



# Asset Management Plan

## Ground Mounted Substations - Distribution

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## Authorisations

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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

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## 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

## 2. Scope

This management plan covers the ground mounted 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

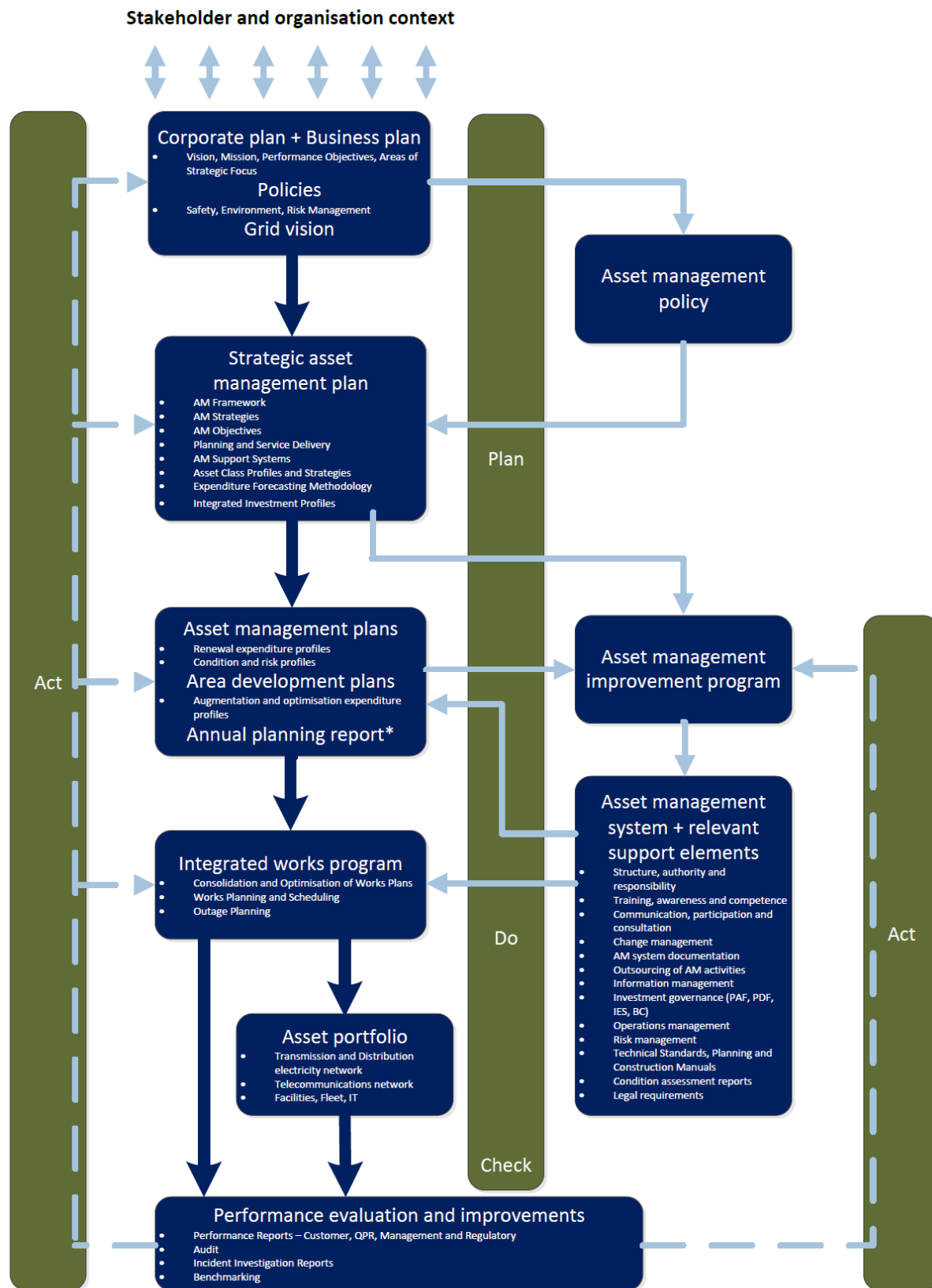
This asset management plan has been developed to align with both TasNetworks' Asset Management Policy and Strategic Objectives.

