Asset Management Plan

Ground Mounted Substations - Distribution

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Responsibilities

This document is the responsibility of the Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

Please contact the Asset Strategy Team Leader with any queries or suggestions.

- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

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Record of revisions

Section number	Details
Table 10	Corrected OPEX Actual($) 2012/13 was 125,707 now 1,257,070

Table of Contents

1 Purpose

The purpose of this document is to describe for Ground Mounted Substations:

- TasNetworks' approach to asset management, as reflected through its legislative and regulatory obligations and strategic plans
- The key projects and programs underpinning its activities
- Forecast CAPEX and OPEX, including the basis upon which these forecasts are derived

2 Scope

This management plan covers the ground mounded substations and their associated assets. The assets covered by this management plan include:

- Ground mounted substations (including high voltage switching stations)
- High Voltage switchgear
- Low voltage switchgear
- Ground mounted transformers

3 Strategic alignment and objectives

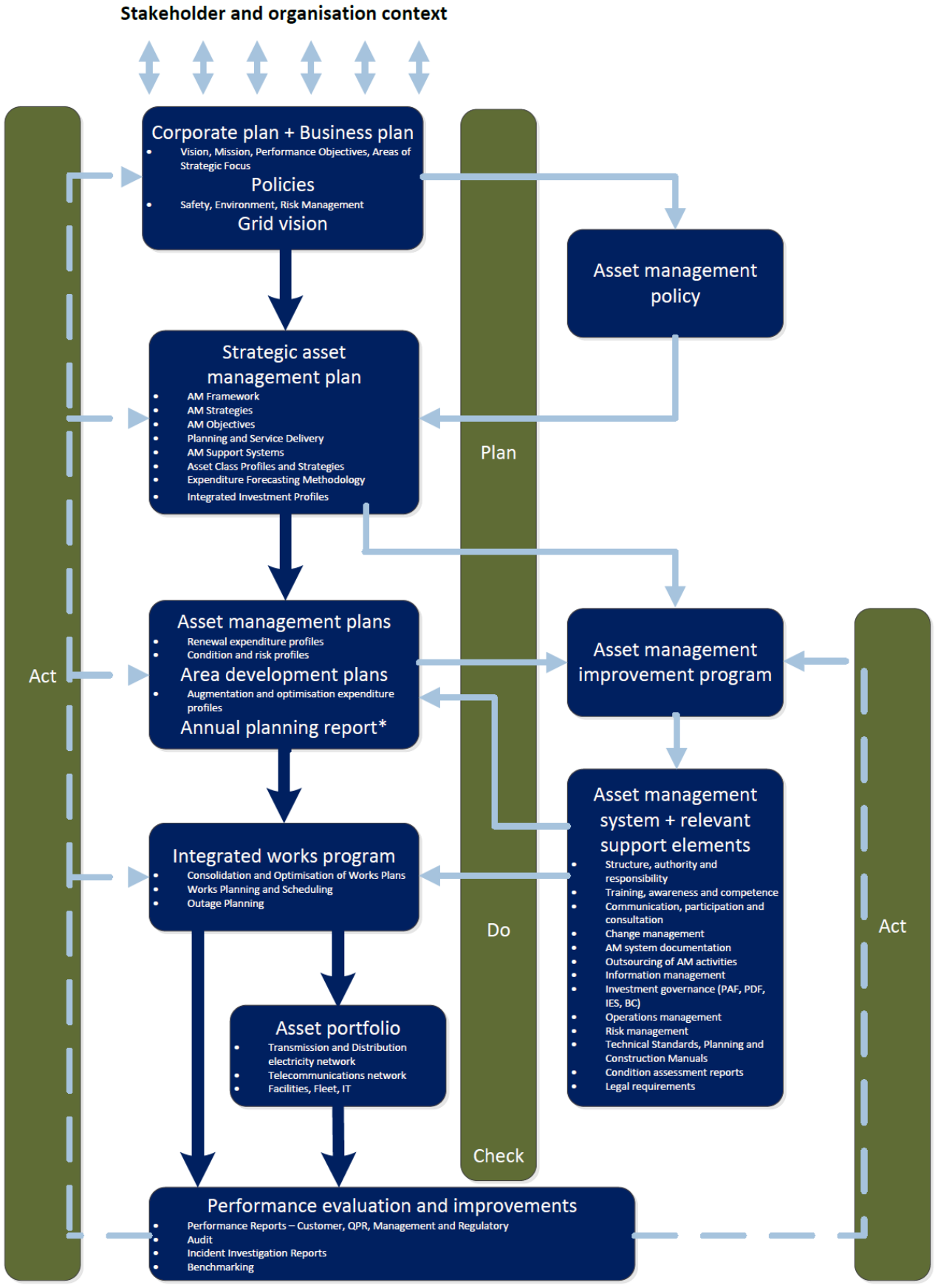
This asset management plan has been developed to align with both TasNetworks' Asset Management Policy and Strategic Objectives.

The asset management policy, contained within the Strategic Asset Management Plan, states 'Consistent with our vision and purpose, we strive for excellence in asset management and are committed to providing a safe working environment, value for our customers, sustainable shareholder outcomes, care for our assets and the environment, safe and reliable network services, whilst effectively and efficiently managing our assets throughout their life-cycle'.

It is part of a suite of documentation that supports the achievement of TasNetworks strategic performance objectives and, in turn, its mission. The asset management plans identifies the issues and strategies relating to network system assets and detail the specific activities that need to be undertaken to address the identified issues.

Figure 1 represents TasNetworks documents that support the asset management framework. The diagram highlights the existence of, and interdependence between, the Plan, Do, Check, Act components of good asset management practice.

Figure 1 – TasNetworks asset management documentation framework



* The Annual Planning Report (APR) is a requirement of sections 5.12.2 and 5.13.2 of the National Electricity Rules (NER) and also satisfies a licence obligation to publish a Tasmanian Annual Planning Statement (TAPS). The APR is a compilation of information from the Area Development Plans and the Asset Management Plans.

The asset management objectives focus on six key areas:

- Zero Harm will continue to be our top priority and we will ensure that our safety performance continues to improve
- Cost performance will be improved through prioritisation and efficiency improvements that enable us provide predictable and lowest sustainable pricing to our customers
- Service performance will be maintained at current overall network service levels, whilst service to poorly performing reliability communities will be improved to meet regulatory requirements
- Customer engagement will be improved to ensure that we understand customer needs, and incorporate these into our decision making to maximise value to them
- Our program of work will be developed and delivered on time and within budget
- Our asset management capability will be continually improved to support our cost and service performance, and efficiency improvements

4 Asset support systems

TasNetworks utilises Asset Management Information Systems which are maintained to contain up to date, detailed information for the ground mounted substations on its network.

The asset information related to ground mounted substations is managed using a spatial data warehouse (G/Tech). This data base stores critical attributes for each site, including the site location and its interconnection to the network.

A works management system (WASP) is used to manage asset management activities and for the recording of asset performance.

4.1 Asset information

Asset related information is stored and accessed through the asset management systems. Where asset information is insufficient audits are undertaken to gather the information.

5 Description of the assets

Ground mounted substations are installed on the network where there is a requirement to supply a large load, large number of customers or provide a single customer supply from the high voltage underground reticulation network. The substations are used to reduce the voltage of the high voltage distribution network down to the customer supply voltage.

5.1 Ground mounted substations

The ground mounted substations consist of a variety of construction types, sizes and configurations. In the majority of installations the substations comprise an enclosure, high voltage switchgear, transformer(s) and a low voltage switchboard. These substations range in size from 300 kVA to 4500 kVA, are supplied at either 22 or 11 kV and have a secondary voltage of 400/230 volts. Switching stations comprise only an enclosure and high voltage switchgear. There are currently 1892 ground mounted substations on the distribution network.

The assets have a typical service life of 40 to 50 years before major refurbishment or replacement is required.

Ground mounted substations can be further divided into the following construction types:

- **Building:** Indoor equipment enclosed in a permanent building. The building may be integrated within a larger building, or stand alone
- **Fence:** Predominantly outdoor equipment, but may be indoor equipment installed in individual weatherproof housings, within a fenced enclosure
- **Kiosk (Padmount):** A complete assembly, which is installed or replaced as a unit. The equipment is enclosed in a common weatherproof housing with limited access. Provision is made for replacement of individual components
- **Vault:** Indoor equipment installed in an underground vault with access by a vertical hatchway from a road or footpath

All ground mounted substations have an external enclosure to provide a secure location for the equipment and to provide for public safety. At some sites an oil containment system is provided to ensure any on site leakage of oil is contained within the site.

Within the Hobart CBD, some ground mounted substations have additional systems installed, which may include auxiliary protection systems, batteries and relays. Protection communications cables, known as pilot wire, provide the link between substations, specific switchgear and associated equipment.

All ground mounted substations have an underground earthing system. These systems are essential for maintaining personnel and public safety and for correct operation of protection equipment under fault conditions. The fault level, protection clearing time and site soil resistivity dictate the design and performance of a substation earthing system. In ground mounted substations the earthing system is typically a copper earth grid, possibly with associated earth pins. All metallic components of the installation, including the enclosure, are connected to the earthing system. This grid is usually interconnected with the surrounding MEN (Multiple Earthed Network) earthing network.

