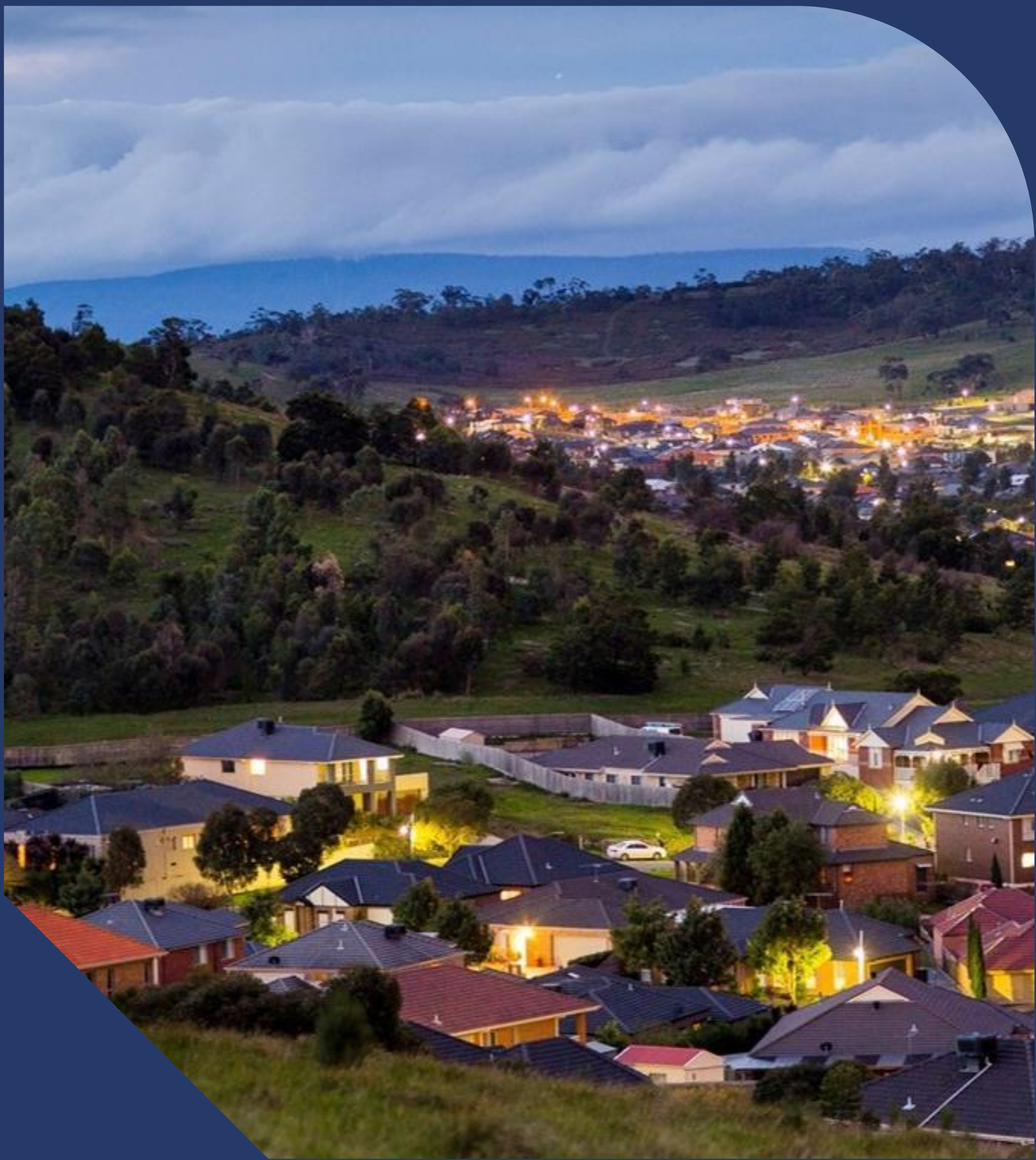
Distribution Transformers

AMS – Electricity Distribution Network



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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 strategy is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of Distribution Transformers in AusNet Victorian electricity distribution network.

This strategy is focused on AusNet's 63,140 Distribution Transformer, operating at predominantly 6.6kV,11kV,12.7kV and 22kV and consisting of pole mounted types (91%) and the remaining are ground mounted types consisting of indoor, outdoor pad mounted and kiosks.

Over the last few years there has been reduced distribution transformer failures resulting in lower community impacts due to customer outages, bushfire and safety risks. The better performance is particularly due to past proactive, planned replacements based on transformer loading measurements using Advanced Metering Infrastructure (AMI) metering and condition-based replacements.

The summary of proposed asset strategies is listed below.

1.1. Asset Strategies

1.1.1 New Assets

- Procure distribution transformers to AusNet specification DES 10-19, DES 10-05 and AS 60076 Standard.
- Install distribution transformers to Standard Installation Manual 4142-2 series respective drawings.
- Install pole mounted transformers on concrete poles in line with AMS 20-70.
- Install new surge arresters on all new and replacement transformer installations in line with AMS 20-67.
- Install fully insulated medium voltage connections to all new and replacement distribution transformer installations as per Standard Installation Manual 4142-2 series respective drawings.

1.1.2 Inspection

- Inspect distribution transformers in accordance with the Asset Inspection Manual 4111-1.
- Review current inspection regime of ground mounted transformers: Ground, Indoor and Kiosk types and prioritise inspections during the EDPR 2026-31 period.

1.1.3 Monitoring

- Use Advanced Meter Interval (AMI) 'smart meter' data to effectively monitor loading and utilisation of transformers identifying potential thermal overload issues.
- Perform targeted thermal monitoring, partial discharge and dissolved gas analysis on large capacity three-phase units, typically Kiosk, indoor and ground type installations.

1.1.4 Refurbishment

- Refurbish larger capacity three-phase units where operating losses and expected remaining service potential post refurbishment is economic compared with a new asset.

1.1.5 Replacement

- Replace-on-condition – Transformers where electrical utilisation exceeds 150% of nameplate rating.
- Replace-on-condition – Transformers where rust threatens the containment of insulating oils or where oil leaks threaten environmental pollution or transformer function.
- Replace-on-condition – Three-phase transformers where operating temperatures, partial discharge emissions or dissolved gasses threaten transformer functioning.
- Replace-on-failure – Transformers damaged by lightning or animal-initiated arcing faults or electrical overload.

2. Abbreviations and definitions

TERM	DEFINITION
AMI	Advanced Metering Infrastructure
AMS	Asset Management Strategy
DT	Distribution Transformer
ISO	Isolation
SWER	Single Wire Earth Return
HBRA	High Bushfire Risk Area
LBRA	Low Bushfire Risk Area
REFCL	Rapid Earth Fault Current Limiter
Zk	Work order Notifications associated with failures (unplanned power interruptions)
ZA	Work order Notifications associated with corrective actions from planned inspections
PUF	Power Utilization Factor

3. Introduction

3.1. Purpose

The purpose of this document is to outline the inspection, maintenance, replacement, and monitoring activities identified for economic life cycle management of distribution transformers in AusNet. This document is intended to be used 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 prudent asset management practices by outlining economically justified outcomes.

3.2. Scope

This Asset Management Strategy applies to all outdoor and indoor type distribution transformers, except station service transformers, connected to medium voltage on the distribution network of AusNet. Zone substation station service transformers are covered under AMS 20-80 Auxiliary Power Supplies.

This strategy is focused on Distribution Transformers, operating at predominantly 6.6kV,11kV,12.7kV and 22kV and consisting of pole mounted and ground mounted types consisting of indoor, outdoor pad mounted and kiosks.

3.3. Asset management objectives

AusNet's 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.

4. Asset description

4.1. Asset function

Distribution Transformers are required to convert electrical energy from medium voltages to low voltages in the AusNet electricity distribution network for electricity supply to customers.