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.



For these assets the management strategy focuses on the following objectives:

- Safety will continue to be our top priority and we will continue to ensure that our safety performance continues to improve.
- 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.
- Cost performance will be improved through prioritisation and efficiency improvements that enable us provide predictable and lowest sustainable pricing to our customers.
- 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.

## 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 is used to manage asset management activities and for the recording of asset performance. TasNetworks is in the process of migrating from a WASP management system to a SAP management system. The transition to the new system is scheduled to occur in February 2017.

### 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 2004 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 Multiple Earthed Network (MEN) earthing network.

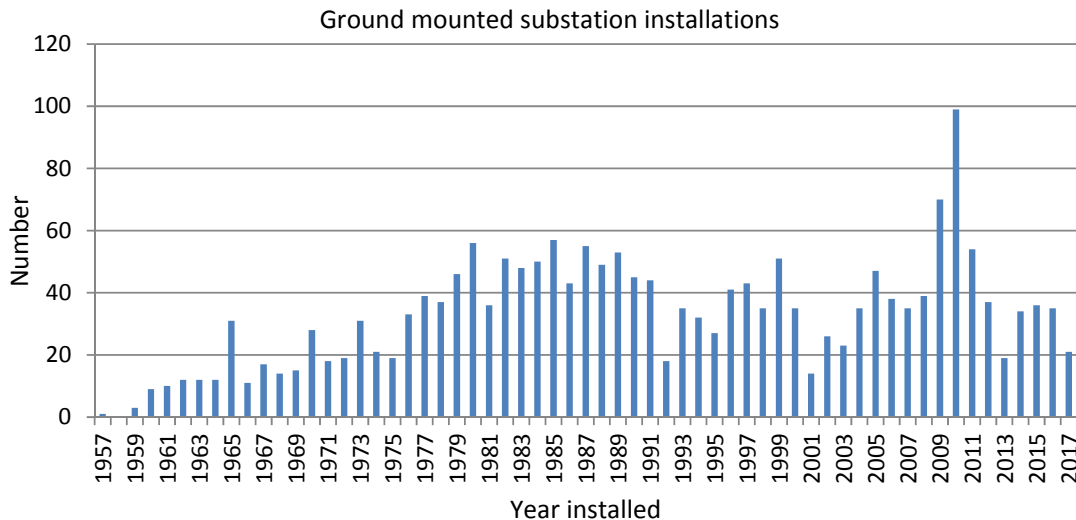
Table 1 details the number of each type of ground mounted substation installed in the network as at September 2015.

**Table 1: Ground mounted substations (as at Aug 2017)**

| Description      | Voltage (kV) | Number Installed |
|------------------|--------------|------------------|
| Building         | 11           | 255              |
|                  | 22           | 109              |
| Fence            | 11           | 95               |
|                  | 22           | 58               |
|                  | 44           | 2                |
| Kiosk (Padmount) | 11           | 870              |
|                  | 22           | 593              |
| Mini-kiosk       | 11           | 6                |
|                  | 22           | 11               |
| Vault            | 11           | 5                |
|                  | 22           | 0                |
| Total            |              | 2004             |

Figure 2 provides an age profile for TasNetworks' ground mounted substations. Although the age profile is quite evenly spread, in the next 10 years, approximately 25 per cent of the 2004 substations will reach or pass the end of their expected service life.

**Figure 2: Total age profile of ground mounted substations (as at Aug 2017)**



### **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 substations 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 ancillary systems. These substations may also include fire detection and suppression systems. They range in size from 300 kVa to 3750 kVA.

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

### **Kiosk substations (Padmount)**

Kiosk substations are stand alone substations that comprise a variety of standard configurations, construction and equipment types. The kiosk enclosures 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 1960s.

