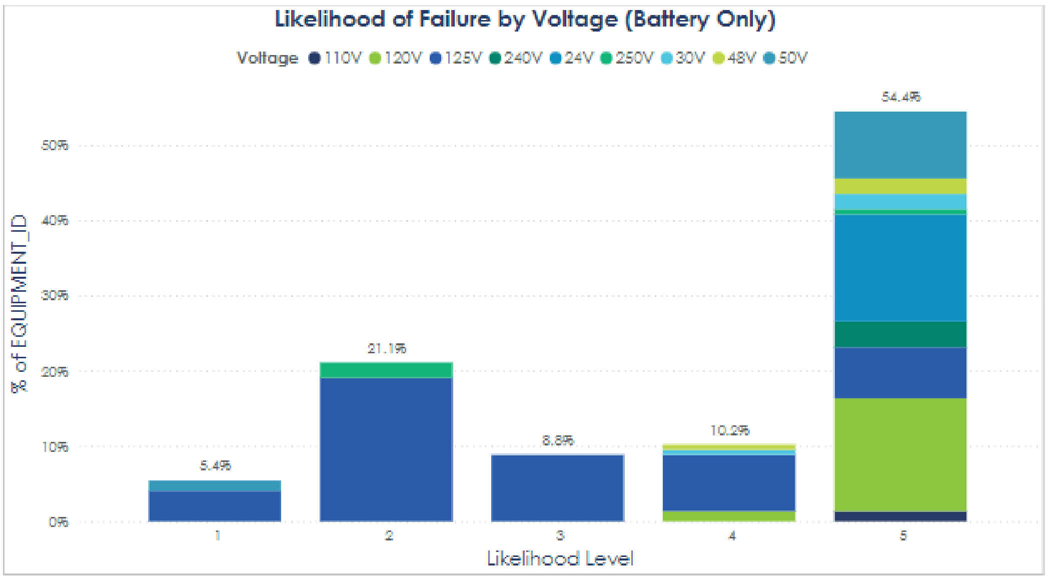

Figure 9: Battery Likelihood Profile

5.2 Consequence of Failure

Refer to *AMS 01-09 Asset Risk Assessment Overview,* section 2 for methodology of consequence of failure.

Failure of Auxiliary Power System has the potential of resulting in failing to supply customers with energy. There is also a possibility the failed Auxiliary Power System injures an employee or member of the public or affect the environment. For instance, failure of both X and Y Auxiliary Power System at the same time as failure of primary plant such as sub-transmission line or transformer etc… may potentially result in fatality or injury to an employee or member of the public. Failure of Auxiliary Power System at the same time as failure of feeder conductor may potentially result in bushfire due to no operation of REFCL equipment.

The cost resulting from Auxiliary Power System failure (cost of failure) is generally viewed through three lenses: Safety, Environment, and Customer / Reputation where it is applicable. **Error! Reference source not found.** is a summary description for each lens.

CONSEQUENCE LENSES	DESCRIPTION
SAFETY	Threat to health and safety of public and employees
ENVIRONMENT	Bushfire damage
CUSTOMER AND REPUTATION	Loss of Supply to Customer Loss of primary plant

Table 1 – Consequence Lenses of Auxiliary Power System

Consequence of value is the product of Cost of Consequence and Likelihood of Consequence.

5.2.1 Safety Cost of Consequence

The Safety Cost of Consequence incorporates all potential health and safety effects that could impact the public, customers, and employees due to failure of Auxiliary Power System and therefore in-operation of protection relays. This cost is further modified by a disproportion factor (DF) of six which recognises the high-risk nature of the electricity industry.

Event tree analysis is employed to determine the safety consequences of Auxiliary Power System. It considers the probability of redundant system failure within ZSS (if any), the probability of primary asset failure and the likelihood of a person in the vicinity of asset failure.

Note: The safety cost is insignificant compared to customer cost.

5.2.2 Environment Cost of Consequence

The Environmental Cost of Consequence which covers consequences relating to the environment which includes bushfire, flooding, contamination, community disruption, and/or pollution. This consequence is only applicable to partially in-operation of REFCL equipment due to failure of Auxiliary Power System. This cost uses bushfire cost of failure calculated for 22kV feeder.