Typically, smaller size, pole mounted distribution transformers supply power to a cluster of low voltage customers whereas larger size ground mounted transformers supply power to larger single or multiple distribution customers.

4.2. Asset population

Population Considerations for Distribution Transformers

The population profile for distribution transformers 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 distribution transformers are essential for maintaining the integrity and reliability of the network. For example, a particular pole-mounted single-phase transformer serving a remote rural area might be deemed essential and require more frequent inspections to ensure uninterrupted service.
- **Allocate resources efficiently:** Plan and allocate maintenance resources effectively by knowing the exact number and location of assets. For instance, knowing that a certain region has a high concentration of kiosk transformers can help in scheduling maintenance activities more efficiently.
- **Risk management:** Assess and manage risks associated with different assets. For example, if the population profile indicates that certain ground-mounted transformers are in flood-prone areas, additional protective measures can be implemented in those areas.
- **Optimise maintenance schedules:** Develop optimised maintenance schedules based on the distribution and condition of assets. For instance, three-phase transformers that form the backbone of feeder circuits from a zone substation might be scheduled for more frequent inspections and maintenance to prevent any potential failures.
- **Enhance reliability and safety:** Ensure that all components, including single-phase, three-phase, single wire earth return (SWER), ISO, and kiosk transformers, meet the required standards for reliability and safety. For example, if the profile reveals that certain pole-mounted transformers have insulation issues that no longer meets safety standards, these can be prioritised for replacement.
- **Support strategic planning:** Inform long-term strategic planning and investment decisions. For instance, the population profile might show that a significant portion of single-phase transformers in a rapidly developing suburban area need upgrading to support increased demand, guiding future investment in that region.

Geographic Impact Areas for Distribution Transformers

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 distribution transformers. Understanding these impacts is essential for effective asset management within the AusNet electrical distribution network.

Notable examples include:

- **High Wind Areas**: High wind areas, particularly in elevated regions and open plains, subject pole-mounted distribution transformers to significant stress and fatigue. Example: The structural integrity of pole-mounted transformers in the elevated regions of the Dandenong Ranges must be robust enough to withstand high wind speeds, ensuring they remain securely in place and do not fail under stress.
- **Corrosive Areas**: Coastal areas and industrial regions where salt and pollutants are prevalent can cause corrosion of metallic components in distribution transformers. Example: Regular maintenance and the use of corrosion-resistant materials are crucial to prolong the lifespan of these transformers. Distribution transformers in coastal towns like Wonthaggi require regular inspections and maintenance to mitigate the effects of salt-induced corrosion.

- **Bushfire Areas**: Bushfire-prone areas, common in many parts of Victoria, pose a risk of fire damage to distribution transformer infrastructure. Example: Fire-resistant materials and strategic vegetation management around transformer installations are essential for reducing this risk. In the bushfire-prone regions of the Yarra Valley, transformers must be designed to withstand high temperatures, and installations must be cleared of nearby vegetation to prevent fire spread.
- **Flood-Prone Areas**: Areas prone to flooding can impact the performance and integrity of ground-mounted distribution transformers. Example: Proper waterproofing and drainage systems are essential to protect these assets. In regions like Gippsland, where flooding is more frequent, ground-mounted transformers must be installed with robust waterproofing measures to prevent water ingress and subsequent failures.
- **Seismic Zones**: Though less common, areas with potential seismic activity may require distribution transformers to be constructed with flexibility and resilience to absorb and dissipate seismic forces, reducing the risk of structural failure. Example: In areas near fault lines, distribution transformers may need to incorporate seismic-resistant features to ensure stability during earth tremors.

Distribution Transformer Asset Types

Single Phase Transformers

- Summary Explanation of Form and Function: Single phase transformers convert medium voltage electricity (typically 12.7kV or 22kV) to low voltage for residential and small commercial use. They consist of a single set of primary and secondary windings and are commonly pole mounted.
- Purpose within the Asset Class: Essential for supplying electricity to areas with lower power demand, typically serving clusters of low voltage customers.
- Purpose within Network Design: Single phase transformers are integral in rural and suburban areas where the load demand is relatively low and spread out, making them cost-effective and efficient for such applications.
- Process Function: They step down the voltage from the medium voltage distribution network to a usable low voltage level for end consumers.
- Historical Application: The design of single-phase transformers has evolved over the last 50 years, focusing on reducing losses and improving reliability. Early designs used painted tanks, which have since transitioned to galvanized tanks for better durability.

Three Phase Transformers

- Summary Explanation of Form and Function: Three phase transformers convert medium voltage electricity to low voltage for distribution to larger residential, commercial, and industrial customers. They consist of three sets of primary and secondary windings and can be either pole-mounted or ground-mounted.
- Purpose within the Asset Class: These transformers handle higher power loads compared to single phase transformers and are crucial for areas with significant electrical demand.
- Purpose within Network Design Three phase transformers are used in denser urban and suburban areas, providing efficient power distribution for larger buildings and industrial sites.
- Process Function: They step down medium voltage to low voltage across three phases, which is ideal for powering large motors and equipment in industrial applications.
- Historical Application: With the expansion of underground residential estates, there has been a steady increase in the number of three-phase kiosk substations, reflecting the growing urbanisation and industrialisation needs.

Single Wire Earth Return (SWER) Transformers

- Summary Explanation of Form and Function: SWER transformers are used in rural areas to supply power over long distances using a single wire for the high voltage distribution and earth as the return path. They are typically pole-mounted and serve isolated rural customers.
- Purpose within the Asset Class: SWER transformers are vital for extending electrical service to remote areas, where traditional three-phase systems would be cost-prohibitive.
- Purpose within Network Design: To provide a cost-effective solution for rural electrification, minimising infrastructure costs by using fewer conductors.
- Process Function: They step down the single-phase medium voltage to low voltage suitable for rural households and farms.
- Historical Application: SWER transformers were widely installed during the electrification of rural Victoria, with many still in service today, reflecting their durability and effectiveness in rural settings.

Isolation (ISO) Transformers

- Summary Explanation of Form and Function: ISO transformers are isolation transformers designed to provide electrical isolation and safety between the primary high voltage and secondary low voltage circuits. They can be either pole-mounted or ground-mounted and supply SWER Transformers.

- Purpose within the Asset Class: They enhance safety by isolating the secondary circuit from the primary, preventing accidental contact with high voltage.
- Purpose within Network Design: ISO transformers are used where safety is a primary concern, such as in sensitive installations or near populated areas to supply SWER Transformers.
- Process Function: They provide galvanic isolation, ensuring that any faults in the high voltage side do not affect the low voltage distribution.
- Historical Application: The development of ISO transformers has improved safety standards within the distribution network, reflecting advancements in electrical insulation and design.

Ground/Indoor Transformers

- Summary Explanation of Form and Function: Ground/Indoor transformers are typically installed on concrete pads or within buildings, converting medium voltage to low voltage for larger residential, commercial, and industrial loads. They are housed in protective enclosures to safeguard against environmental conditions.
- Purpose within the Asset Class: These transformers are essential for high-demand areas, providing reliable and protected power distribution.
- Purpose within Network Design: They are used in urban areas where space constraints and environmental protection are critical factors, offering robust and secure power supply solutions.
- Process Function: They step down medium voltage to low voltage within a protected environment, ensuring continuous and safe power supply to urban infrastructure.
- Historical Application: Ground/Indoor transformers have been pivotal in the expansion of urban infrastructure, supporting the growth of cities by providing stable and secure power distribution.