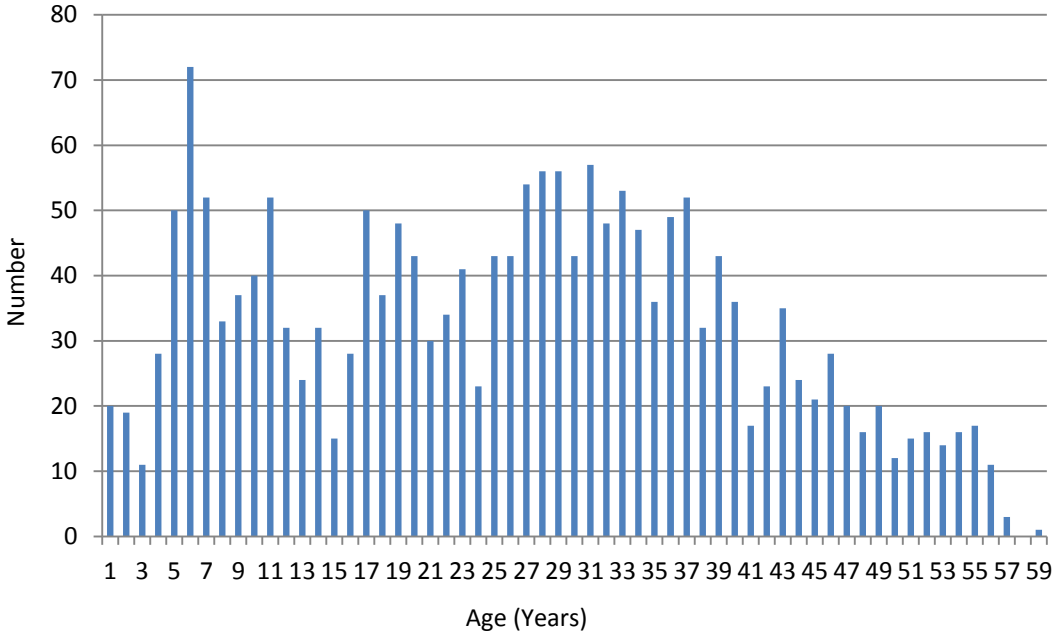
Table 1 details the number of each type of ground mounted substation installed in the network as at September 2015.

Table 1: Ground mounted substations (as at September 2015)

Description	Voltage (kV)	Number Installed
Building	11	246
	22	105
Fence	11	107
	22	51
	44	2
Kiosk(Padmount)	11	817
	22	561
Vault	11	3
	22	0
	Total	1892

Figure 2 provides an age profile for TasNetworks' ground mounted substations. Although the age profile is quite evenly spread, in the next 5 to 10 years, approximately 25% of the 1892 substations will reach or pass the end of their expected service life.

Figure 2: Total age profile of ground mounted substations (as at Sept 2015)



Building substations

Building type substations are often of larger capacity and used to supply commercial customers. They may comprise either a stand alone building, or be incorporated as part of a privately owned building.

These susbtations are individually designed to suit the network and customer requirements and are made up from individual components and usually consist of HV switchgear, transformer(s), LV switchboards and anciliary systems. These substations may also include include fire detection and supression systems. They range in size from 300 kVa to 3750 kVA.

Building type substations have been installed on the network since the 1960's.

Kiosk substations (Padmount)

Kiosk substations are stand alone substations that comprise a variety of standard configuations, construction and equipment types. The kiosk enclsoures have been historically made from fibreglass panelling, brick, steel and precast concrete. New kiosks have a steel enclosure. They range in size from 300 kVA to 2 MVA.

Kiosk type substations have been installed on the network since the 1960's.

Figure 3 – Block wall kiosk (1977)

Figure 4 – Modern kiosk (2012)

Fence type substations

Fence type substations are stand alone outdoor installations. These substations have an external perimeter fence and usually consist of HV switchgear, transformer(s), LV switchboards. They range in size from 100 kVA to 4500 kVA. Figure 6 represents a typical Fence Type installation.

These substations have been installed on the network since the late 1950's.

Figure 5 – Fence Type substation (1967)

Vault type substations

Vault type substations are building type substations that are installed below ground level. They are incorporated as part of a privately owned building.

These susbtations are individually designed to suit the network/customer requirements. These substations are made up from individual components and usually consist of HV switchgear, transformer(s), LV switchboards and anciliary systems. These substations may also include fire detection and supression systems. They range in size from 750 kVa to 1500 kVA.

Vault type substations have been installed on the network since the early 1970's.

5.2 High voltage switchgear

The switchgear installed in ground mounted substations primarily provides for disconnection, connection and isolation of high voltage installations on the network.

There are a variety of ground mounted high voltage switchgear types installed on the distribution network, with installations dating back to the late 1950s. The switchgear operates at 11 kV or 22 kV, uses air, gas or oil as the insulating medium and may be installed indoors or outdoors. Table 2 lists the switchgear types and volumes of each that are installed within ground mounted substations.

With older high voltage switchgear oil is often used as the insulating medium, and although very effective in arc suppression, the medium does result in an increased safety risk under fault. The significant quantity of oil in the switchgear amplifies the intensity of a fire if an explosive failure occurs. Due to the operator safety risk associated with this type of switchgear oil is no longer used as an insulating medium. Modern switchgear uses either air or gas as an insulating medium. Figure 7 provides an overview of the types of oil field switchgear on the network and their age.

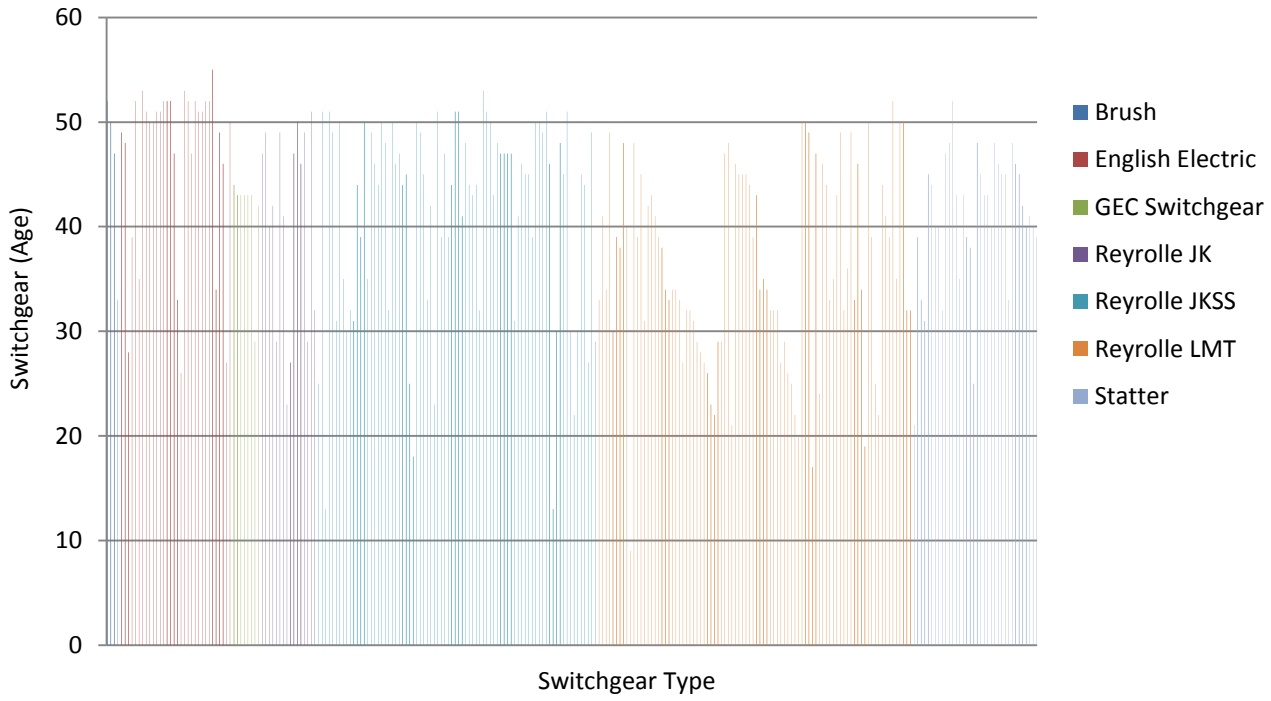
Under fault conditions older switchgear is limited in its ability to contain internal arc faults. This deficiency can result in an increased risk to operational staff and the public. Modern switchgear is available with the capability to contain internal arc faults. This design feature reduces the safety risk if an internal fault occurs.

Table 2: High voltage switchgear installed in ground mounted substations (Sept. 2015)

Manufacture	Type	Voltage (kV)	Insulating medium	Volume	Years installed	Arc fault containment capability
ABB	CTC12	11	Gas	1	1999	No
ABB	CTC24	22	Gas	81	1975-1999	No
ABB	RGB12	11	Air	487	1972-2003	No
ABB	RGB24	22	Air	20	1977-2000	No
Brush			Oil	3	1960-1979	No
English Electric	OLX/OLX2	11	Oil	23	1960-1984	No
Fluokit	MC40 & M24	11 & 22	Air	137	1973-2001	No
GEC	DDFC	11	Oil	5	1968-1983	No
Hazemeyer	MD4	11	Air	82	1969-2003	No
Merlin Gerin	M6	11 & 22	Gas	97	1982-2006	No
Merlin Gerin / Schneider	RM6	11 & 22	Gas	494	1999-2015	Partial (Front and lateral)
Merlin Gerin / Schneider	SM6	11 & 22	Gas	34	1999-2015	Partial (Front and lateral)
Minipad KPX2	Fuse	11 & 22	-	14	2005-2010	No
Reyrolle	JK	11	Oil	15	1961-2004	No
Reyrolle	JKSS	11	Oil	76	1959-1999	No
Reyrolle	LMT	11	Oil	62	1962-1993	No
Reyrolle	LMVP	11	Air	33	2010-2015	Partial (Front and lateral)
Siemens	8CK	22	Oil	1	1980	No

Manufacture	Type	Voltage (kV)	Insulating medium	Volume	Years installed	Arc fault containment capability
Statter	ODSA	11	Oil	40	1964-2003	No
Yorkshire	YSF6	11	Gas	3	1986	No

Figure 6 – Oil filled switchgear age profile



5.3 Transformers

Ground mounted substations contain one or more transformers. They are used to transform the high voltage of the distribution feeder down to a lower secondary voltage (400/230 V).