Event tree analysis employed to determine the environmental consequences of Auxiliary Power System. It considers the probability of redundant system failure within ZSS (if any), the probability of primary asset failure and the likelihood of a person in the vicinity of asset failure.

Note: The environmental cost is insignificant compared to customer cost

5.2.3 Customer Cost of Consequence

The Community and Reputation financial costs which arise from customers not being supplied with energy and the energy market not dispatching the cheapest generators is due de-energisation of ZSS when both X and Y Auxiliary Power System fails. It also considers the amount of transferable load to adjacent ZSS and mean time to repair or replace the failed systems.

Event tree analysis employed to determine the customer consequences of Auxiliary Power System. It considers the probability of redundant system failure within ZSS (if any), the probability of primary asset failure, the VUE associated with these assets and the time taken to repair.

Refer to AMS 01-09-02 for event tree diagram of Auxiliary Power System customer consequence of failure.

5.2.4 Consequence Profile

Figure 10 illustrates the consequence of failure of Battery Systems as percentage of the population.

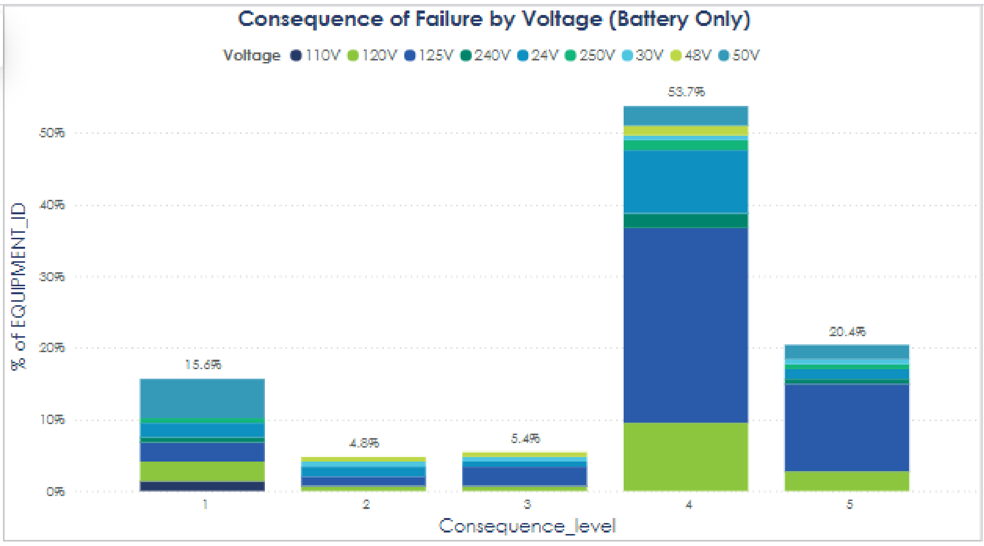

Figure 10: Battery Consequence Profile

5.3 Risk Treatment

Risk treatments are required to maintain risk by targeting reduction of PoF or CoF depending on the nature of the risk. Treatment measures include asset replacement, asset refurbishment, inspections, testing or system redesign, and are achieved through capital projects or operational expenditures. Risk treatment options are described in the section on 'Risk Treatment' in AMS 01-09.

Capital replacement is a major component of asset risk management. The prerequisites for replacing assets:

- Replacement of an asset will result in a material risk reduction
- Risks can't be feasibly managed through maintenance or refurbishment

- Monetised risk exceeds the replacement cost – i.e. replacement is economic

6 Performance

Performance assessments are a critical element of lifecycle management for Auxiliary Power Systems. These assessments provide vital information on the current state and performance of batteries, battery chargers, station service transformers, isolation boards, distribution cubicles and peripheral equipment, enabling informed decision-making regarding maintenance, repair, and replacement. Understanding how assets perform over time allows for proactive management, reducing the risk of unexpected failures. The assessment employed by AusNet involves analysing failure trends and any significant impacts resulting from failure, which provides valuable insights into the health and reliability of the assets.

6.1 Performance Analysis

In the context the management of assets and asset types within an Electrical Distribution Networks, assessing asset performance is a vital tool for effective lifecycle management. Performance information provides a comprehensive understanding of how these assets behave under various conditions, enabling asset managers to make informed decisions that enhance the reliability, safety, and efficiency of the electrical distribution network.