Kiosk Transformers

- Summary Explanation of Form and Function: Kiosk transformers are ground-mounted units enclosed in metal or concrete kiosks, converting medium voltage to low voltage for urban and suburban areas. They are designed to be tamper-proof and aesthetically pleasing for urban environments.
- Purpose within the Asset Class: They provide a secure and reliable power distribution solution in areas with higher population densities.
- Purpose within Network Design: Kiosk transformers are used extensively in residential estates and commercial areas, ensuring that the electrical infrastructure is both safe and unobtrusive.
- Process Function: They step down medium voltage to low voltage, housed in a protective kiosk that prevents unauthorised access and protects against environmental factors.
- Historical Application: The adoption of kiosk transformers has facilitated the modernisation of urban electrical infrastructure, providing a reliable and visually unobtrusive solution for power distribution in densely populated areas.

4.3. Age

Age Considerations

An in-depth understanding of the age profile of distribution transformers 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.

Summary of Age Profile

Single Phase Transformers

- Summary Explanation of Age Profile: Approximately 61% of the distribution transformer population are single phase type. The design of single-phase transformers has evolved over the last 50 years, with reductions in losses, improvements in bushing porcelain, and a transition from painted to galvanised tanks in the 1990s.
- Historical Application: The average service age of single-phase transformers is approximately 34 years, with the oldest being over 100 years.
- Implications: Older single-phase transformers may require more frequent inspections and condition assessments to ensure they continue to operate safely and efficiently. Example: Inspections of older single-phase transformers and replace on their condition is cost effective than repair /overhaul.

Three Phase Transformers

- Summary Explanation of Age Profile: Approximately 39% of the distribution transformer population are three phase type. The rapid growth of underground residential estates has driven a steady increase in the number of three-phase kiosk substations.
- Historical Application: The average service age of three-phase transformers is approximately 23 years, with the oldest being 98 years.
- Implications: As three-phase transformers age, they may experience insulation breakdown and joint failures due to thermal ageing and environmental stress. Example: Analysing the age profile helps identify three-phase transformers at higher risk of failure, allowing for prioritised maintenance or replacement.

SWER Transformers

- Summary Explanation of Age Profile: Approximately 17.5% of the distribution transformer population comprise SWER transformers which are single phase type operating at 12.7kV. The electrification of rural areas drove the installation of SWER networks in more remote areas of Victoria.
- Historical Application: The average service age of SWER transformers is 34.9 years, with the oldest being 74 years.
- Implications: SWER transformers, being critical for rural electrification, may require targeted interventions to replace or refurbish aging units. Example: Replacing older SWER transformers can reduce the risk of power outages in remote areas and improve overall service reliability.

ISO Transformers

- Summary Explanation of Age Profile: ISO transformers are used to provide electrical isolation and safety between high and low voltage circuits and supply SWER transformers.
- Historical Application: The average service age and distribution of ISO transformers can vary but understanding their age profile is essential for maintaining safety standards.
- Implications: Older ISO transformers may need more frequent condition assessments to ensure they continue to provide effective electrical isolation. Example: Regular testing of insulation resistance in older ISO transformers can prevent electrical faults and maintain safety standards.

Ground/Indoor Transformers

- Summary Explanation of Age Profile: Ground/Indoor transformers are typically installed on concrete pads or within buildings and are crucial for high-demand areas.
- Historical Application: The average service age of these transformers can vary significantly based on installation conditions and maintenance history.
- Implications: Older ground/indoor transformers may require targeted maintenance to prevent failures due to environmental factors such as moisture ingress. Example: Installing advanced monitoring systems on older ground/indoor transformers can help detect early signs of failure and schedule timely maintenance.

Kiosk Transformers

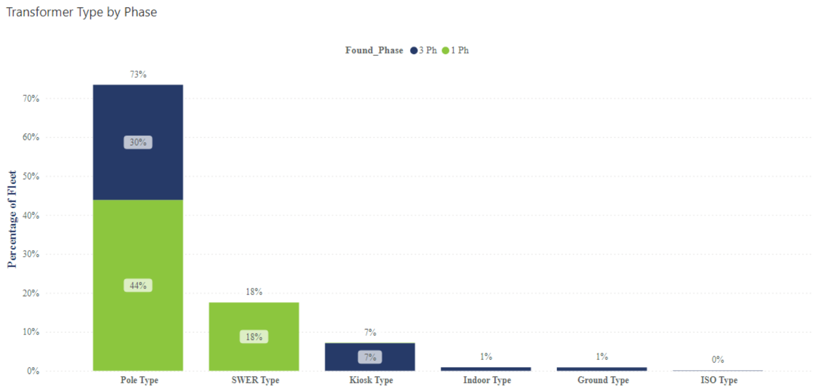
- Summary Explanation of Age Profile: Kiosk transformers are ground-mounted units enclosed in metal or concrete kiosks, designed for urban and suburban areas.
- Historical Application: The average service age of kiosk transformers can provide insights into their reliability and the need for upgrades or replacements.
- Implications: Kiosk transformers in high-density areas must be regularly inspected to ensure they meet the increasing demand and safety requirements. Example: Replacing older kiosk transformers in rapidly developing areas can enhance network reliability and accommodate growing electrical loads.

Age Profile

Population by Type

AusNet has a total of 63,140 distribution transformers installed in the electricity distribution network. A summary of the distribution transformer population by transformer type by phase and mounting type is shown in figure 1.

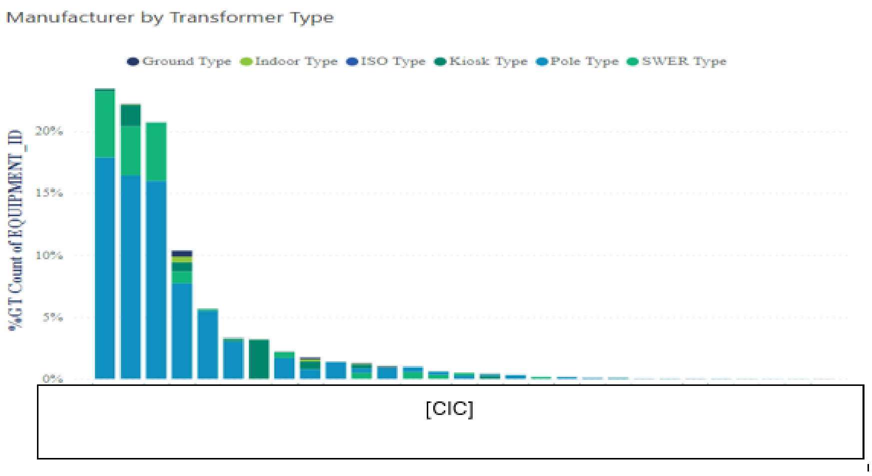
Figure 1: Distribution Transformer Type by Phase and Mounting Type



Pole mounted distribution transformers represent approximately 91% of the total population of distribution transformers and they can be either three phase or single phase. SWER type distribution transformers are pole mounted and they are single phase transformers generally used in rural distribution network in single wire earth return (SWER) medium voltage distribution systems.

Figure 2 shows the age profile of distribution transformers by type and manufacturer. Top 5 manufacturers of pole top, SWER, ISO, ground and indoor types are from [CIC], [CIC], [CIC], [CIC] and [CIC] while Kiosks are mainly from [CIC] and [CIC].

Figure 2: Distribution Transformers by Type and Manufacturer



Service Age

The average service age of all distribution transformer population is 29.8 years and the oldest being over 100 years. Figure 3 shows the service age profile against service voltage. There is a small percentage of older distribution transformers less than 2% of the population scattered in the regions with uncertainty of its installed dates and other data. These assets are being inspected during pole inspections and data is planned to be gathered and equipment data bases updated. (Refer section 7.4)

Figure 3 shows the service age profile against service voltage

Average service age of Fleet by Voltage An...

Found_Nominal_Voltage	AVG Service Age	%Population
6.60	30.71	0.25%
11.00	9.00	0.00%
12.70	34.80	17.72%
22.00	28.72	82.02%
Total	29.80	100.00%

Age profile of distribution transformers by type and service voltage is shown in figure 4 and figure 5. Approximately 10.3% of distribution transformers are more than 50 years old and approximately 8.1% of them are installed on the 22kV distribution system.