The transformers range in size from 100 – 2000 kVA, are supplied at 11 and 22 kV and can be installed either outside in an enclosed yard, or within an enclosure or building.

The standard transformer sizes are:

- 500 kVA
- 750 kVA
- 1000 kVA
- 1500 kVA
- 2000 kVA

There are a small number of older transformers in the system of non-standard sizes. Where replacement is required these transformers will be replaced with a standard size transformer.

The number and size of each transformer units is dependent on the connected load or customer requirements at a particular point within the distribution system. Table 2 details the number of transformers installed in the network by size and voltage.

Table 2: Ground mounted distribution transformers (as at September 2015)

Size (kVA)	Voltage (kV)	Number Installed
Less than 500	11	195
	22	38
	44	2
500	11	479
	22	247
750	11	302
	22	271
1000	11	111
	22	62
1500	11	171
	22	136
Greater than 1500	11	52
	22	33
	Total	2099

5.4 Low voltage switchgear

All ground mounted substations, with the exception of high voltage switching stations have a low voltage switchboard. The switchboard is supplied from the low voltage side of the transformer and operates at 400 volts.

The low voltage switchgear installed in ground mounted substations provides for disconnection, connection and isolation of the low voltage distribution network and customer load.

There are a variety of types of switchboard types and configurations. Switchboards installed on the network prior to the 1980's were often of an open design (live front) where the live equipment is not fully encapsulated. Due to the risk associated with this type of arrangement this design is no longer used and with later switchboards all live equipment is enclosed within the switchboard (dead front).

Low voltage switchgear includes circuit breakers, busbars, links, fuses and isolators. Table 4 provides a summary of the different types of ground mounted switchgear on the distribution network.

Table 3: Low voltage switchgear installed in TasNetworks' distribution network as at September 2015

Description	Number Installed
B&S	1
Emmco	1
Engineered Switchboards	25
English Electric	13
GEC	13
HEC	22
Mechanical Services	583
Merlin Gerin/ Schneider	562
Nilsen	34
Saifway	106
Standard Waygood	24
Weber	1
Other/Fuses/Unknown Circuit Breaker	467
Total	1852

6 Associated Risk

An assessment of the risks associated with the ground mounted substations has been undertaken in accordance with TasNetworks' risk management framework. For each asset in this class the assessments have been made based on:

- Condition of ground mounted substations currently in service across the network
- Criticality of ground mounted substations and associated assets
- Probability of failure (not meeting business requirement)
- Consequence of failure
- Performance
- Safety risk
- Environmental risk
- Customer

The quantification of risk is undertaken using the Condition Based Risk Management (CBRM) framework. This approach allows the risks of individual assets to be quantified against the defined assessment.

Due to the level of risk identified in some of the assessment criteria a requirement to actively manage these risks has been identified.

6.1 Condition of Assets

Ground mounted substations assets currently in service in the TasNetworks system are prone to specific issues as discussed in the following sections.

6.1.1 Safety/Security Issues

Ground mounted substations contain energised electrical equipment that can be hazardous to both operational staff and the public. To manage this risk substations are secured to prevent unauthorised access by the personnel and public. Signage is also provided at the substations to inform people of the risks of entering the sites.

Incident reporting has identified five incidents within the last three years that involved some form of unauthorised access to kiosk substations (fibreglass enclosures). The doors of this type of enclosure are easier to lever off than normal steel enclosures. This exposes the public to equipment containing live parts.

As at September 2015, there are approximately 182 substations with fibreglass enclosures in the distribution system.

6.1.2 Live exposed electrical equipment

Some of the older substations on the distribution network may contain live exposed electrical equipment.

The low voltage distribution boards installed in many of the older building and kiosk substations have live equipment that is not fully encapsulated ('Live front' board). This results in an elevated safety risk as the live equipment is easily accessible. Many of these boards are located in cramped operating conditions with little access for escape in the event of contact with live parts. The majority of live front boards in building type substations have been covered with Perspex, and it is estimated that there are less than 50 of these remaining on the network.

Whilst these distribution boards met the standard of the day they were installed, they do not reflect the current level of safety expected in modern installations and do not comply with current standards.

Older transformers installed in both indoor and outdoor substations may contain live bushings that may also present an elevated safety risk due to the access to the live equipment not being adequately restricted.

6.1.3 Fire

Fire within substations and the consequences of it presents a significant business risk.

6.1.3.1 Fire/Explosion risk

Due to the energy contained in the electrical equipment within a substation, if a failure occurs there is the potential for a fire to occur. Should a fire occur and the transformer is ruptured the oil within it can increase the volatility of the fire.

Substations located within buildings and close to neighbouring buildings and sensitive area represent a higher consequential risk. The consequences of fire are a consideration in the location of new installations and it can also influence the removal/relocation of existing installations.

6.1.3.2 Compliance with fire standards

All building and vault type substations are required to comply with the Building Code of Australia (BCA) and the maintenance of the fire systems should comply with AS 1851 Maintenance of Fire Protection Systems and Equipment.

Australian standard AS 1851 specifies that inspection and maintenance should be completed on all entry and exits, ventilation and building penetrations. These types of substations typically have one access door and a number of vents, which require inspection.

Other equipment that forms part of the fire integrity of the installation and require inspection includes fire dampers and fire proofing of cables.

6.1.3.3 Fire and Exit Doors

Fire and exit doors within TasNetworks' building integrated substations are required to comply with AS 2067 Substations and high voltage installations exceeding 1 kV a.c. and the Building Code of Australia (BCA).

As described above, the requirements for inspection and maintenance on these assets is covered under AS 1851 Maintenance of fire protection systems and equipment.

6.1.3.4 Fire Suppression System Issues

Integrated building and vault type substations pose a greater risk from fire than other substations due to them being incorporated into other buildings. This arrangement makes it easier for a fire to spread to adjacent infrastructure which increases the risk of extensive damage occurring, with an increased risk to public safety. These installations can be less accessible which can impact the fire authority's ability to extinguish a fire should it occur.

6.1.4 Emergency and Exit Lighting

The emergency and exit lighting within TasNetworks' substations is required to comply with the BCA.

The inspection and maintenance requirements of these assets is covered under AS/NZS 2293.2 Emergency evacuation lighting for buildings – Inspection and maintenance.

6.1.5 Corrosion Issues

Current maintenance programs have identified higher levels of corrosion on assets located in harsher environments such as those located in close proximity to coastal and also industrial areas.

As at September 2015, there are seven substations that are within twenty metres of coastal areas or major estuaries.

6.1.6 Confined Spaces

There are 3 ground mounted substations that are classified as confined spaces due to their below ground location and limited access and egress.

All of these substations contain fire suppression systems which TasNetworks routinely inspects and maintains to ensure that they will operate as designed in the event of a fire.

6.1.7 Asbestos

Asbestos is a material that has historically been used in the electrical industry. Asbestos has been identified as a hazardous material that can cause harm to health. Substations on the distribution network installed prior to 1980 may contain asbestos.

TasNetworks is required to comply with Work Health and Safety Act and Regulations 2012 and the Workplace Standards Tasmania: How to Manage and Control Asbestos in the Workplace Code of Practice 2012 with regards to the management of sites containing asbestos.

Equipment that may contain Asbestos Containing Material (ACM) within substations includes switchboards, metering panels, roof lining, conduits and doors.

As at September 2015, TasNetworks has 573 substation sites that contain asbestos. TasNetworks created a register of these sites in 2009.

Where asbestos has been identified in substations labelling is installed to provide notification of the presence of the material and warn of the hazard.

6.1.8 Switchgear

Switchgear failures usually result in notable customer disruptions, with often the loss of a part or full feeder. Explosive failures can also present an elevated safety risk to operational personnel and the public.

Under fault conditions older switchgear is limited in its ability to contain internal arc faults. This deficiency can result in an increased risk to operational staff and the public. Modern switchgear is available with the capability to contain internal arc faults. This design feature reduces the safety risk if an internal fault occurs.

Periodic inspections and routine maintenance programs are undertaken to manage the risks associated with asset failures.

6.1.8.1 Oil-filled switchgear

Oil-filled switchgear was installed on the network from the 1960's to 1980's. This type of switchgear is contained in building, fence and kiosk type substations throughout the state, with a total population of 224 sites as at September 2015.

Although oil is very effective for arc suppression, the medium results in an increased safety risk under fault. The consequences of explosion of oil-filled switchgear are much greater than other types of switchgear due to the flammability of the oil. The significant quantity of oil in the switchgear amplifies the intensity of a fire if an explosive failure occurs.

This type of switchgear presents a higher risk to operational personnel, public safety and damage occurring to adjacent assets, than other types of switchgear.

Due to the operator safety risk associated with this type of switchgear, oil is no longer used as an insulating medium. Modern switchgear uses either air or gas as an insulating medium.

Additionally with this type of switchgear, there is the risk of environmental harm, such as contaminated land or waterways, in the event of an oil spillage for sites that do not have oil containment facilities.

6.1.8.2 Siemens switchgear

Siemens 8CK switchgear was installed on the network since the early 1970s. For this switchgear type there has been a higher than expected failure rate. In 2001, a management plan was put in place with special arrangements for maintenance of Siemens switchgear and a replacement program established.

Despite these measures, the condition of the switchgear has further deteriorated, with a live operating ban being placed on the units in 2008. There is currently only one substation on the network with Siemens switchgear. This substation is scheduled for removal in October 2015.

6.1.8.3 Brown Boveri RGB24

Brown Boveri RGB24 switchgear was installed on the network from the late 1970s to the early 1980s. The design of the rear epoxy spouts allows the collection of dirt and moisture over time, which eventually causes insulation failure and flashover that leads to switchgear failure and outage of the entire site. Generally, complete switchgear replacement is required if this occurs.

Access to the spouts for cleaning cannot be performed unless the switchgear is fully dismantled.