**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 5 represents a typical Fence Type installation.

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

**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 substations 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 ancillary systems. These substations may also include fire detection and suppression systems. They range in size from 750 kVA to 1500 kVA.

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

## **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.

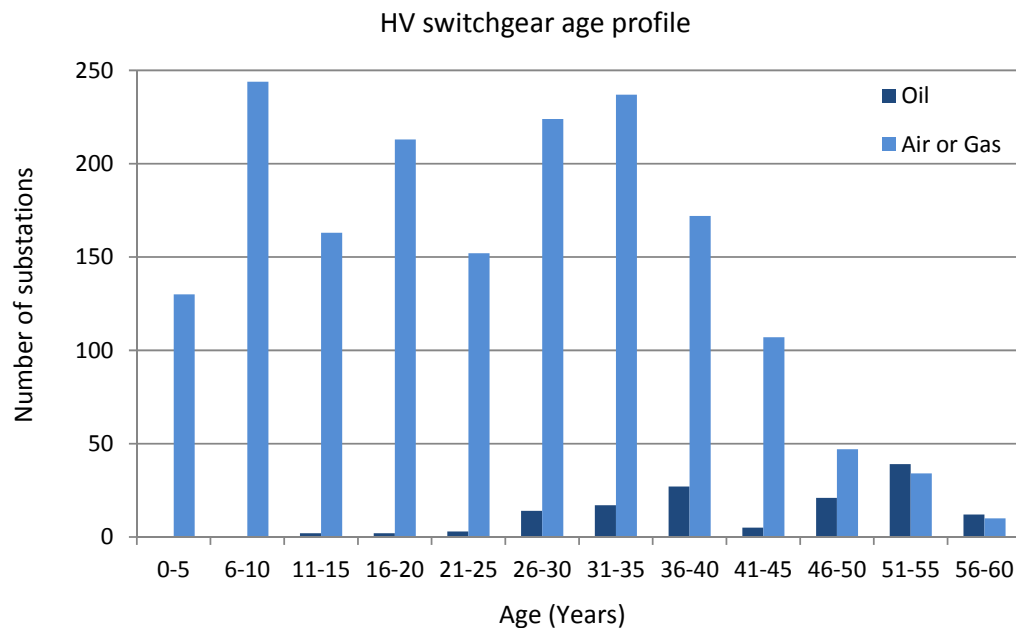
Under fault conditions older switchgear is limited in its ability to contain internal arc faults. This deficiency can result in an increased risk to operational staff and the public. Modern switchgear is available with the capability to contain internal arc faults. This design feature reduces the safety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