Figure 4: Distribution Transformer Service Age by Transformer Type

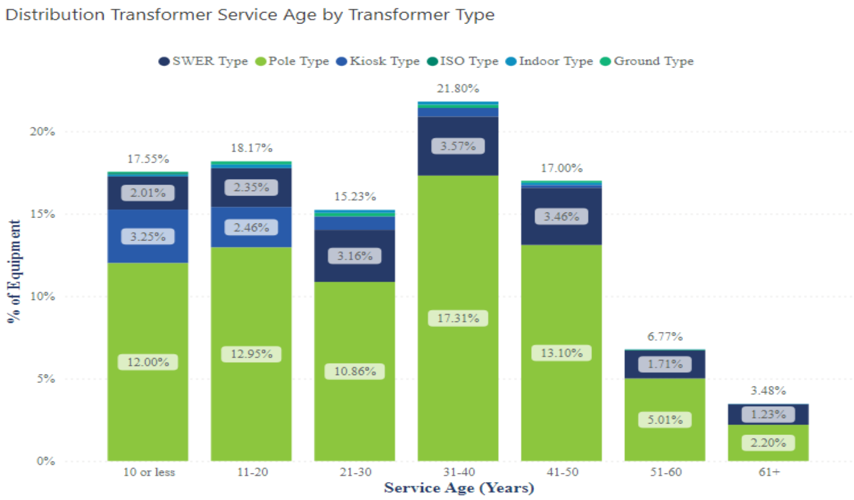
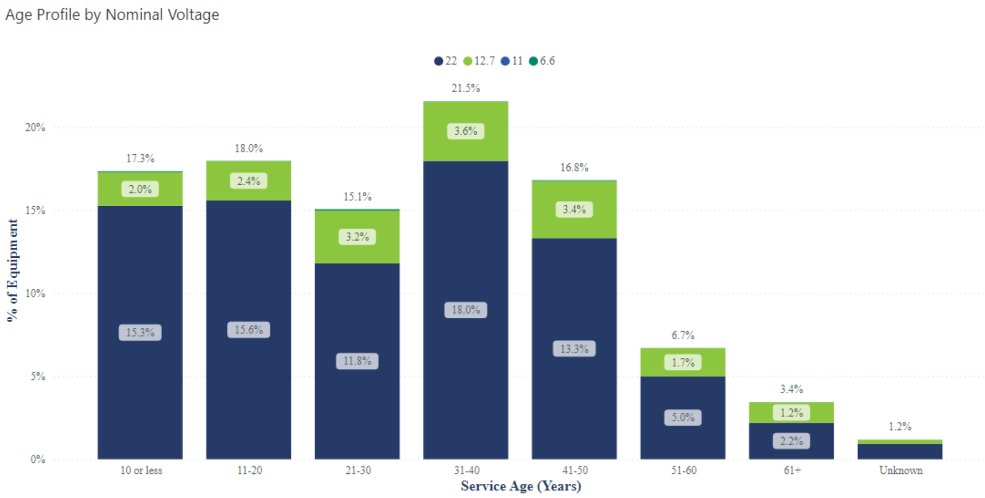


Figure 5: Distribution Transformer Service Age by Service Voltage



Single phase Transformers

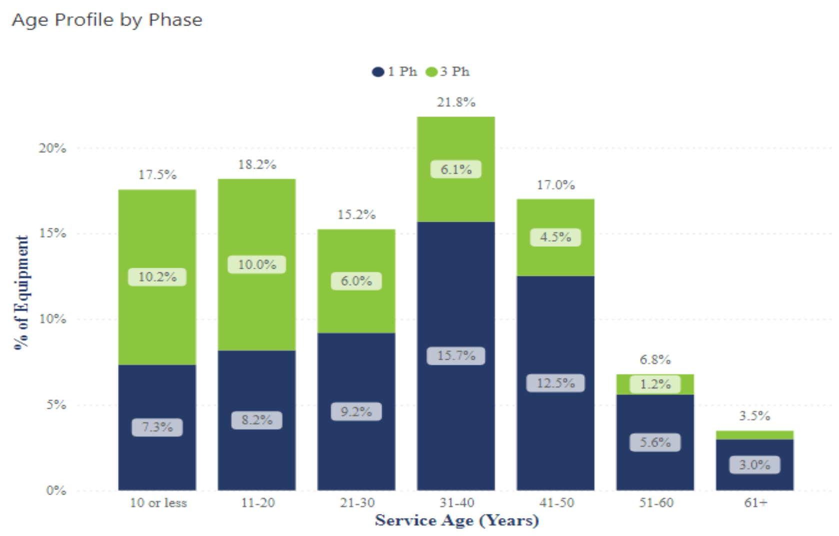
Approximately 61% of the distribution transformer population are single phase type. The design of single-phase transformers has evolved over the last 50 years with reductions in losses, improvements in bushing porcelain, and a move in the 1990s from painted to galvanized tanks. This has resulted in more reliable DTs on the network as AusNet single phase transformers were purchased to the prevailing Australian Standard and can be regarded as a homogenous population with an average service age of approximately 34 years, oldest being over 100 years.

Three phase transformers

Approximately 39% of the distribution transformer population are three phase type. The rapid growth of underground residential estates to the south-east and north of Melbourne between has driven a steady increase in the number of three-phase Kiosk substations. Three-phase transformers have been purchased to the prevailing Australian Standard and can be represented by a homogenous population with an average service age of approximately 23 years, oldest being 98 years.

Figure 6 shows the service age profile of single phase and three phase transformers.

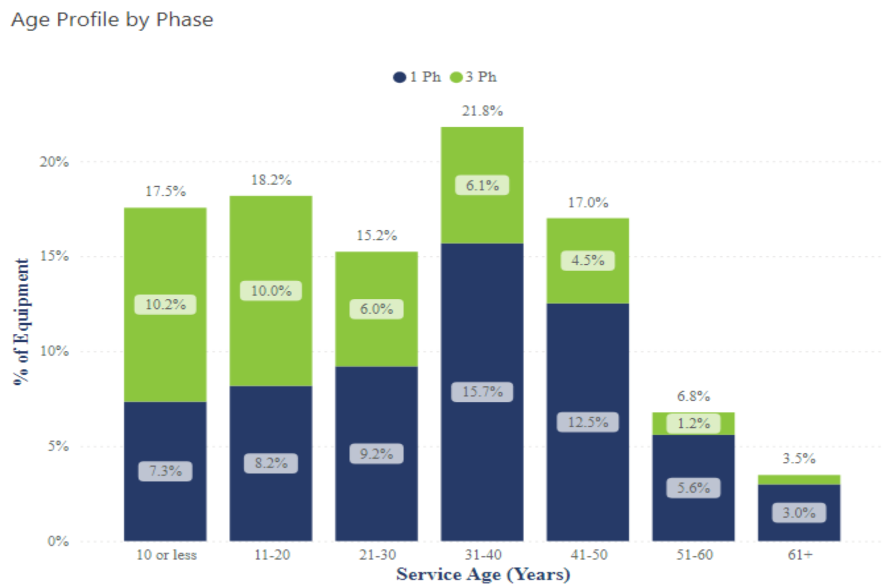
Figure 6: Age profile of single phase and Three Phase transformers



SWER transformers

Figure 7 shows the service age profile of distribution transformers. Approximately 17.5% distribution transformer population comprise of SWER transformers on the AusNet distribution network. They are single phase transformers operating at 12.7kV. The electrification of the rural areas of Victoria drove the installation of SWER networks in the more remote areas of rural Victoria. The older SWER transformers have average service age of 34.9 years, oldest being 74 years. Approximately 10.3% of the SWER population are more than 50 years old.