There have been three recorded incidents of this nature, but anecdotal evidence from field staff has also indicated there has been other sites fail due to this type of fault that have not been recorded in TasNetworks' incident reporting system.

There has been a further three incidents associated with the RGB switchgear of a different nature, the most recent failure was attributed to a cable failure within the switchgear cubicle which caused the loss of the switchgear.

As at September 2015 there are 20 substations on the network that contain this type of switchgear.

6.1.8.4 Hazemeyer Switchgear

The majority of Hazemeyer switchgear was installed on the network from the 1970s to the late 1980s. This type of switchgear is contained within building and kiosk type substations, with a total population of approximately 82 sites as at September 2015.

In 2010 due to safety concerns operating restrictions were placed on Hazemeyer high voltage switchgear such that it cannot be closed during fault-finding operations. As a result of this ban, outage times are often extended and the customers affected by these outages are increased.

6.1.8.5 Asbestos arc chutes

Nilsen circuit breakers were installed in ground mounted substations from the 1960s and were primarily used in the Hobart CBD and Hobart urban area where HV-LV intertripping protection was installed.

These circuit breakers have asbestos arc chutes and when operated can expose personnel to the hazards of asbestos.

TasNetworks has management practices in place for the management of asbestos are for working in proximity to it. TasNetworks is required to comply with the Work Health and Safety Act and Regulations 2012 and Work-Safe Tasmania – How to Manage and Control Asbestos in the Workplace Code of Practice 2012.

6.1.9 Oil containment

Distribution transformers contain mineral insulating oil for both electrical insulation of the internal components and cooling. Older switchgear may also use oil as the insulating medium. Mineral oil can be harmful to the environment.

Unlike newer installations, older installations may have limited capability to contain the leakage of oil and consequently represent a higher level of risk to the environment should an asset fail.

The Australian standard covering high voltage installations, AS 2067 (Clause 6.7.11) requires that every high voltage installation containing equipment with more than 500 litres of a liquid dielectric such as transformer oil shall have provision for containing the total volume of any possible leakage. The containment system is required to meet the overall objectives of Appendix H of AS 1940, the storage and handling of flammable and combustible liquids (Reference 4).

Only approximately ten percent of the substations on the network contain an oil containment system that is compliant with this Australian standard.

TasNetworks has experienced a small number of oil spill incidents in recent years where the oil has not been contained on site due to an oil containment system not being present. Two of these incidents were in close proximity to waterways.

6.1.10 Earthing systems

Earthing systems in ground mounted substations are designed to ensure that all step and touch potentials that are generated under fault conditions pose a negligible level of risk to TasNetworks staff and the public. Distribution substation earthing systems usually include a large interconnected multiple earthed network (MEN) which significantly lowers the overall earth potential rise (EPR) and shock hazard during high voltage fault conditions.

For safety compliance TasNetworks uses the probabilistic approach outlined in ENA DOC 025 *EG-0 Power system earthing guide - Part 1: management principles* (reference 14) to risk assess each site. Generally, the standard earthing designs that have been used historically for TasNetworks' ground mounted substations pose negligible risk for highly interconnected sites with typical levels of public contact. In areas with higher frequency contact scenarios or little interconnection, voltages may be present under fault conditions which pose a risk to nearby persons.

TasNetworks undertakes routine auditing of distribution substation earthing systems to ensure the risk of shock under fault conditions is at a manageable level.

6.1.11 Ferro-resonance

Ferro-resonant circuits pose a risk of damage and/or loss of distribution assets and injury to personnel or public and increase reliability performance. While risks can be controlled adequately using operating procedures, where these introduce an unacceptable level of impact to the operation of the network, these are considered for accelerated replacement.

There are three set conditions that must exist for ferro-resonance to occur on the network:

- The presence of a capacitance in series with a non-linear inductance
- Unloaded or lightly loaded conditions
- At least one single-phase operation of a switch or protection device in a three-phase system

There are approximately 60 ground mounted substation sites within the 11 kV and 22 kV distribution network as at April 2014, where ferro-resonance may be a potential issue. These sites are ground mounted substations connected to the overhead system via underground cables and protected by single-phase switching devices such as single-phase Expulsion Drop Out fuses (EDOs).

In many instances Hazemeyer MD4 high switchgear was classified as a single phase switching device. The single phase switching has the potential to cause a ferro-resonance situation. The majority of the substations containing Hazemeyer have been converted to three phase operation which has greatly reduced the likelihood of likelihood of ferro-resonance occurring.

6.2 Criticality of asset

Ground mounted substations are critical installations on the distribution network. Substations are used to supply customer load, with individual substations supplying up to approximately 250 customers.

On the underground sections of the distribution network the ground mounted substations are used to provide network interconnectivity.

6.3 Probability of failure

Each year TasNetworks experiences approximately five to ten asset failures within ground mounted substations.

Over the last three years there have been ten high voltage switchgear failures, of which all but two were near or over 50 yearsof age at the time of failure and used oil as the insulating medium.

Routine inspections and maintenance programs are in place to monitor and maintain the assets to reduce the likelihood of failure occurring. These activities reduce the probability of a failure down to a manageable level.

6.4 Consequence of Failure

The results of asset failures within ground mounted substations can be categorised under the following main groups:

- Safety risk due to potential for explosives failures and risk of fire
- Disruption to customer supply
- Impact to network performance due to network disruption
- Environmental hazards due to oil and gas spills

7 Management plan

7.1 Historical

TasNetworks' asset management practices for these assets have been stable for a number of years and are generally considered to be providing a well-balanced trade-off between maintenance and capital expenditure. In particular, TasNetworks believes the practices of condition based renewal, driven by asset inspection and maintenance practices are enabling the development of sound asset management strategies.

Due to the critical nature of this asset class, frequent maintenance is required to defer unnecessarily early capital expenditure. TasNetworks believes that the existing practices are appropriate and the assets are meeting business requirements.

The frequency of unplanned events and associated repair outside of programmed maintenance has been stable over the past five years; indicating the existing frequency of planned maintenance cycles is maintaining the level of reliability for the assets.

Changes to the Occupational Licensing Act 2005 that became effective on the 19 January 2009 have required TasNetworks to be compliant with The Occupational Licencing Code of Practice 2013. This code of practice sets the minimum standards for electrical work in Tasmania.

Incorporated into this Code of Practice is the requirement to comply with:

- AS 2067 (Substations and high voltage substations)
- AS/NZS 3000 (Wiring Rules)
- AS/NZS 7000
- Any additional obligations imposed by AS 2067, AS/NZS 3000 and AS/NZS 7000 referring to further Australian Standards or documents, including any amendments or revisions of those Australian Standards or documents from time to time

The Code of Practice requires that any person performing electrical work within Tasmania complies with these Australian Standards.

These changes have mandated the requirement to comply with the regulatory, contractual and legal responsibilities outlined in section 7.2

In 2011 as part of a company restructure the Protection and Control asset management thread was created. At this time the asset management of batteries and protection systems inside ground mounted substations was transferred across to this new thread.

7.2 Strategy

The four key principles of TasNetworks' asset management strategy are:

- Minimising the cost of supply to the customer to the lowest sustainable level
- Maintaining network performance
- Managing the business operating risks at an appropriate level
- Complying with regulatory, contractual and legal responsibilities

The factors relevant to the management of the ground mounted substation assets that influence each principle are listed in the following sections.

Minimising cost of supply to the customers to the lowest sustainable level:

- Ensuring cost effective trade-offs are made between pro-active and reactive maintenance practices

- Ensuring all reasonable routine maintenance (as per manufacturer's recommendations) precautions are implemented to protect the asset for the duration of its service life
- Capturing adequate information on the assets to facilitate informed decision making

Maintaining network performance:

- Ensuring contingency procedures (redundant capacity and portable generators) are in place for any (n-1) events, as the impact of failures is significant and exact failure is difficult to predict even after frequent condition monitoring
- Ensuring appropriate spares are maintained as the lead-time for some of the assets (specifically transformers and some HV switchgear) is very long
- By identifying trends in asset performance to target future likely failures

Managing business operating risks at an appropriate level:

- Ensuring adequate security of sites and building enclosures to comply with legislation and ensure public safety as these sites contain dangerous voltages in areas generally frequented by the public
- Failure of transformers and switchgear can cause explosive failure and needs to be avoided where practical
- Ensuring all equipment is suitably secured and earthed
- Ensuring adequate monitoring and inspection activities cover legislative compliance obligations and duty of care safety obligations
- Ensuring all risks are identified and have adequate management plans integrated into the business' practices
- Ensure adequate monitoring and inspection activities cover regulatory, contractual and legislative compliance requirements and duty of care safety obligations

Complying with regulatory, contractual and legal responsibilities:

- Ensure adequate monitoring and inspection activities cover regulatory, contractual and legislative compliance requirements and duty of care safety obligations.

Some of the identified compliance requirements are detailed below:

- Ensuring oil (with or without Polychlorinated Biphenyl (PCB)) spill risks are managed in compliance with TasNetworks' Health, Safety, Sustainability and Environment Policy
- Ensuring confined space entry signage and records are in accordance to AS 2865: 2009, Confined Spaces and Work, Health and Safety Regulations 2012.
- Ensuring installations of assets (including earthing) are compliant to:
  - AS 2067 Substation and high voltage installations exceeding 1 kV a.c.
  - AS1940 The storage and handling of flammable and combustible liquids
  - Electricity Network Association (ENA) guidelines
  - Building Code of Australia:
    - Protection of Openings C3.5 Doorways in firewalls
    - Part E1, Fire fighting equipment
  - Part E2 Smoke Hazard Management generally and in particular, with clause E2.2 and E2.3 regarding air handling, smoke detection and alarm, and special hazards of fire risk
  - Part E4 Emergency lighting, Exit signs and warning systems

- Ensuring inspection and monitoring practices are compliant to:
  - AS 1851 Maintenance of fire protection system and equipment
  - AS/NZS 2293.2 Emergency evacuation lighting for buildings – Inspection and maintenance
  - Workplace Standards Tasmania: How to Manage and Control Asbestos in the Workplace Code of Practice 2012

7.2.1 Routine maintenance

There is a fundamental requirement for TasNetworks to periodically inspect and maintain these assets to ensure their reliability is maintained and their physical state and condition does not represent a hazard to the public. Other than visiting the assets, there is no other economic solution to satisfy this requirement.