**Table 2: High voltage switchgear installed in ground mounted substations (August 2017)**

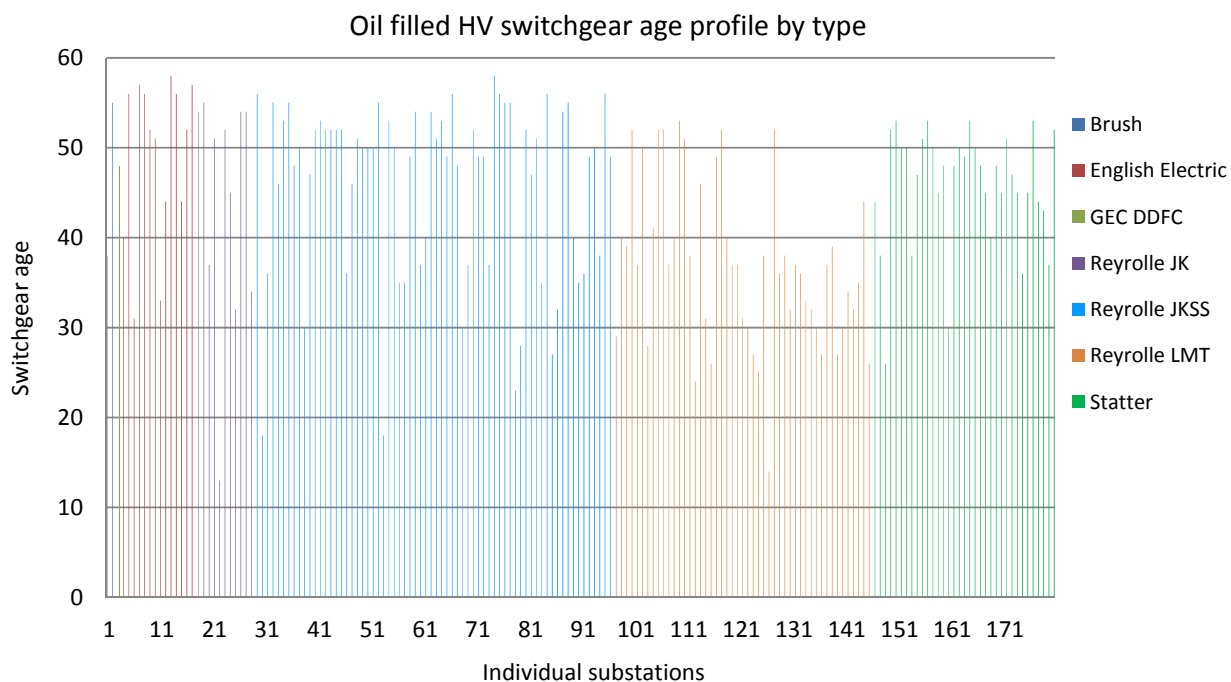
| <b>Manufacture</b>       | <b>Type</b> | <b>Voltage (kV)</b> | <b>Insulating medium</b> | <b>Volume</b> | <b>Years installed</b> | <b>Arc fault containment capability</b> |
|--------------------------|-------------|---------------------|--------------------------|---------------|------------------------|-----------------------------------------|
| ABB                      | CTC12       | 11                  | Gas                      | 1             | 1999                   | No                                      |
| ABB                      | CTC24       | 22                  | Gas                      | 82            | 1975-1999              | No                                      |
| ABB                      | RGB12       | 11                  | Air                      | 491           | 1972-2003              | No                                      |
| ABB                      | RGB24       | 22                  | Air                      | 17            | 1977-2000              | No                                      |
| Brush                    |             |                     | Oil                      | 2             | 1960-1979              | No                                      |
| English Electric         | OLX/OLX2    | 11                  | Oil                      | 14            | 1960-1984              | No                                      |
| Fluokit                  | MC40 & M24  | 11 & 22             | Air                      | 138           | 1973-2001              | No                                      |
| GEC                      | DDFC        | 11                  | Oil                      | 1             | 1968-1983              | No                                      |
| Hazemeyer                | MD4         | 11                  | Air                      | 78            | 1969-2003              | No                                      |
| Merlin Gerin             | M6          | 11 & 22             | Gas                      | 95            | 1982-2006              | No                                      |
| Merlin Gerin / Schneider | RM6         | 11 & 22             | Gas                      | 509           | 1999-2015              | Partial<br>(Front and lateral)          |
| Merlin Gerin / Schneider | SM6         | 11 & 22             | Gas                      | 42            | 1999-2015              | Partial<br>(Front and lateral)          |
| Minipad KPX2             | Fuse        | 11 & 22             | -                        | 17            | 2005-2010              | No                                      |
| Reyrolle                 | JK          | 11                  | Oil                      | 11            | 1961-2004              | No                                      |
| Reyrolle                 | JKSS        | 11                  | Oil                      | 68            | 1959-1999              | No                                      |
| Reyrolle                 | LMT         | 11                  | Oil                      | 49            | 1962-1993              | No                                      |
| Reyrolle                 | LMVP        | 11                  | Air                      | 61            | 2010-2015              | Partial<br>(Front and lateral)          |
| Siemens                  | 8CK         | 22                  | Air                      | 1             | 1983                   | No                                      |
| Siemens                  | H251 20/630 | 22                  | Air                      | 1             | 1973                   | No                                      |
| Statter                  | ODSA        | 11                  | Oil                      | 35            | 1964-2003              | No                                      |
| Yorkshire                | YSF6        | 11                  | Gas                      | 3             | 1986                   | No                                      |

With a shift in the 1970s to a greater utilisation of undergrounding network expansion there was a notable increase in the number of ground mounted substations being installed in the 1970s and 1980s compared to the previous decades. The impact of this change on the ground mounted substation switchgear age profile can be seen in Figure 6.