Figure 7: Age Profile of Distribution Transformers



5. 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, suppliers, and the communities in which we operate.

The risk of each asset is calculated as the multiplication of probably 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 treatments that are unique to Distribution Transformers.

5.1. Probability of Failure

An asset is deemed to have failed when it does not meet the functional requirements for which it was acquired. Both quantitative and qualitative analysis is used to assess the condition of the asset to determine the probability of failure and to estimate the remaining useful life. AMS 01-09 describes the detail methodologies used in calculating and deriving the probability of a failure considering the four key factors: asset life, asset utilization, location and physical condition.

5.1.1. Failure Causes

Distribution Transformers are used to convert electrical energy from medium voltages to low voltages in the AusNet electricity distribution network for electricity supply to customers. Distribution transformers fails to meet the functional requirement due to gradual deterioration of insulation due to internal and external factors, thermal overloading, seal degradation due to ageing and other factors resulting in ultimate failure.

5.1.2. Failure Modes

5.1.2.1. Application of 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. Typical failure modes of distribution transformers are described below.

Typical Failure Modes

Insulation Degradation

- Mechanism: Thermal ageing, environmental exposure such as lightning, moisture ingress.
- Impact: Reduced dielectric strength, internal arcing, electrical faults.
- Example: Single-phase transformers in humid regions experiencing insulation breakdown due to moisture ingress.

Mechanical Wear

- Mechanism: Wear and fatigue of components, e.g.: tap changers
- Impact: Slow or incomplete disconnection, operational failures.
- Example: Three-phase transformers experiencing mechanical stress and eventual failure of bushings due to repeated thermal cycling.

Environmental Degradation

- Mechanism: Exposure to harsh environments, corrosion.
- Impact: Compromised structural integrity, reduced lifespan.
- Example: SWER transformers in coastal regions experiencing accelerated corrosion of external components due to salt spray.

Moisture Ingress

- Mechanism: Water or moisture penetration.
- Impact: Corrosion of internal components, reduced insulation effectiveness.
- Example: Ground-mounted transformers in high humidity areas experiencing corrosion of windings due to moisture ingress.

Thermal Overload

- Mechanism: Excessive current flow, overheating.
- Impact: Thermal degradation, potential failure.
- Example: Three-phase transformers experiencing winding insulation degradation due to sustained high load.

Component Fatigue

- Mechanism: Repeated fault clearing.
- Impact: Reduced effectiveness, increased risk of failure.
- Example: Kiosk transformers experiencing wear of internal components due to regular exposure to fault currents.

UV Degradation

- Mechanism: Ultraviolet radiation exposure.
- Impact: Reduced mechanical strength, housing degradation.
- Example: Outdoor transformers experiencing seal degradation due to prolonged sunlight exposure.

5.1.3. Probability of Failure Assessments

As per the methods of calculation described in section 3 of AMS 01-09, the conditional PoF for distribution transformers is derived from health index based on asset life, asset utilisation, location and asset physical condition based on observed condition.

5.2. Consequence

Failure of a distribution transformer has the potential of resulting in failing to supply customers with energy. There is also a possibility the failed asset injures an employee or member of the public.

Following key consequences of distribution transformer failure effects have been considered viewed through two lenses.

1. Safety impact,
2. Community impact due to outages (unserved energy)
3. Environmental impact due to oil spill

The detail methodology of the consequence assessment is described in AMS -01-09.

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 expenditure. 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 – ie replacement is economic.

6. Performance

6.1.1. Performance Analysis

In the context of asset management for distribution transformers, 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.

6.1.2. Performance Profile

Figures 8 to 12 show the distribution transformer performance during the current period 2020-2024 against Zk notifications for distribution transformers.