7.2.2 Routine maintenance versus non routine maintenance

Asset failures can result in serious or catastrophic damage to the asset. These assets are generally located in close proximity to the public, so allowing failures to occur represents a real risk to the public and surrounding infrastructure. These assets also have a high unit value which is why a preventative corrective maintenance program represents a cost effective alternative to a reactive corrective maintenance program.

7.2.3 Refurbishment

Where substation assets are removed from the network in good operating condition by capacity drivers or other drivers the assets are assessed for redeployment back into the network where it is deemed to be an economic proposition.

7.2.4 Planned asset replacement versus reactive asset replacement

Similarly to Section 7.2.2, a reactive replacement does not represent an attractive alternative to a planned renewal activity. Ground mount substations are predominately supplying high density urban, commercial or CBD communities, with a high service level expectation in the Tasmanian Electricity Code. Reactive replacements are significantly more expensive than planed replacements due to higher labour costs, penalties for unplanned outages and additional repair costs to other infrastructure impacted by the failure.

7.2.5 Non-network solutions

Ground mounted substations are a fundamental requirement of the network with very limited alternatives available for providing the functionality.

7.3 Routine maintenance

7.3.1 Condition monitoring and load checks (AIDSM)

TasNetworks has a substation inspection program in place to monitor the condition of the assets and ensure they are in sound condition and secure. As part of the inspection partial discharge testing is undertaken on the high voltage equipment.

The opportunity is also taken to capture substation load data during this process to support the Capacity Management Planning processes. The frequency of inspection listed in Table 4 considers the varying risk profiles across the assets.

The timing of these inspections has been chosen to coincide with Tasmania's peak load (i.e. winter), as this will demonstrate how the assets are performing under maximum conditions.

Table 4: Inspection frequency for ground mounted substations

Classification	Frequency
CBD substations	Once per year (winter)
All other substations greater than 100% load	Once per year (winter)
All other substations less than 100% load	Once every two years (winter)

7.3.2 Fire system inspections (AIDSM)

Fire System Inspections comprise the following programs:

- Fire Suppression Compliance Inspection
- Fire and Exit Doors Inspection
- Emergency and Exit Lighting Inspection

Each of these is described in the following sections.

7.3.2.1 Fire suppression compliance inspection

Where fire suppression systems are installed TasNetworks are requires to comply with the requirements of the Australian standard (AS 1851). TasNetworks undertakes monthly inspections of the fire panels and smoke alarms at the sites, with other less frequent maintenance completed occurring to the standard.

7.3.2.2 Fire and exit doors inspection

The fire and exit doors at substations that contain fire suppression systems are inspected by an external fire maintenance firm. This activity is done in accordance with AS1851 on a six monthly basis and is aligned with the fire suppression maintenance. The fire and exit doors at all other substations are inspected as part of the routine substation inspections.

7.3.2.3 Emergency and exit lighting

Substation buildings may be classified as a class 8 building as part of the Building Code of Australia (BCA). The installation of emergency lighting, exit lights and warning systems are governed by the requirements of the BCA volume 1 (Part E4 Emergency lighting, Exit signs and warning systems).

The maintenance requirements for emergency lighting in ground mounted substation buildings are specified in AS/NZS 2293.2 Emergency evacuation lighting for buildings – Inspection and maintenance.

Similar to the doors above, the testing of emergency and exit lighting at substations that contain a fire suppression system is done by an external fire maintenance firm. This activity is done in accordance with AS 2293.2 on a six monthly basis and is aligned with fire suppression maintenance. The emergency exit lighting at all other substations is completed as part of the routine substation inspections.

Table 5: Inspection frequency for fire systems

Classification	Frequency
Fire suppression compliance inspection	Monthly
Fire and exit doors inspection	Six Monthly
Emergency and exit lighting Inspection	Six Monthly

7.3.3 Earthing audits (Injection testing) (AIDSM)

TasNetworks undertakes routine auditing of distribution substation earthing systems, which acts as an effective condition assessment of the earth mat and ensures the risk of shock to personnel

and the public under fault conditions is acceptable in accordance with AS 2067 and ENA DOC 025 *EG-0 Power system earthing guide - Part 1: management principles*.

In identifying sites that may pose non-negligible shock or fatality risks, the following attributes are considered:

- Substations with little earthing system interconnection via cable screens or MEN networks
- Areas with high fault levels or high soil resistivity
- Sites with above average contact scenarios (schools, swimming pools, shopping centres, etc)

Currently TasNetworks undertakes routine testing of five high risk substation earthing systems per year that fit within these criteria to verify the integrity of the earthing system.

7.3.4 Special audits (AIDSM)

Where special audits are required on the ground mounted substations due to emerging risks or issues they are undertaken under this program. This program also covers SF_6 reporting requirements.

A program shall be created in the annual Program of Work as required to cover any expenditure in this area.

7.3.5 Switchgear maintenance (RMDSR)

TasNetworks undertakes invasive routine maintenance on all ground mounted high voltage switchgear. The switchgear maintenance frequency ranges from three to eight years and is dependent on the switchgear type. The maintenance frequencies are shown in Table 6.

Table 6: Switchgear maintenance frequencies

Switchgear type	Frequency
Yorkshire YSF6 Siemens 8CK	Once every 3 years
Asea Brown Boveri RGB12/24 English Electric OLX Brush COQ Fluokit M C40 and M24 GEC DDFC GEC Oil RMU Hazemeyer MD4 Reyrolle JK/JKSS Reyrolle LMT Slatter	Once every 4 years
Asea Brown Boveri RGB12 Reyrolle LMVP	Once every 6 years
Asea Brown Boveri CTC12 and 24 Merlin Gerin/Schneider (M6, RM6, SM6) Yorkshire (Gas)	Once every 8 years

The maintenance ensures the reliable operation of the switchgear until the next maintenance cycle. The maintenance also includes the removal of vegetation build-up within the substation enclosures, thermal and partial discharge inspections and other general maintenance activities. Protection systems are also checked at this time.

The maintenance program is also used to identify assets where their condition has deteriorated to a level where renewal has become necessary and to monitor risks associated with specific programs identified within the asset category.

The following inspections are also conducted as part of the routine maintenance:

- Asbestos containing materials
- Confined spaces

Asbestos Inspection

Asbestos Containing Material (ACM) in substations is routinely inspected to ensure the hazard does not present an unacceptable risk. Where the hazard cannot be satisfactorily managed the asset is scheduled for replacement.

Confined Spaces Inspection

The definition of a confined space is contained in Regulation 51 of the Work Health and Safety Regulations 2012.

Safe entry into confined spaces to perform work is governed by these regulations and is detailed in the Workplace Standards Confined Space Code of Practice 2012.

To comply with relevant legislation around confined space management, TasNetworks checks the accuracy of the confined space register and confined space labelling once every 4 years in conjunction with the switchgear maintenance.

Table 7: Switchgear and associated components maintenance frequency

Classification	Frequency
Switchgear maintenance	3-8 years (Refer Table 8)
Asbestos inspection	According to asbestos monitoring register
Confined space inspection	4 years

7.3.6 Transformer PCB Levels (RMDSR)

As part of the routine switchgear maintenance, if asset records indicate that the status of the oil in a transformer is 'unknown' then a sample of oil is taken from the transformer for PCB testing. If the PCB test results indicate PCB levels equal to or greater than 50 ppm, the transformer is assessed for removal from the network.

7.3.7 Civil Maintenance (RMDSR)

Civil maintenance is routinely performed at TasNetworks' fence type distribution substations every 4 months to ensure the sites are kept in a good condition. This maintenance is completed by an external service provider.

7.4 Non-routine maintenance

7.4.1 Minor and major asset repairs (ARDSR)

Defects identified during asset inspections, routine maintenance, other ad-hoc site visits or customer reports, are prioritised and rectified through the general asset defects management process and maintenance programs.

7.4.2 Graffiti removal (ARDSR)

It is TasNetworks' practice to remove all offensive graffiti within 24 hours of notification of the presence of it. Graffiti that covers substation signage is given priority for removal. All other graffiti may be removed within the normal asset repair time frames.

7.5 Reliability and quality maintained

The key drivers for asset replacement are unsatisfactory condition, specific issues (As identified in Section 6) and risks identified from the routine inspection and maintenance practices. Asset failure may also result in early asset replacement occurring.

7.5.1 Upgrade ground mounted earthing systems (REGEA)

The knowledge of the condition of the earthing systems at ground mounted substations is limited.

TasNetworks' substations are located in a wide variety of situations. The following installation types may pose an increased risk to the public:

- Substations within 100 m of swimming pools because of the large number of public gathered at these sites in a wet environment with no footwear (approximately 15 sites)
- Substations within 15 m of schools because of the large number of children (who are more susceptible to electric shock than adults) gathered at these sites (approximately 171 sites)
- Substations within 15 m of shopping centres and bus stops because of the larger number of people that may gather at these sites (approximately 100 sites)

TasNetworks has an ongoing program in place to perform earthing injection testing on five sites per year. The sites selected for testing are those that have the potential to be more hazardous under fault conditions.

7.5.2 Preliminary design work – Substations (SIPRS)

Where future work has been identified, the opportunity may arise to undertake preliminary substations designs. This approach provides for a continuation of design work throughout the whole financial year.