Performance data helps identify trends and patterns in asset behaviour, which are crucial for making strategic decisions regarding maintenance, upgrades, and replacements. Understanding how assets perform over time allows for proactive management, reducing the risk of unexpected failures. The assessment employed by AusNet involves analysing failure trends and any significant impacts resulting from failure, which provides valuable insights into the health and reliability of the assets.

6.2 Performance Profile

Records of unplanned maintenance work undertaken on DC and AC Systems are maintained in the Asset management system, SAP. The defects found during planned & unplanned maintenance inspections carried out in DC Systems during the period of the last five years are shown in Figure 11 below.

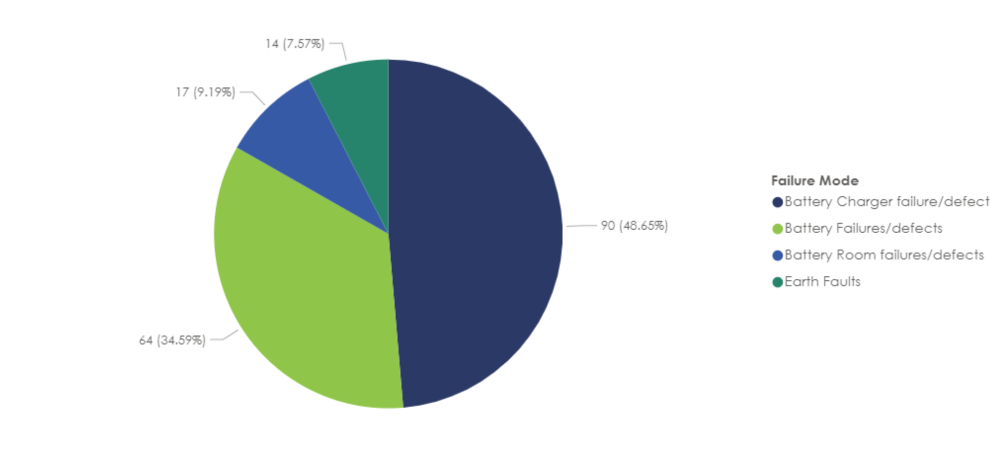

Figure 11: Corrective Maintenance analysis 2015 - 2024

The majority of issues are charger component failures that typically require a card, component, or complete charger replacement.

The second dominant issue is battery terminal corrosion, cracked cases and electrolyte leakage, connection lead failure and DC cells unable to hold sufficient charge.

6 Regulatory Framework

6.1 Compliance Factors

6.1.1 Regulatory and Legislative

Effectively managing compliance obligations specific to legislation and policies is a core element of Asset Class Planning and supports the sustainable operation and management of Network Assets. Ensuring adherence to relevant laws, policies and codes helps prevent legal and regulatory breaches, which can lead to significant penalties, operational disruptions, and reputational damage.

There is no requirement which Auxiliary Power system must be complied with. However, AusNet Auxiliary Power system has been designed to maintain DC supply to 10 hours after AC interruption for system black or ZSS black purpose.

6.1.2 Technical Standards and Procedures

Effectively managing compliance with technical standards and operational procedures is an important element of Asset Class Planning. Adhering to these standards ensures that the assets are designed, constructed, maintained, and operated in a manner that meets industry best practices, enhances safety, and ensures reliability. Compliance with technical standards helps prevent asset failures, reduces risks, and ensures interoperability within the electrical distribution network.

AusNet Auxiliary Power System must be designed or upgraded to where required in accordance with

- AS/NZS 3000
- AS 2676.2
- AusNet SDM

6.2 External Factors

6.2.1 Technical Factors

Understanding and managing the technical factors that can directly impact the lifecycle planning for Network Assets across all the AusNet Asset Classes is a core element of effective asset management. These factors encompass various design, engineering, and technical performance considerations that directly impact the ability to manage and maintain these assets efficiently. Ensuring that Network Assets meet specific technical performance standards is vital for maintaining the reliability and safety of the electrical distribution network.