Figure 8: Zk notifications by Transformer type – Period 2020-2024

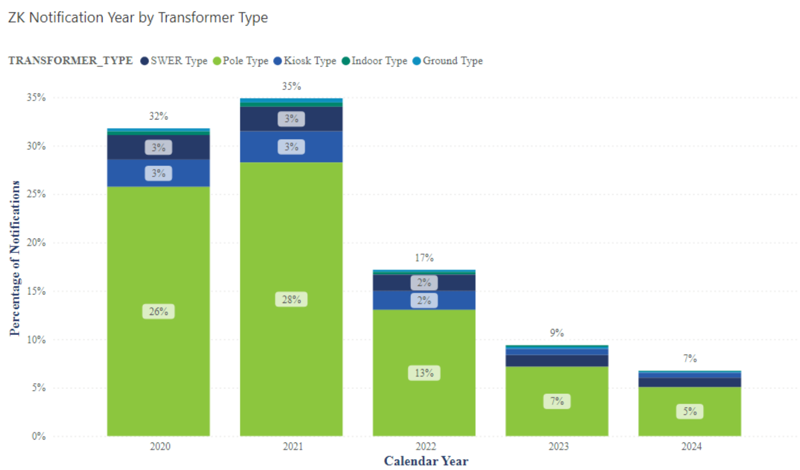


Figure 9: Zk notifications by Transformer type and Defect – Period 2020-2024

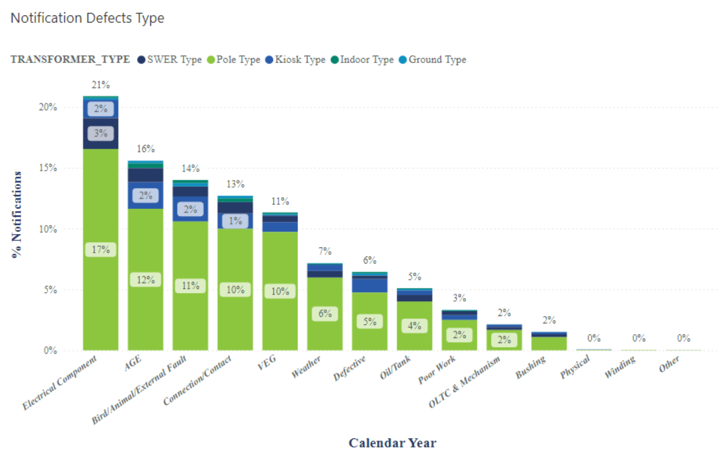


Figure 10: Zk notifications by age group – Period 2020-2024

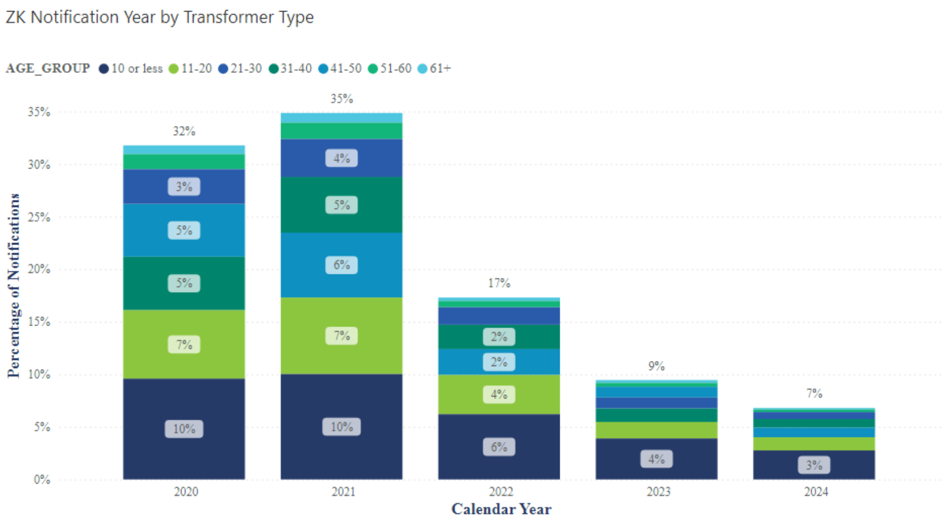


Figure 11: Zk notifications by single phase and three phase – Period 2020-2024

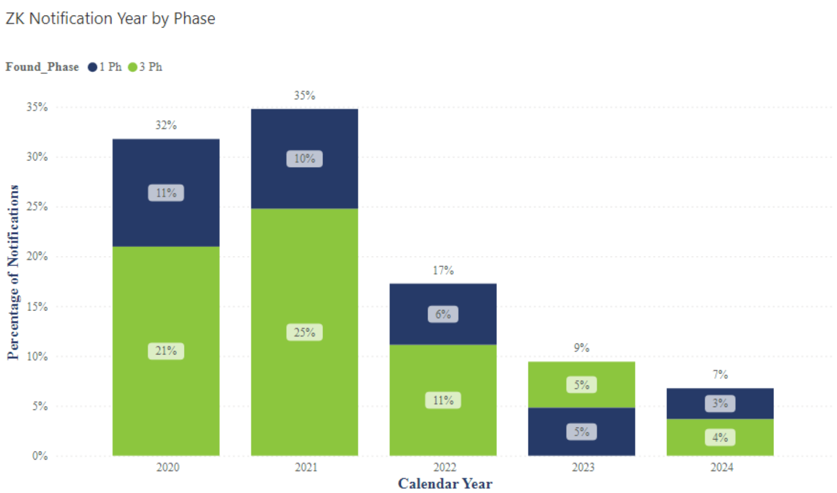


Figure 12: Zk notification rate table (2020-2024 period)

ZK Notifications

TRANSFORMER_TYPE	Count of NOTIFICATIONS	Population	Notitifcations / year/Total DT population
Pole Type	15738	10168	11.6%
Kiosk Type	2134	1407	1.6%
SWER Type	1626	1458	1.2%
Indoor Type	313	210	0.2%
Ground Type	285	196	0.2%

Figure 13 & 14 shows the estimated number of asset replacements carried out in the period 2020-2024 by replacement category and transformer types. It is observed that replacements during the period 2020-2024. They were mainly based on transformer failures. It is noted that that transformer replacements were mainly due to pole top type (78%), SWER type (18%) and kiosks contribute to about 2.5% of the total replacement during the period 2020-2024.

Figure 13: DT replacements (2020 -2024 period) by DT condition and failures

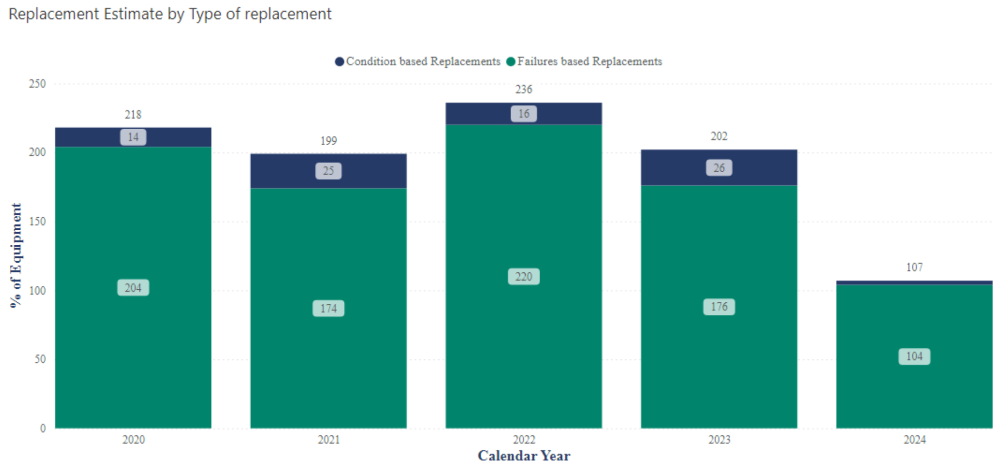


Figure 14: DT replacements (2020 -2024 period) by type

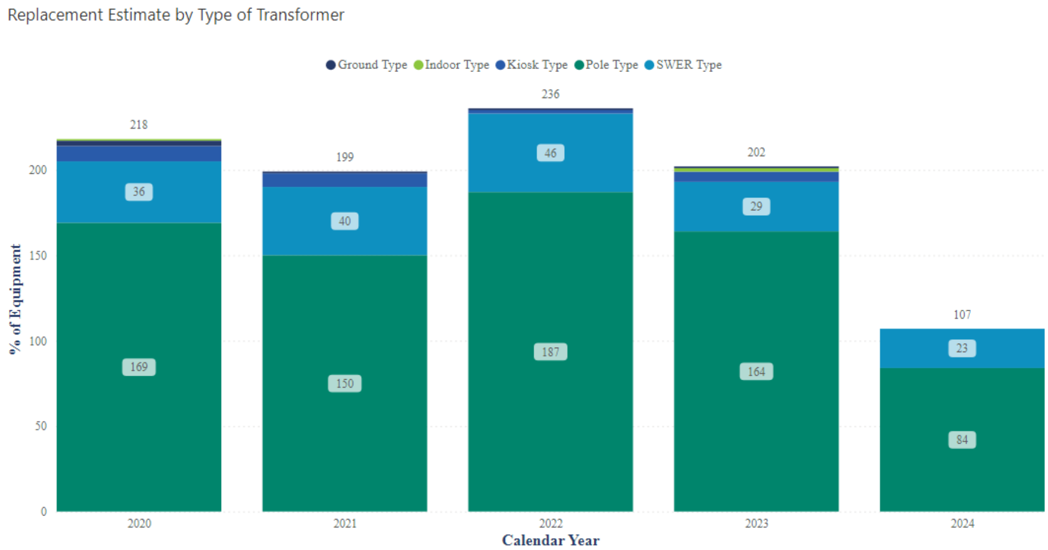
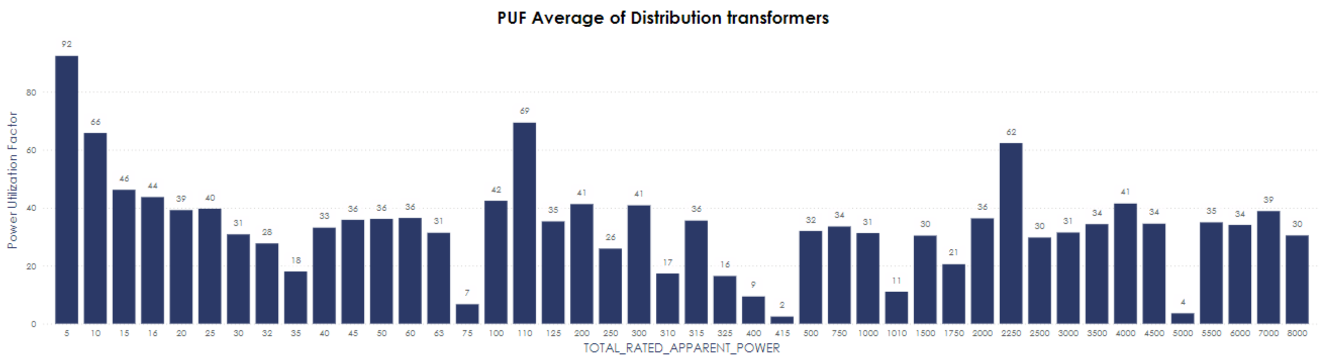


Figure 15: Annual Average PUF of Distribution transformers -2023



The duration that a transformer is operated under high PUF ratios will determine the rate of deterioration of the electrical insulation of the transformer core and coils. With the roll out of Advanced Metering Infrastructure (AMI) meters, data is collected for each transformer which can then produce the % PUF of that particular unit every 15 minutes.

Average annual Transformer Power utilization factors (PUF) for all transformer capacities in 2023 are shown in figure 15. Overall average utilization had been about 34% in 2023.