7.6 Regulatory obligations

7.6.1 Reinforce fibreglass doors (REGMQ)

There are specific areas within the network that have been identified as carrying a higher risk of unauthorised access to substations due to vandalism and a higher density of human traffic (e.g. schools). The doors on the fibreglass kiosks can be more accessible for unauthorised entry. To reduce this risk there is a program in place to reinforce the doors on fibreglass substations.

TasNetworks began a program in 2012/13 to reinforce the doors on 179 kiosks in the system. At the end of the 2015/16 financial year there will be 17 units remaining in the system where the doors have not been reinforced. TasNetworks plans to have the doors on all these kiosks reinforced by the end of the 2016/17 financial year.

7.6.2 Address safety or environmental issues in ground mounted subs (SIGMS)

This program has four components:

- Address asbestos issues
- Address confined space issues
- Address fire standard compliance issues
- Address oil containment issues

Each of these is described in the following sections.

7.6.2.1 Address asbestos issues

TasNetworks has a program in place to remove asbestos in substations where the risk cannot be satisfactorily managed.

7.6.2.2 Address Confined Space issues

As at September 2015, there are 3 substations that are classified as confined spaces. Substations that are classified as confined spaces are usually below ground installations. These sites have restricted access to minimise the safety risk to operational staff.

When the substation is scheduled for refurbishment or upgrading, options are considered for relocating the substation above ground so that the Confined Space classification can be removed. The ability to relocate the substation above ground is dependent on the availability of a suitable site.

7.6.2.3 Address fire standard compliance issues

This program has the following components:

- Fire/explosion risk
- Fire suppression system

Each of these is described in the following sections.

Fire/explosion Risk

All sites identified as a fire/explosion risk are assessed to determine whether relocation or replacement is necessary. As at September 2015, no sites have been identified for attention for the 2015/16 financial year.

Fire Suppression System

In liaising with TasFire, TasNetworks requires a program to progressively convert all existing CO_2 fire suppression systems in vault type and building integrated substations to a new Stat-X fire suppression system.

A program consisting of five sites per year commenced in 2013/14 with all 19 sites to be completed by 2016/17 financial year.

Address oil containment issues

TasNetworks has an Environmental Management Plan for managing the impact of its network on the environment. Where an installation has the potential to impact the environment the risk is assessed against TasNetworks Risk Framework. Where the level of risk is above a manageable level, options are assessed to reduce the risk. This may include modifications to the existing installation or relocation of it.

7.7 Replacement

7.7.1 Replace Ground Mounted Substation (REGMS)

A prioritised replacement of ground mounted substations is being undertaken based on the individual risk of each substation. The assessment of risk is done in accordance with TasNetworks Risk Framework.

The replacement of a substation is usually driven by risk associated with the increased probability of an asset failure occurring, particularly the high voltage switchgear and the consequences of the failure e.g. safety risk to operational personnel and the public, network disruption and environmental impact.

Each substation identified for replacement is prioritised based on an assessment against the following criteria:

- Risk to safety i.e. level of exposure e.g. enclosure type, location
- Criticality of the installation
- Condition

- Compliance
- Age

Due to the risks associated with high voltage switchgear failures, in the majority of cases the replacement of the switchgear is the driver for the replacement of the substation.

The increased rate of failure with the switchgear in substations over 50 years of age has resulted in the overall rate of replacement being developed with a target of having all substations replaced prior to them reaching 50 years of age. Historically the strategy was to replace the substations at a rate of 15 sites per year, but for a 5 year period from 2015 the future rate of replacement has been increased to 23 sites per year to ensure the risks can be maintained at a manageable level.

Where the most cost effective solution to replace the switchgear is the complete replacement of the substation i.e. installation of a new kiosk, the replacement is undertaken under the REGMS program.

This program has a number of sub-programs with their own drivers. These programs consist of:

- Substation replacement (Oil-filled switchgear)
- Substation replacement (Non oil-filled switchgear)
- Other
- Fault replacement

Each of these is described in the following sections.

7.7.1.1 Substation replacement (Oil-filled switchgear)

Due to the risks associated with oil filled switchgear TasNetworks began a replacement program in 2012 to remove it from its network.

The failure rate of oil-filled switchgear has increased in recent years with 80% of the failures being from this type of switchgear, yet it only represents 10% of the switchgear population.

The rate of replacement is based on an overall target of no switchgear being in service for more than 50 years because above this age the likelihood of a major failure escalates, increasing the risk of a major incident. To achieve this objective the replacement rate has been set at thirteen sites per year, reducing to ten sites per year in 2020.

Where the switchgear is installed in a kiosk substation in the majority of instances the most cost effective solution is the replacement of the kiosk in its entirety. This is due to the fact that by the time of replacement the substations have usually been in service for 50 years or more years and also near end of life

The majority of the substation replacements are driven by the replacement of the oil-filled switchgear. Of the 23 substations being replaced per year, 13 are driven by the replacement of the oil-filled switchgear.

7.7.1.2 Substation replacement (Non oil-filled switchgear)

Where issues are identified with other switchgear types asset replacement is considered.

<u>ABB RGB24 switchgear replacement</u>

Due to the increased probability of failure with this switchgear type a replacement program is in place to remove it from the network. As at September 2015 there were 20 substations remaining on the network containing RGB24 switchgear. The rate of replacement is typically 1 to 2 sites per year. Replacement may consist of either replacement of the switchgear or complete substation replacement. Where complete substation replacement is the preferred option the work is undertaken under the REGMS program.

Hazemeyer switchgear replacement

There are operational restrictions in place for Hazemeyer due to the exposed design creating an elevated risk to operators undertaking operational work on this type of switchgear. Where the operational restriction impacts upon network restorations or other issues are identified, asset replacement is undertaken.

7.7.1.3 Other

Substation replacement may also be driven by other factors. This can be due to a deterioration in the condition of the substation enclosure, transformers, or a change in external conditions e.g. sensitivity of the area.

7.7.1.4 Fault Replacement

In addition to the planned replacement programs, TasNetworks experiences a number of switchgear failures each year due to random failures and faults. These are the results of incidents such as lightning strikes, vehicles hitting substations and equipment failures.

Incident reporting reports an average rate of approximately eleven incidents per year. The majority of these incidents relate to other specific programs already accounted for, but there are approximately four incidents per year that may result in asset replacement.

7.7.2 Replace high voltage switchgear (REHSW)

TasNetworks has a prioritised replacement program for high voltage switchgear in ground mounted substations. The need to undertake replacement is made based on the risk of each installation. The assessment of risk is done in accordance with TasNetworks Risk Framework.

The replacement of a substation is usually driven by risk associated with the increased probability of an asset failure occurring, particularly the high voltage switchgear and the consequences of the failure e.g. safety risk to operational personnel and the public, network disruption and environmental impact.

Due to an increased rate of failure with the switchgear in substations over 50 years of age the overall rate of replacement has been developed based on a target of having all switchgear in substations replaced prior to reaching 50 years of age. The rate of replacement has been set at 8 sites per year to ensure the associated risks can be maintained at a manageable level.

Due to the risks associated with oil-filled high voltage switchgear, in 2012 TasNetworks began a replacement program for this type of switchgear. There are currently 224 substations on the network that contain oil-filled switchgear.

Each substation identified for replacement is prioritised based on an assessment against the following criteria:

- Risk to safety i.e. level of exposure e.g. enclosure type, location
- Criticality of the installation
- Condition
- Compliance
- Age

As part of the routine substation inspections (yearly or two yearly), the switchgear is monitored for partial discharge. If a site is found to have any issues that result in an elevated risk it may be considered for asset replacement.

The removal of oil filled switchgear from the network will result in a reduction of operational costs as modern switchgear requires less frequent and less intrusive maintenance. It is estimated from

current maintenance on oil-filled switchgear that a saving of $71 000 per year will result from the removal of this type of switchgear from the network.

The replacement from oil filled to air/gas switchgear also allows for added functionality such as remote controlling.

7.7.3 Replace ground mounted low voltage switchgear (RELSW)

There are two components to this replacement program:

- Replace asbestos arc chutes
- Replace live front boards

Each of these is described in the following sections.

7.7.3.1 Replace asbestos arc chutes

This is a continuation of an existing program to remove low voltage circuit breakers that contain asbestos in the arc chutes. TasNetworks began a replacement program in March 2007 to replace the 90 sites within the system. There are currently 32 sites remaining in the system and it is anticipated that this program will continue at a rate of 6 sites per year, with all low voltage circuit breakers containing asbestos arc chutes being removed by the end of 2019/20 financial year.

The rate of replacement has ensured that circuit breakers are removed from the network prior to the asbestos becoming 'friable' and more hazardous.

Replacement of asbestos equipment reduces the total number of sites that are audited under asbestos inspections, resulting in a decrease in operational expenditure.

7.7.3.2 Upgrade live front boards

Live front low voltage distribution boards exist in 233 substations on the distribution network. The construction of these boards means that live equipment is easily accessible and poses an elevated risk to personnel safety. Many of these boards are located in restrictive sites, near doorways and in some instances near lights switches, with little access for escape in the event of contact with live parts.

In 2007 TasNetworks began a program to address the safety risk at these sites.

In the majority of instances the most cost effective solution to address the risk is to cover up the board so that there are no exposed live parts. The program was initially addressing 10 sites per year.

A live front board audit was completed in 2012/13 to quantify the precise number of sites with live front boards and the risk at each particular site. This audit determined the replacement prioritisation. At this time due to this high level of safety risk identified the current replacement program was increased from 10 sites to 40 sites per year until all the live front boards are removed from the network.

At the end of the 2015/16 financial year there will be less than 50 sites remaining on the network and TasNetworks plans to have these removed by 2017/2018.

A significant reduction in the risk has resulted due to this change in replacement rate. This is because the live front board risk will be removed 25 years sooner than the previous program. Based on TasNetworks' risk framework the severity remains at 'major' (fatality) until all sites are addressed, although the likelihood of an incident occurring has significantly reduced.