Targeted Activities (Technical Factors)

<table>
<tr><th>REF</th><th>DETAILS OF MATERIAL CONSIDERATIONS</th></tr>
<tr><td>01</td><td>DC System
DC Systems exhibit several different issues:
• Old battery rooms may not have sufficient space for duplicated X and Y battery banks and the presence of asbestos makes augmentation financially impractical.
• Lack of SCADA monitoring in old battery rooms:
• lack of monitoring equipment may void the DC cell warranty as the manufacturer requires proof that the DC cell was operated in a controlled regime and environment.
• full discharge test is impractical on zone substations with a single battery bank as this would leave the zone substation without an auxiliary power supply for several hours during the test. This leads to a reduction in a DC cell lifespan.
• discharge rate test is impractical on zone substations with a single battery bank thus the accurate measurement of the DC system available capacity is not possible. There is a risk (increasing with the age of the battery) that certain battery banks cannot supply the control and communication loads for 10 hours as designed. This may result in a loss of protection hence ZSS black if the case of a charger or AC S/S Tx failure.</td></tr>
<tr><td>02</td><td>AC System
AC Systems exhibit a number of different issues:
• Old AC switchboards:
    o Do not have auto-changeover functionality. The lack of auto-changeover functionality may result in up to two hours loss of auxiliary power supply in case of a S/S Tx failure.
    o Contain asbestos, which is a health and safety hazard.
    o The wiring is not compliant with AS/NZS 3000. Switchboards which are not AS/NZS 3000 compliant are prone to result in earth fault incidents.
• S/S Tx maintenance and testing is impractical in zone substations with single station services transformer. This may impact on the auxiliary power supply reliability.</td></tr>
</table>

6.2.2 Environmental Factors

Effectively managing obligations specific to environmental management is a core element of Asset Class Planning and supports the sustainable operation and management of Civil Infrastructure. Ensuring adherence to relevant environmental laws and standards helps prevent legal and regulatory breaches, which can lead to significant penalties, operational disruptions, and reputational damage.

Targeted Activities (Environmental Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Battery disposal shall be in accordance with EPA rules / guideline

6.2.3 Safety Factors

Safety is a paramount concern in the management of electricity distribution network assets. Effective asset management planning and activities are crucial for protecting employees, contractors, the public, and the environment from potential hazards associated with electrical infrastructure. Ensuring adherence to safety regulations and standards through diligent asset management helps prevent accidents, minimise risks, and maintain the integrity of the network.

Targeted asset management activities include conducting regular safety audits and risk assessments, maintaining a robust Bushfire Mitigation Plan, providing ongoing safety training and competency assessments, regularly reviewing and updating emergency response plans, engaging with the community to raise awareness about electrical safety, and adopting new technologies and practices to enhance network safety. By integrating these safety-focused activities into asset management planning, AusNet can effectively minimise safety risks "as far as practicable," as outlined in the Electricity Safety Act 1998 and reflected in **ESMS 20-01**.

Targeted Activities (Safety Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	**Occupational Safety Risk** Older battery rooms are sized for a single DC battery bank and without equipment to monitor the battery temperature and room environment in terms of temperature and ventilation. Additionally older battery rooms and AC switchboards contain asbestos. The solution adopted to mitigate these risks is installing a new modern battery room in the zone substation in the vicinity of the old battery room.

7 Future Development

7.1 Technology and Innovation Factors

Effectively managing the process of tracking future technology developments and innovations is a core element of asset class planning. Staying informed about technological advancements ensures that asset management practices remain up-to-date, efficient, and competitive. Innovations can lead to improved materials, better monitoring systems, and enhanced maintenance techniques that increase the reliability, safety, and longevity of critical infrastructure. For example, advancements in diagnostic tools for detecting early signs of battery deterioration and the development of advanced materials for battery can significantly enhance their performance and maintenance.

Targeted Activities (Technology and Innovation Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Actively keep up to date on new battery technology type available on the market which may provide smaller footprint, high temperature tolerant, environmentally friendly materials and longer life cycle.

7.2 Research and Development Factors

Effectively managing the process of investing in research and development (R&D) and seeking funds for R&D activities is a core element of asset class planning. R&D investment ensures that the organisation stays at the forefront of technological advancements, develops innovative solutions to emerging challenges, and enhances the reliability, safety, and efficiency of its assets.

Targeted Activities (Research and Development Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Research and develop trial on advanced battery monitoring of individual battery cells and battery capacity test to estimate battery remaining useful life

8 Asset Strategies

8.1 New Assets

8.1.1 New Asset Considerations

A strategic asset strategy for the introduction of new assets provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of asset upgrades or changes, detailing the conditions under which new assets may be introduced into the network. This is not a like-for-like replacement but rather a strategic change or upgrade to a different type of asset to enhance reliability, improve efficiency, and incorporate advanced technologies. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for integrating new assets into the AusNet network.