The widespread adoption of rooftop solar systems has alleviated the strain on some distribution transformers over time by reducing grid dependency with the possibility of two-way power flow through distribution transformers. However, in many areas, the growth in the number of customers has led to increased demand, resulting in higher transformer loading despite the benefits of solar generation.

Distribution transformer notification analysis revealed following issues.

1. It is observed that approximately 80% of the Zk failure notifications were reported from pole top transformers during the period 2020-2024. It should be noted that these Zk failure notifications have shown a declining trend in the last 3 years. The top five defect type reported are Electrical component failures, connections, damage due to bird /animals/external faults, vegetation and weather many of which needed intervention. (refer Figure 8 & 9)
2. It is also noted that approximately 50% Zk failure notifications were reported from distribution transformers that are less than 20 years of age. Approximately 65% of the Zk notifications were reported from 3 phase transformers which is about 39% of the total transformer population. (refer Figure 10 &11)
3. Pole top distribution transformers recorded the highest Zk failure notification rate/year (11.6%) compared to indoor and ground types (0.2%) which recorded the lowest during the period 2020-2024.Kiosks Zk failure rate is the second highest (1.6%) which involve HV and LV switchgear in addition to the distribution transformer.(refer figure 12) Further customer impact is much higher in kiosks due to larger customer numbers affected than for a single pole top transformer in the event of a failure incident.
4. Further review of notifications revealed that Zk failure notifications were mostly reported from [CIC] (45.9%), [CIC] (14%) and [CIC] (13.7%) manufacturer models which are generally younger (< 30 years) compared to much older types (>30 years) such as [CIC] (11.3%). Currently there are no planned maintenance inspections carried out for ground, kiosk and indoor substations other than a trial project in place currently for a selected number of substations.
5. It is observed a decline in total distribution transformer replacements in the last few years, especially the pole top transformers (refer Figure13 &14)

Above observations indicate the following:

1. Necessity of reviewing the planned maintenance regime of ground-based transformer and kiosks & associated switchgear and its implementation. Refer section 8.2.
2. Collect and update technical data of distribution transformers including kiosks for better analysis of distribution transformer and kiosk including event / performance data in SAP. Refer section 7.2 and 7.4.
3. Prioritise condition based proactive replacement of pole mounted distribution transformers and ground-based transformers and kiosks based on planned inspection results. Refer section 8.4.

7. Related Matters

7.1. Regulatory Framework

Compliance Factors

Under Clause 7 (i) Electricity Safety (Bushfire Mitigation) Regulations 2013, distribution transformers located in HBRA and LBRA areas are required to be inspected under bushfire mitigation plans at interval not exceeding the prescribed periods.

Regulatory and Legislative Reference

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.

Refer to **Section 9** for detailed guidance notes and references, supplied to support the assessment of this factor and the ways it impacts and influences the management of this Asset Class.

Note: further to the above, **Section Eight (8)** provides a quick reference table for the legislative and regulatory laws, acts, and policies that are of material consideration for this Asset Class (with links to the reference material).

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. For example, ensuring that all components of various asset types are installed and maintained according to Australian Standards can prevent unplanned failure and operational faults, enhancing network reliability.

Refer to Distribution Standard Installation Manual 4142-2 series respective drawings for detailed guidance notes and references, supplied to support the assessment of this factor and the ways it impacts and influences the management of this Asset Class.

7.2. External Factors

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. For example, selecting construction materials with appropriate durability and weather resistance is essential to prevent faults and ensure consistent performance under varying environmental conditions.

Targeted Activities (Technical Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	**HV Switchgear Issues in Kiosks / Indoor and Ground type Transformers** There are several older types HV and LV side switchgear associated with ground mounted distribution transformers developing issues and operation and maintenance of these switchgear is becoming difficult due to technical obsolescence and no manufacturer support. The non availability of accurate technical data for the switchgear associated with distribution transformers has been a hindrance for their life cycle planning.

Environmental Factors

Environmental Management

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	**PCB in Distribution Transformers** There may be older distribution transformers that have traces of PCB in oil. Polychlorinated Biphenyls (PCBs) in oil require special handling procedures to be followed during their life cycle management due to health and safety and environment concerns if contaminated with environment. The number of oil spills due to distribution transformers have reduced due to early replacements of leaking transformers reducing the environment damage due to oil leaks and possible PCB contamination.

Stakeholder/ Social Factors

Social Factors

Understanding social factors is essential for the effective management of critical network infrastructure assets. Social factors, including community expectations, public safety, and environmental impacts, play a significant role in shaping asset management strategies. Ensuring that these social considerations are addressed helps build public trust, maintain social license to operate, and enhance the organisation's reputation. For instance, ensuring that maintenance activities for Civil Infrastructure do not disrupt local communities or pose safety risks is crucial for maintaining public support and compliance with social responsibilities.

Stakeholder Factors

Understanding the requirements of stakeholders with a direct interest in the assets associated with the [Civil Infrastructure] asset class is an important aspect of effective asset management. Key stakeholders, including customers, regulatory bodies, and industry partners, have specific expectations that influence asset management strategies and operational decisions. Ensuring clear communication and alignment with these requirements helps maintain regulatory compliance, enhance service reliability, and build robust partnerships. For example, customers expect reliable infrastructure and timely responses to issues, which requires minimal disruption during maintenance activities of Civil Infrastructure. Similarly, regulatory bodies impose standards that must be adhered to, such as safety requirements for buildings and environmental systems, to avoid legal penalties and ensure operational legitimacy.

7.3. Internal Factors

Training and Competency Factors

Effective training and competency development is a core element of asset class. Ensuring that asset managers, engineers, operational staff, and field personnel possess the necessary skills and knowledge is crucial for maintaining the reliability, safety, and efficiency of the asset network. Competent staff can effectively perform inspections, maintenance, and repairs, preventing asset failures and minimising downtime. Continuous training helps in keeping up with technological advancements, regulatory changes, and best practices, thereby enhancing overall asset management performance.

Resource Management Factors

Resource Management is a core element of asset class planning for Network Assets. Proper oversight ensures that the management of AusNet's resource bases meets stringent quality and performance standards, which is essential for preventing asset failures, managing risks, and maintaining compliance with regulatory requirements. Effective resource management contributes to cost efficiency via activities such as leveraging the expertise of specialised in-house skills and contractors while avoiding hidden costs associated with inefficiencies and non-compliance.

There are three sub-categories of consideration for this factor, which are:

- Resourcing strategies
- Outsourcing
- Supply Chain Management

Economic Factors

Economic factors significantly influence the lifecycle management of network assets, impacting financial stability, investment decisions, and overall network performance. Major contracts being tendered, such as those for infrastructure development, maintenance, and technology upgrades, can materially affect asset management. These contracts involve substantial investments, requiring rigorous management to align with long-term asset goals, mitigate risks, and control costs. Effective contract management ensures that service providers deliver value, supporting the network's reliability and performance while maintaining financial health.

Material developments and significant commercial agreements also play pivotal roles in the economic landscape of asset management. Commercial agreements, including customer service agreements, dictate service levels, performance metrics, and penalties, impacting operational priorities. Regular reviews of these agreements ensure adaptability to changing economic conditions, customer expectations, and regulatory landscapes. Additionally, planned renewal programmes and changes to asset types and purchasing strategies must be evaluated for their financial impact to ensure efficient resource allocation. By addressing these economic factors, AusNet can manage financial risks, optimise investments, and support robust lifecycle models, aligning financial planning with operational goals and regulatory requirements.

Safety Factors

Safety is a paramount concern in the management of electricity distribution network assets, as outlined in **ESMS 20-01**. 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**.

7.4. Future Developments

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 wear and the development of advanced materials for asset components can significantly enhance their performance and maintenance. **For technology and innovation, this is a process that looks to existing technologies, processes, or practices that have been proven in the market and have already been taken to market**.