7.7.4 Replace ground mounted transformer (REGTF)

Transformer replacement is initiated where the condition is such that there is a high likelihood of a failure occurring that would result in an unacceptable consequence. Transformers in poor

condition likely to considered for replacements are those supplying critical or commercial loads, or where a failure could present a safety or environmental risk.

Where transformers with exposed live bushings or PCB contamination are identified consideration is given for their replacement.

Table 8: Assets replacement volumes

Classification	Annual volume
Replace ground mounted substations (REGMS)	
Oil-filled switchgear	13
Non oil-filled switchgear	10
Fault replacement	As required
Replace switchgear (REHSW)	
Oil filled switchgear	7
Non oil-filled switchgear	1
Fault replacement	As required
Underground Mounted LV Switchgear (RELSW)	
Replace low voltage switchgear with asbestos arc chutes	2
Upgrade live front boards	40
Replace ground mounted transformers (REGTF)	4

7.8 Investment Evaluation

Where investment is required to achieve compliance with TasNetworks' business objectives an options analysis is undertaken to determine the most appropriate solution.

Economic analysis is undertaken using TasNetworks' investment evaluation tool.

7.9 Spares management

Strategic spares for distribution substations are managed in accordance with the Spares Management Strategy[1].

7.10 Disposal plan

Materials that pose a risk to human health as well as being a possible environmental hazard are disposed of in accordance with the Environmental Management Pollution Control Act 1994, TasNetworks' internal safety and environmental management plan and ANZECC.

7.10.1 Recovery and Disposal of Redundant SF6 Switchgear (ARDSO)

To comply with legislative requirements for the disposal of redundant equipment containing SF_6, TasNetworks is required to comply with National Environment Protection Measures and the Environmental Management Pollution Control Act 1994.

[1] Spares Management Strategy – Distribution Substations R247679

Equipment containing SF_6 that is removed from service is stored at the nearest depot until a storage container is full. It is then transported by an accredited transportation corporation interstate for SF_6 recovery and disposal of units at an accredited end of life facility.

Historical data shows that approximately six units of ground mounted substations and pole mounted assets are recovered and disposed of every year.

TasNetworks is required to report the loss and disposal of SF_6 in accordance with the National Greenhouse and Energy Reporting Act 2008. This process is managed by TasNetworks' Environmental Management team.

Disposal of SF_6 is managed in accordance with TasNetworks' Environmental Management Procedure EW-M12-01

7.10.2 Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) were used in insulating oils and other products from the 1930s to the 1970s. It has been shown to be toxic material and carcinogenic and has been banned in Australia since the 1970s.

TasNetworks manages PCBs in accordance with its Environmental Management Procedure EM-M09 Management of PCBs. This management process meets the requirements of the Australian and New Zealand Environment and Conservation Council (ANZECC) Polychlorinated Biphenyls Management Plan and the Environmental Management Pollution Control Act 1994.

Whilst records indicate that no distribution transformers were purchased with PCB insulating material, cross contamination has occurred over time where oil management was undertaken using equipment also used for oil management of PCB-contaminated assets. This has led to a number of transformers with PCB contamination.

As part of the routine switchgear maintenance, if asset records indicate that the status of the oil in a transformer is 'unknown' then a sample of oil is taken from the transformer for PCB testing. If the PCB test results indicate PCB levels equal to or greater than 50 ppm, the transformer is assessed for replacement.

7.11 Summary of Programs

Table 9 provides a summary of all of the programs described in this management plan.

Table 9: Summary of programs

Work program	Work category	Project/Program
Routine maintenance	Ground mounted substation inspection and load monitoring (AIDSM)	Condition monitoring and Load Checks
		Fire system Inspections
		Earth-grid Audits (Injection Testing
		Special audits
	Ground mounted substation routine maintenance (RMDSR)	Switchgear maintenance
		Transformer PCB levels
		Asbestos inspection
		Confined space inspection
		Civil maintenance
Non-routine maintenance	Asset repair (ARDSR)	Minor and major asset repairs
		Graffiti removal – Offensive
		Graffiti removal - Other
Reliability and quality maintained	Upgrade ground mounted substation earthing (REGEA)	Upgrade ground mounted earthing systems
	Preliminary design Work – Substations (SIPRS)	Preliminary design work – Substations
Regulatory obligations	Replace ground mounted substations (REGMQ)	Reinforce fibreglass doors
	Address safety or environmental issues in ground mounted substations (SIGMS)	Address asbestos issues
		Address confined space issues
		Address fire standards compliance issues
		Address oil containment issues
Replacement	Replace ground mounted substations (REGMS)	Substations with oil-filled switchgear
		Substations without oil-filled switchgear
		Other
		Fault replacement
	Replace high voltage switchgear (REHSW)	Replace switchgear (Oil filled)
		Replace RGB24 switchgear
	Replace ground mounted low voltage switchgear (RELSW)	Replace asbestos arc chutes
		Replace live front boards
	Replace ground mounted transformers (REGTF)	Replace PCB containing transformers
Spares management	System spares management (RMSSM)	Management of spares
Disposal	Asset repair (Other) (ARDSO)	Recovery and disposal of redundant SF6 switchgear

8 Financial Summary

TasNetworks' makes a concerted effort to prepare a considered deliverability strategy based on the planned operational and capital programs of work for distribution network assets. A number of factors contribute to the successful delivery of the program of work. These factors are utilised as inputs to prioritise and optimise the program of work and to ensure sustainable and efficient delivery is maintained. This program of work prioritisation and optimisation can impact delivery of individual work programs in favour of delivery of other programs. Factors considered include:

- Customer-driven work we must address under the National Electricity Customer Framework (NECF).
- Priority defects identified through inspection and routine maintenance activities.
- Identified asset risks as they relate to safety, the environment and the reliability of the electrical system.
- Adverse impacts of severe storms and bushfire events.
- System outage constraints.
- Changes to individual project or program delivery strategy.
- Size and capability of its workforce.
- Support from external contract resources and supplementary service provision.
- Long lead equipment and materials issues.
- Resolution of specific technical and functional requirement issues.
- Complex design/construct projects with long lead times.
- Approvals, land acquisition or wayleaves.
- Access issues.

Specific to ground mounted substations asset management plan, these factors have had minimal impact on the delivery of the operational programs of work, but have resulted in delayed delivery of the capital programs of work.

8.1 Proposed OPEX Expenditure Plan

TasNetworks is satisfied that its current practices are meeting business requirements. In-service failures are rare and the assets are achieving and exceeding their expected service life.

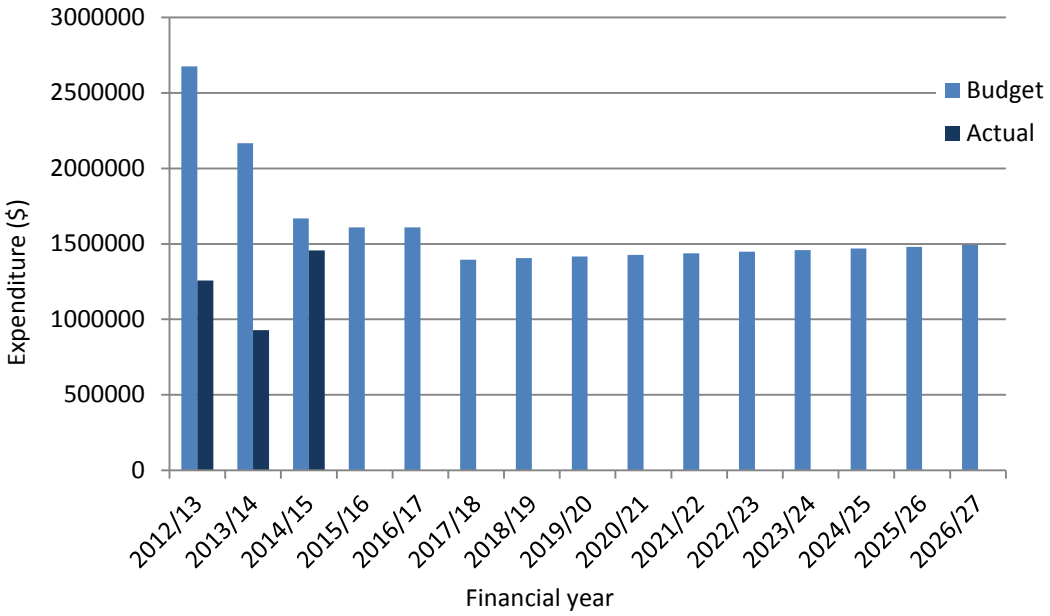
The current routine maintenance programs shall continue at current levels due to the critical nature of these assets and the need to ensure their reliable operation.

Table 10 Provides the historical operational expenditure and the proposed future spend for the OPEX programs.