**Figure 6: HV switchgear age profile (as at August 2017)**



**Figure 7: Oil filled HV switchgear age profile by type (as at August 2017)**



### 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

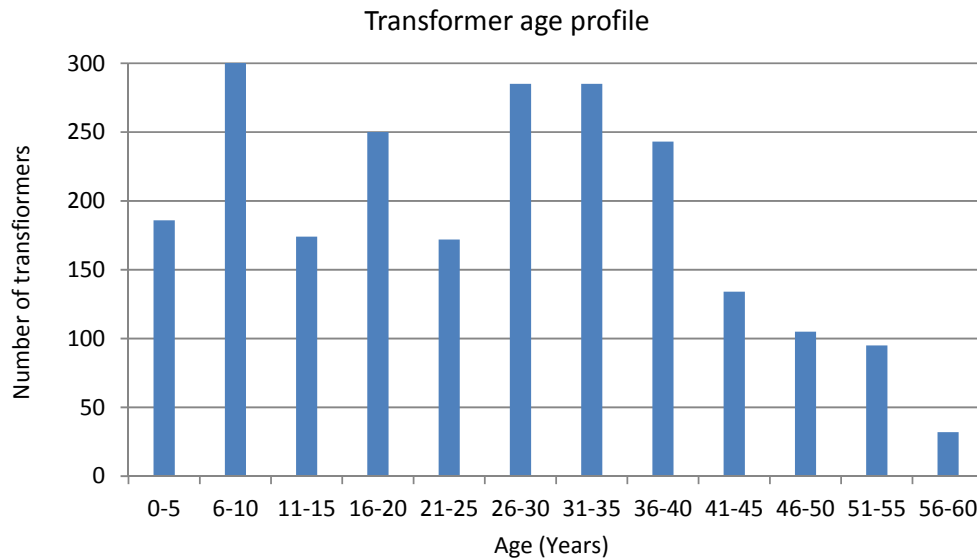
There are a small number of older transformers in the system of non-standard sizes. Where replacement is required these transformers will be replaced with a standard size transformer.

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 3 details the number of transformers installed in the network by size and voltage.

**Table 3: Ground mounted distribution transformers (as at August 2017)**

| Size (kVA)        | Voltage (kV) | Number installed |
|-------------------|--------------|------------------|
| Less than 500     | 11           | 178              |
|                   | 22           | 40               |
|                   | 44           | 2                |
| 500               | 11           | 543              |
|                   | 22           | 268              |
| 750               | 11           | 490              |
|                   | 22           | 358              |
| 1000              | 11           | 59               |
|                   | 22           | 52               |
| 1500              | 11           | 43               |
|                   | 22           | 61               |
| Greater than 1500 | 11           | 4                |
|                   | 22           | 11               |
| Total             |              | 2109             |

**Figure 8 – Transformer age profile (as at August 2017)**

## 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 1980s 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 4: Low voltage switchgear installed in TasNetworks' distribution network as at September 2015**

| Switchgear type                        | Number installed |
|----------------------------------------|------------------|
| B&S                                    | 1                |
| Emmco                                  | 1                |
| Engineered Switchboards                | 24               |
| English Electric                       | 10               |
| GEC                                    | 12               |
| HEC                                    | 20               |
| Mechanical Services                    | 564              |
| Merlin Gerin                           | 142              |
| Nilsen                                 | 25               |
| Saifway                                | 109              |
| Schneider                              | 487              |
| Standard Waygood                       | 23               |
| Weber                                  | 1                |
| Other/Fuses/Unknown<br>Circuit Breaker | 436              |
| <b>Total</b>                           | <b>1855</b>      |

## 6. Associated risk

TasNetworks has developed a Risk Management Framework for the purposes of

- Demonstrating the commitment and approach to the management of risk – how it is integrated with existing business practices and processes and ensure risk management is not viewed or practiced as an isolated activity.
- Setting a consistent and structured approach for the management of all types of risk.
- Providing an overview on how to apply the risk management process.