Targeted Activities (Technology and Innovation Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	It is necessary to explore other technologies available for pole top and other distribution transformer types using of non-oil insulation medium to minimise the impact due to oil contamination into waterways and soil in the event of an oil leak or failure. EPA Act 2017 requires taking reasonably practicable steps to eliminate or minimise the risk to human health and the environment. Presently a trial study underway using a fully sealed type of distribution transformer.

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. For example, developing new materials with improved structural properties for buildings or advanced monitoring systems for environmental systems can significantly extend their lifespan and reduce maintenance costs. **Research and development is the process of researching and investing in an idea, process, practice, or technology that has not been realised in the market yet; it is a step before tracking innovation and technology because the investment to build and take the item to market still needs to be proven**.

Continuous Improvement

Continuous Improvement (CIP) is a critical lynchpin process in the overall application of asset management, particularly for managing Distribution Assets. CIP ensures that asset management practices remain effective, efficient, and adaptive to changing conditions and emerging challenges. By consistently seeking ways to enhance processes, technologies, and strategies, organisations can maintain high levels of performance, reliability, and safety. For example, regularly updating maintenance protocols for buildings, environmental systems, and security fences based on feedback and new insights can prevent issues before they become major problems, thereby extending the lifespan of critical infrastructure.

Best practice asset management promotes a culture of continuous improvement, encouraging organisations to regularly evaluate their asset management systems, identify areas for enhancement, and implement changes. This iterative process involves monitoring performance, analysing data, and applying lessons learned to refine practices. By focusing on CIP, organisations can ensure that their asset management activities remain dynamic, resilient, and aligned with best practices and strategic objectives. This approach not only enhances the overall efficiency and effectiveness of asset management but also supports long-term sustainability and success. **CIP differs from technology and innovation as well as R&D because it involves the ongoing enhancement of existing processes and practices based on real-world feedback and performance data, rather than the development and introduction of new technologies or the exploration of unproven ideas**.

Targeted Activities (Technology and Innovation Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Data of the large population of distribution transformers (>63000 in numbers) need to be improved by periodically verifying the data and updating SAP enterprise system with essential data such as installed dates, manufacturer, model including kiosk technical data.
02	Process review of the use of appropriate assembly codes, maintenance cause, object part, damage type used in ZA and Zk notifications is needed as a continuous improvement opportunity in SAP enterprise management systems.

8. Asset Strategies

8.1. New Assets

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	Procure distribution transformers to AusNet specification DES 10-19, DES 10-05 and AS 60076 Standard.
02	Install distribution transformers to Standard Installation Manual 4142-2 series respective drawings.
03	Install pole mounted transformers on concrete poles in line with AMS 20-70.
04	Install new surge arresters on all new and replacement transformer installations in line with AMS 20-67.
05	Install fully insulated medium voltage connections to all new and replacement distribution transformer installations as per Standard Installation Manual 4142-2 series respective drawings.

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	All pole mounted distribution transformers are subject to regular condition inspections in conjunction with line asset inspections. Kiosk, ground type and indoor substations are periodically inspected as part of the key switch inspection regime in accordance with the Asset Inspection Manual (4111-1).
02	Distribution transformers are visually inspected together with their support structure every 37 months in the Hazardous Bushfire Risk Areas (HBRA) while pole-mounted transformers in LBRA regions are inspected every 61 months. The types include all pole mounted distribution transformers, Kiosks, ground type and indoor type transformers.
03	The civil aspects for ground-mounted installations include site surfacing, hazard signage, gates, fences and vegetation management.
04	AusNet is enhancing the inspection and monitoring process for large capacity installations supplying major loads to high profile commercial enterprises such as shopping centres. This occurs to ensure that flooding, fire or vegetation does not jeopardise supply reliability.

REF	DETAILS OF MATERIAL CONSIDERATIONS
05	Installation earths are tested and maintained in accordance with AusNet earth testing program. More detailed plant condition assessments such as operating temperatures, oil sampling/analysis, partial discharge and thermo-vision are being implemented on selected installations. This program is prioritised by customer criticality and plant utilisation.
06	Use Advanced Meter Interval (AMI) 'smart meter' data to effectively monitor loading and utilisation of transformers identifying potential thermal overload issues and consider for capacity upgrade.

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	Distribution transformers are essentially maintenance-free devices and relatively little maintenance is undertaken on site. Minor bushing damage, such as chips in the glazing of bushing sheds and small rust spots in paint work are restored on site. Such works are not part of scheduled maintenance programs but are a by-product of other maintenance activities such as inspection of the civil aspects of ground type substations, Kiosk and indoor substations or cross arm, pole and conductor replacements.
02	Maintenance activities such as replacement of bushings or bushing seals are undertaken in a workshop in conjunction with oil replacement and tank re-conditioning, as part of a refurbishment or overhaul program.

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	Refurbish larger capacity three-phase units where operating losses and expected remaining service potential post refurbishment is economic compared with a new asset.
02	Replace-on-condition – Transformers where electrical utilisation exceeds 150% of nameplate rating.
03	Replace-on-condition – Transformers where rust threatens the containment of insulating oils or where oil leaks threaten environmental pollution or transformer function.
04	Replace-on-condition – Three-phase transformers where operating temperatures, partial discharge emissions or dissolved gasses threaten transformer functioning.
05	Replace-on-failure – Transformers damaged by lightning or animal-initiated arcing faults or electrical overload.

06	Refurbish larger capacity three-phase units where operating losses and expected remaining service potential post refurbishment is economic compared with a new asset.
07	Refurbishment of larger capacity units is economic if the core and coil are in sound condition and there is a high probability of achieving decades of further service life considering its asset age and physical condition.

8.5. Decommissioning

A strategic asset strategy for decommissioning provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of safely and efficiently removing assets from service, detailing the conditions under which decommissioning may occur. It ensures that the process is conducted in a way that minimises disruption, manages environmental impacts, and complies with regulatory requirements. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for decommissioning assets from within the AusNet network.

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9. Legislative References

STATE	REGULATOR	REFERENCE
VIC	WorkSafe Victoria	Occupational Health and Safety Act 2004
VIC	EPA Vic	Environment Protection Act 2017
VIC	Energy Safe Victoria	Electricity Safety (Bushfire Mitigation) Regulations 2013

10. Resource References

NO.	TITLE	DOCUMENT TITLE
1	QMS 20-04	Documented information Control
2	AMS 01-09	Asset Risk Assessment Overview
3	AS ISO 31000	Risk Management – Guidelines
4	AMS 01-01	Asset Management System Overview
5	AMS 20-01	Electricity Distribution Network Asset Management Strategy
6	4111-1	Asset Inspection Manual
7	4142-2	Distribution Standard Installation Manual 4142-2 series for all distribution transformer types
8	DES 10-19	Equipment specification for Distribution Transformer Pole & Ground Type
9	DES 10-05	Equipment specification for Kiosk Distribution Transformer Substations

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11. Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE
1	2007/08	A Prodhan	Update of 1995 strategy
2	12/2008	D Postlethwaite M Butson	Failure rates, replacement forecasts & RCM studies
3	03/02/09	D Postlethwaite M Butson	Incorporate comments from field staff
4	12/03/09	J Kenyon D Postlethwaite	Editorial by technical writer
5	25/11/09	N Bapat D Postlethwaite	Editorial
6	15/07/10	P Bryant	Added bird & animal covering program
7	16/03/15	D Erzetic-Graziani J Stojkovski T Gowland	Major revision for the EDPR 2016-20
8	12/06/2019	Nandana Boteju	Update of strategy for EDPR 2021-25
9	22/01/2025	Nandana Boteju	Review and update

AusNet

Level 31
2 Southbank Boulevard
Southbank VIC 3006
T +613 9695 6000
F +613 9695 6666
Locked Bag 14051 Melbourne City Mail Centre Melbourne VIC 8001
www.AusNetservices.com.au

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