Table 10: OPEX for period between 2012/2013 and 2019/2020 financial years

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Budget ($)	2 675 745	2 167 227	1 668 000	1 609 000	1 609 000	1 394 370	1 405 199	1 416 028
Actual ($)	1 257 070	929 204	1 456 508					

Figure 7 : OPEX expenditure profile



8.2 Proposed CAPEX Expenditure Plan

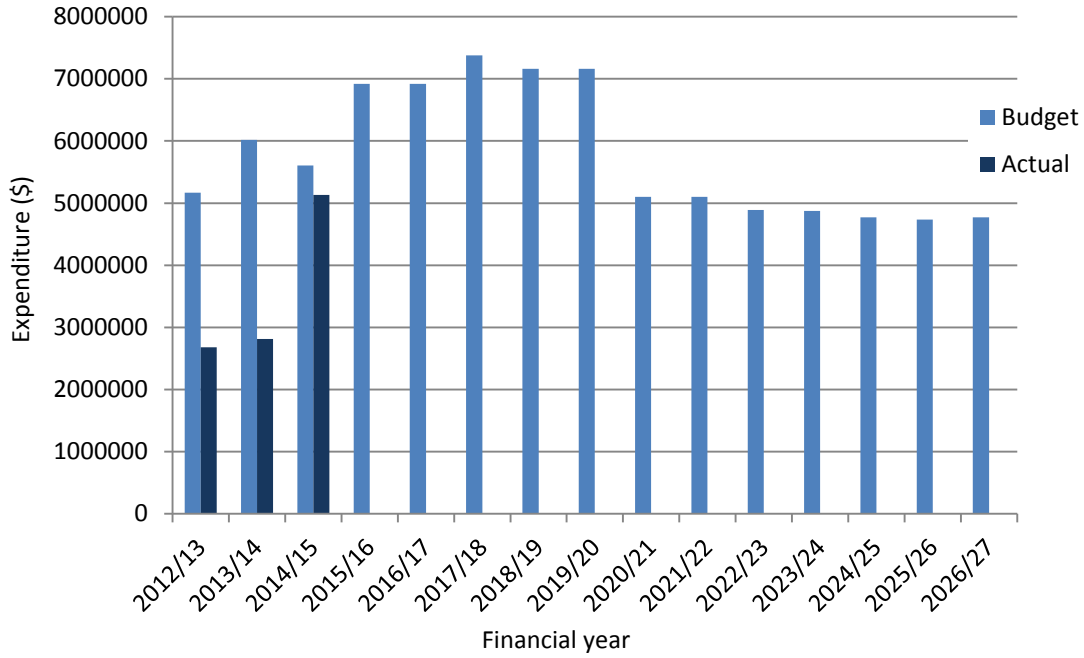
The capital programs and expenditure identified in this management plan are necessary to manage operational and safety risks and maintain network reliably in compliance with business objectives. All capital expenditure is prioritised based on current condition data, field failure rates and prudent risk management.

Table 11 Provides the historical operational expenditure and the proposed future spend for the CAPEX programs.

Table 11: CAPEX for period between 2012/2013 and 2019/2020 financial years

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Budget ($)	5 167 822	6 017 505	5 604 102	6 919 039	6 919 039	7 375 374	7 159 374	7 159 374
Actual ($)	2 680 465	2 814 970	5 131 388					

Figure 8: CAPEX expenditure profile



8.2.1 CAPEX – OPEX trade offs

The operating expenditure programs are essential for identifying assets that require replacement for condition-based reasons. An example of this is the routine inspection and condition monitoring of substations for identification of defective assets allowing for replacement to occur prior to failure.

There is a positive relationship between these two categories in that regular inspection programs gather continuous condition information, identify any asset trends supporting the targeting of asset for replacement. Maintenance and repair activities also defer the requirement for capital expenditure and increase the likelihood of achieving a reasonable service life from the asset.

9 Responsibilities

Maintenance and implementation of this management plan is the responsibility of the Asset Strategy Team.

Approval of this management plan is the responsibility of the Asset Strategy Team Manager.

10 Related Standards and Documentation

The following documents have been used to either in the development of this management plan, or provide supporting information to it:

1. Strategic Asset Management Plan - R248812
2. Risk Management Framework – R209871
3. Australian and New Zealand Environment and Conservation Council (ANZECC) Polychlorinated Biphenyls Management Plan (Revised Edition April 2003)
4. AS 1940 The storage and handling of flammable and combustible liquids
5. AS 2067 Substations and high voltage installations exceeding 1 kV AC.
6. Workplace Standards Tasmania – Confined Spaces Code of Practice 2012
7. AS 1851 Maintenance of fire protection systems and equipment
8. AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)
9. Work Health and Act and Regulations 2012
10. The National Environmental Protection Measures (NEPMS)
11. The Environmental Management and Pollution Control Act 1994
12. Building Code of Australia
13. Work-Safe Tasmania – How to Manage and Control Asbestos in the Workplace 2012
14. ENA DOC 025 EG-0 Power system earthing guide - Part 1: management principles
15. AS 1851 Maintenance of fire protection system and equipment
16. AS/NZS 2293.2 Emergency evacuation lighting for buildings – Inspection and maintenance
17. Ground Mounted Substations – Live Asset Record v2 - R237021

11 Appendix A – Summary of Programs and Risk

Table 6 Summary of Programs and Risks - Opex

Description	Work Category	Risk Level	Driver	Expenditure Type	Residual Risk	12/13	13/14	14/15	15/16	16/17	17/18	18/19
Ground mounted substation (GMS) - Minor asset repairs	ARDSR	Medium	Safety/Reliability	Opex	Low	221 606	243 567	381 407	220 000	220 000	200 912	200 912
GMS - Major asset repairs	ARDSR	Medium	Safety/Reliability	Opex	Low				80 000	80 000	100 645	100 645
GMS – Graffiti removal	ARDSR	Low	Environment and community	Opex	Low				10 000	10 000	20 000	20 000
GMS - Asset Inspection (Visual, load check and condition monitoring)	AIDSM	Medium	Safety/Reliability	Opex	Low	359 786	352 326	338 508	350 000	350 000	216 398	216 398
GMS - Fire system inspections	AIDSM	High	Safety/Compliance	Opex	Low				75 000	75 000	81 000	81 000
GMS – Earth grid Audits (injection testing)	AIDSM	High	Safety/Compliance	Opex	Low				50 000	50 000	85 000	85 000
GMS – Special audits (Asbestos inspections)	AIDSM	Medium	Safety/Compliance	Opex	Low				80 000	80 000	20 000	20 000
Recovery and Disposal of Redundant SF6 Switchgear	ARDSO	Low	Safety/Compliance	Opex	Low	0	0	0	30 000	30 000	50 000	50 000
GMS – Civil maintenance	RMDSR	Medium	Safety/Reliability	Opex	Low	676 315	352 519	736 593	21 000	21 000	48 900	48 900
GMS - Switchgear Maintenance (3,4,6 & 8 yearly)	RMDSR	High	Safety/Reliability	Opex	Low				653 000	653 000	441 943	441 943
GMS – Transformer oil tests (PCB)	RMDSR	Medium	Safety/Compliance	Opex	Low				10 000	10 000	34 000	34 000
System Spares Management	RMSSM	Low	Safety/Reliability	Opex	Low	4 108	8 525	3 780	-	-	10 000	10 000

Table 8 Summary of Programs and Risks - Capex

Description	Work Category	Risk Level	Driver	Expenditure Type	Residual Risk	12/13	13/14	14/15	15/16	16/17	17/18	18/19
Upgrade earthing systems	REGEA	High	Safety/Reliability	Capex	Low	20 355	41 463	-	279 539	100 000	100 000	100 000
Replace fibreglass doors	REGMQ	High	Safety/Reliability	Capex	Medium	10 884	61 665	130 829	50 000	50 000	50 000	50 000
Replace ground mounted substations	REGMS	High	Safety/Reliability	Capex	Medium	1.49m	913 709	2.37m	3.15m	3.15m	4.9m	4.9m
Replace high voltage switchgear	REHSW	High	Safety/Reliability	Capex	Medium	566 430	1.02m	1.73m	2.17m	2.17m	1.6m	1.6m
Replace low voltage switchgear	RELSW	High	Safety/Reliability	Capex	Medium	477 374	445 537	493 574	270 000	270 000	90 000	90 000
Replace ground mounted transformers	REGTF	Medium	Safety/Reliability	Capex	Low	19 606	3 410	32 053	150 000	150 000	230 374	230 374
Address safety and environmental issues in ground mounted substations	SIGMS	High	Safety/Compliance	Capex	Low	81 261	327 337	397 582	850 000	850 000	145 000	145 000

12 Appendix B – Prioritisation tables

Table 7: Oil-containment prioritisation matrix

Condition	State	Rating
Volume of oil on site	<500 L	0
	≥ 500 L	2
Number of transformers	1	1
	≥ 2	0.5
Proximity to waterway	≤ 10 m	2
	< 50 m	1
	≥ 50 m	0
Town water supply	Yes	1
	No	0
Environmentally sensitive area	Yes	1
	No	0
PCB contaminated	> 2 ppm	1
	≤ 2 ppm	0

Table 8: RGB24 Switchgear Replacement Prioritisation Matrix

Priority	Description
1	Open points, as identified by Distribution Operations
2	Sites with maintenance issues, as identified by Network Services
3	All other sites

Table 9: Transformer replacement prioritisation matrix

Condition	State	Rating
Substandard clearance	Yes	3
	No	0
Exposed bushings in fence type substation	Yes	1
	No	0
Corrosion	Bad	3
	Mild	1
	None	0
PCB contamination	≥ 50 ppm	8
	> 2 ppm	1
	≤ 2 ppm	0

Table 10: Earthing testing prioritisation matrix

Priority	Description
1	Swimming pools (100 m)
2	Schools (15 m)
3	High pedestrian areas (15 m)
4	All others

Table 11: Fire Suppression System Installation Prioritisation Matrix

Priority	Description
1	Vault type sites
2	First floor sites
3	Ground floor building integrated

Table 12: Switchgear replacement Prioritisation Matrix

Criteria	State	Rating
Sensitivity	Schools	40
	High density commercial	25
	Residential	15
	High density rural	5
Reliability area	Critical infrastructure	4
	High density commercial	3
	Urban	2
	High density rural	1
Switchgear type	English Electric OLX	20
	Reyrolle LMT	10
	GEC DDFC	10
	Reyrolle JK	15
	Reyrolle JKSS	15
	ABB RGB 24	10
	Hazemeyer	10
	Statter	10
	Other switchgear types	0
Age of switchgear	Age of switchgear from 0-60 years	Scale from 0-40
KVA rating of substation	0-3000 kVA	Scale from 0-10

Table 13: Enclosure safety/security prioritisation matrix

Priority	Description
1	Schools
2	Highly prone vandalism areas
3	All others