For the assets in the ground mounted substations the risk assessment was 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 previously identified five incidents within three years that involved some form of unauthorised access to kiosk substations (fibreglass or block wall 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 August 2017, there are approximately 217 kiosk substations with fibreglass enclosures installed on the network.

#### **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 five 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. Where an installation is deemed to be hazardous the exposed equipment is either covered or the asset is replaced.

#### **6.1.3 Fire**

Fires within substations and the consequences of them can be a significant risk. A fire can result in loss of customer supply, significant financial cost, and they also have the potential to result in harm or death to operational staff and the public.

Where substations are located within buildings or close to neighbouring buildings there is also the potential for damage to occur to these buildings.

The consequences of fire are a consideration in the location and design of new substations and it can also influence the removal or relocation of existing substations.

These risks are mitigated through compliance with standards, fire containment and suppression systems, and routine inspections.

### **6.1.3.1 Compliance with fire standards**

TasNetworks ensures that its design and management practices are compliant with the legislative requirements and relevant standards.

All new substations are compliant with the requirements of AS 2067 : Substations and high voltage installations exceeding 1 kV a.c. All new building and vault type substations are also compliant with the Building Code of Australia (BCA).

### **6.1.3.2 Inspection and maintenance**

Fire detection and suppression systems in substations are routinely inspected and tested in compliance with Australian standard AS 1851. Inspections are also routinely undertaken on all external access ways, ventilation and building penetrations.

### **6.1.3.3 Containment**

Fire containment measures are incorporated into the design of substations to minimise the risk of a substation fire to surrounding property.

For kiosk substations careful consideration is given to the location of new installations and ensuring that the fire separation zones defined in AS 2067 are adhered to.

For building type substations the design of the substation is required to provide containment of a fire within the confines of the substation for a minimum period of two hours. This time period is designed to provide sufficient time for a fire authority to attend to a fire before it can spread outside of the substation.

The containment is achieved through the use of fire resistant materials in the external walls, floor and ceiling of the substation, the installation of fire rated doors and fire barriers across all other external openings.

### **6.1.3.4 Fire suppression**

Integrated building and vault type substations present a greater risk from fire than other substations due to them being incorporated into larger buildings because the arrangement results in an elevated risk of a fire spreading to an adjacent property. This increases the risk of more extensive damage occurring and an increased risk to public safety. These substations can also sometimes be less accessible which can impact the fire authority's ability to extinguish a fire should it occur.

To manage this risk, in addition to the installation of containment measures used for building type substations, fire detection and suppression systems are also installed where the risk is high enough to warrant their installation.

### **6.1.4 Emergency and exit lighting**

Building substations do not usually contain any natural lighting which makes evacuation of them more hazardous under blackout conditions. To mitigate against this risk emergency and exit lighting is installed in all new building substations.

The installation of emergency and exit lighting within substations is a requirement of the BCA. The inspection and maintenance requirements of the lighting systems are 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 August 2017, there are approximately nine substations located within twenty metres of coastal areas or major estuaries. Modern kiosk substations installed in these areas are installed with specially manufactured corrosion resistant enclosures.

### **6.1.6 Confined spaces**

There are three 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.

TasNetworks has approximately 600 substation sites that contain asbestos. To manage the risk TasNetworks initiated an asbestos audit of substations in 2009 and created a register of these sites as well as setup on site registers.

Where asbestos has been identified in substations, in addition to the on-site registers, labelling is installed to provide notification of the presence of the material and warn of the hazard. These asbestos containing materials are also routinely inspected.

### **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 1960s to 1980s. This type of switchgear is contained in building, fence and kiosk type substations throughout the state, with a total population of 180 sites on the network containing this switchgear as at August 2017.