Targeted Activities (New Asset Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	All new DC Systems shall be installed with 125V DC X and Y batteries and chargers fully duplicated and segregated.
02	All new DC Systems shall be installed with isolation boards, distribution cubicles as per appropriated Australian Standards and AusNet SDM
03	All new DC Systems shall be installed with DC / DC converters where other voltage levels are required
04	All new DC Systems shall be installed with individual battery cell monitoring system (voltage and impedance)
05	All new DC Systems shall be installed with SCADA alarm monitoring and control
06	All new DC Systems shall be installed with battery room / container / kiosk which comply with Australian Standard and AusNet SDM
02	All new AC Systems will be installed with a new switchboard fitted with Auto-changeover and wired in compliancy with AS/NZS 3000.

8.2 Inspections and Monitoring

A strategic plan for inspections and monitoring provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the ideal framework and objectives for conducting inspections and monitoring activities, such as enhancing reliability, improving efficiency, and incorporating advanced technologies. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for establishing comprehensive inspection and monitoring protocols within the AusNet network.

Targeted Activities (Inspection and Monitoring Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue existing inspection and monitoring activities in line with PGI 02-01-04 and SMI 32-01-01
02	Review existing SAP fault reporting methodologies and codes

8.3 Maintenance Planning

A strategic plan for maintenance provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the ideal framework and objectives for conducting maintenance activities, such as enhancing reliability, improving efficiency, and incorporating advanced technologies. It serves as a roadmap that guides the decision-making process for establishing comprehensive maintenance protocols within the AusNet network. This involves creating a structured approach to regular maintenance activities to ensure optimal performance and longevity.

Targeted Activities (Inspection and Monitoring Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue existing maintenance activities in line with: PGI 02-01-04, SMI 32-01-01. Ensure any issues to be resolved as soon as possible
02	Investigate and acquire (if feasible) the use of spare battery trailer or other methods to keep spare batteries for individual cell replacement or emergency full battery bank replacement.

8.4 Renewals Planning

A strategic asset strategy for renewals and replacements provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of asset refurbishments or like-for-like replacements, detailing the conditions under which existing assets may be renewed or replaced within the network. This process ensures continued reliability and efficiency, manages obsolescence, and maintains adequate spares. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for renewing or replacing assets within the AusNet network.

Targeted Activities (Renewal Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Replace various DC auxiliary power systems as per the risk analysis. Replacement of critical ZSS must be performed as per new Auxiliary Power System asset requirement.
02	Replace single, aging and poor health battery bank of critical Zone Substation as per new Auxiliary Power System asset requirement. Duplication of battery bank and charger may not be required
03	Replace of aging and high risk AC auxiliary power system as part of replacement of battery bank as per new Auxiliary Power System asset requirement.
04	Replace ageing auxiliary DC supply cables that are causing battery earth problems.

9 Legislative References

STATE	REGULATOR	REFERENCE
VIC	WorkSafe Victoria	Occupational Health and Safety Act 2004
VIC	EPA Victoria	Environment Protection Act 1970

10 Resource References

NO.	TITLE	LINK
1	SDM	Station Design Manual
2	AMS 01-01	Asset Management System Overview
3	AMS 01-09	Asset Risk Assessment Overview
4	AMS 20-01	Electricity Distribution Network Asset Management Strategy
5	PGI 02-01-04	Summary of Maintenance Intervals – Distribution Plant Guidance and Information
6	SPP 02-00-01	General Requirements SECONDARY PRACTICE AND PROCEDURE
7	AMS 01-09-02	Consequence Analysis - Addendum

11 Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE	APPROVED BY
1	06/03/2009	T Page	Initial draft	
2	07/04/2009	GL, DR	Review and update	G Towns
3	09/06/2009	GL, DR	Review and update	G Towns
4	24/11/2009	Nilima Bapat	Editorial and other minor changes	G Towns
5	31/10/2019	A Bugheanu	Update strategy for 2021-2025 EDPR submission	P Ascione
6	02/09/2024	Binh Ton	New template	

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