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 in new switchgear. Modern switchgear uses either air or gas as the 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 remaining on the network that contains Siemens 8CK switchgear.

### **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 August 2017 there are 17 substations on the network that contain this type of switchgear.

### **6.1.8.4 Hazemeyer MD4 switchgear**

The majority of Hazemeyer MD4 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 78 sites on the network containing this type of switchgear as at August 2017.

In 2010 due to safety concerns operating restrictions were placed on Hazemeyer MD4 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 inter-tripping 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 and for working in proximity to equipment containing asbestos. 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.

Where the condition of these circuit breakers presents an elevated risk they are replaced.

### **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: HV substations exceeding 1 kV ac (Clause 6.7.11) requires that every high voltage installation containing equipment with more than 1000 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 AS 1940: Storage and handling of flammable and combustible liquids.

Approximately only 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 [2]) 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 MD4 switchgear have been converted to three phase operation which has greatly reduced the 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 five years there have been ten high voltage switchgear failures, of which all but two were near or over 50 years of age at the time of failure and used oil as the insulating medium.

Routine inspection, testing and maintenance programs are in place to monitor and maintain the assets to reduce the likelihood of failure occurring. These activities when combined with the asset replacement programs in place 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 Licensing 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 planned 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 5: 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 systems
- Fire and exit doors
- Emergency and exit lighting

Each of these is described in the following sections.

#### 7.3.2.1 Fire suppression inspections

Where fire suppression systems are installed TasNetworks are required 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 inspections

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 inspections

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 2: 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<sub>6</sub> reporting requirements.

Special audit are also created to where deficiencies in asset information are identified.

Where special audits are required, programs are created in the annual Program of Work.

### **7.3.5 Transformer oil testing (RMDSR)**

TasNetworks has historically undertaken oil testing of transformers to monitor their condition and to also test for hazardous materials e.g. PCBs.

Where the PCB status of the oil in a transformer is 'unknown' a sample of oil is taken from the transformer for 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.

Transformers are critical for customer supply and a failure will result in loss of customer supply. In critical areas of the network e.g. commercial areas and critical customers the impact from a failure and resultant loss of supply can be significant. Transformer failures are usually self-contained, but do also have the potential to fail catastrophically which can present a safety risk to the public.

Due to the increasing age profile of the transformer fleet and corresponding lengthy service life of many of the transformers, an oil testing programs exist to assist with undertaken condition assessments of transformers. The testing is predominantly undertaken on older transformers where an in service failure would have a notable impact on supply e.g. 'Critical infrastructure' and 'High density commercial' zones on the network.

### **7.3.6 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          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Siemens 8CK                                                                                                                                                                                              | Once every 3 years |
| Asea Brown Boveri RGB12/24<br>English Electric OLX<br>Brush<br>COQ<br>Fluokit M C40 and M24<br>GEC DDFC<br>GEC Oil RMU<br>Hazemeyer MD4<br>Reyrolle JK/JKSS<br>Reyrolle LMT<br>Statter<br>Yorkshire YSF6 | Once every 4 years |
| Reyrolle LMVP                                                                                                                                                                                            | Once every 6 years |
| Asea Brown Boveri CTC12 and 24<br>Merlin Gerin/Schneider (M6, RM6, SM6)                                                                                                                                  | 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 to 8 years (Refer Table 6)              |
| Asbestos inspection       | According to asbestos monitoring register |
| Confined space inspection | 4 years                                   |

### **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.

## **7.6 Regulatory obligations**

### **7.6.1 Address safety or environmental issues in ground mounted subs (SIGMS)**

Programs undertaken under the SIGMS category are those that are driven by safety, environment or compliance factors. This program has the following subcomponents:

- Fire standard compliance
- Asbestos management
- Management of 'Confined spaces'
- Management of deficient oil containment systems
- Reinforcement of substation doors

Each of these components is described in the following sections.

#### **7.6.1.1 Fire standard compliance**

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 May 2017, no sites have been identified for future treatment.

##### **Fire suppression systems**

Fire suppression systems are installed where the risks from fire deem it necessary to reduce the risk down to a manageable level. Fire systems are typically installed in integrated building substations. TasNetworks uses the Stat-X suppression system for its standard system.

TasNetworks had historically used CO<sub>2</sub> fire suppression systems in vault type and building integrated substations. These systems are no longer supported by TasFire and so have been replaced by a Stat-X fire suppression system.

#### **7.6.1.2 Asbestos management**

TasNetworks has a program in place to remove asbestos in substations. Where the risk cannot be satisfactorily managed the asbestos contacting material/equipment is replaced with an alternative.

#### **7.6.1.3 Management of confined spaces**

As at May 2017, there are three 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.

#### **7.6.1.4 Management of deficient oil containment systems**

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 Upgrades to substation earthing systems (REGEA)**

Where testing of substation earthing systems has identified deficiencies that may present a safety risk they are rectified under this program.

The remedial work usually incorporates modifications or additions to the current earthing system to reduce the risk to a manageable level and achieve compliance with current standards.

### **7.7.2 Replacement of ground mounted substations (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

The assessment of condition for the substation condition considers the substation enclosure, HV switchgear, transformer, LV switchboard. Due to the risks associated with a high voltage switchgear failure, in the majority of cases the replacement of the switchgear is the driver for the replacement of the substation.

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

- planned substation replacement
- replacement under fault.

Each of these is described in the following sections.

#### **7.7.2.1 Planned substation replacement**

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.

##### Reyrolle JK and JKSS switchgear

The historical switchgear failures in substations have been predominantly with the older oil filled switchgear. For this reason the majority of substation replacements are for the replacement of substation containing this type of switchgear.



#### ABB RGB24 switchgear replacement

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 May 2017 there were seventeen substations remaining on the network that contained RGB24 switchgear. The rate of replacement is typically one to two 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 MD4 switchgear replacement

There are operational restrictions in place for Hazemeyer MD4 switchgear 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. In these instances the only viable option is replacement of the complete substation.

Historically under the replacement strategy was to replace the substations at a rate of twenty sites per year, but due the ageing population this rate will not achieve the required outcome. To ensure the risks can be maintained at a manageable level, for the five year period from 2019/20 to 2023/24 a gradual increase in the rate of replacement is required up to a rate of twenty four sites per annum at the end of the period. For the period from 2024/25 to 2028/29, an increase from twenty four to twenty eight sites per annum will be required.

If the driver for the work is the HV switchgear the work is undertaken under the REGMS program where the most cost effective solution to replace the switchgear is the complete replacement of the substation i.e. installation of a new kiosk.

#### **7.7.2.2 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.

#### **7.7.2.3 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.

#### **7.7.3 Refurbishment of substation buildings (REGMS)**

As part of routine substation inspections the condition of is assessed. Where the condition of the building is such that there is the potential for a fault to occur that may impact on the security of the installation or the equipment in no longer adequately protected from the environment, planned refurbishment work is undertaken on the building prior to there being a need to undertake reactive asset repairs.

#### **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 that are likely to be considered for replacement are those supplying critical or commercial loads, or where a failure could present a safety or environmental risk.

The transformer condition is assessed through asset inspections and oil analysis.

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

Where major upgrade work is occurring in substations e.g. high voltage switchboard replacement and the transformers are near end of life the transformers may also be replaced at this time if it presents a more economical solution than to undertake the replacement at a later time.

### **7.7.5 Replace high voltage switchgear (REHSW)**

Due to the risks associated with high voltage switchgear failures, TasNetworks has a prioritised replacement program in place to replace it prior to failure occurring.

Switchgear failures have the potential to result in harm to the public and operational personnel. They also result in notable customer supply disruption for extended period.

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.

Due to an increased rate of failure with the switchgear in substations over fifty 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 fifty years of age. To ensure the risks can be maintained at a manageable level, for the five year period from 2019/20 to 2023/24 the rate of replacement has been set at ten sites per annum. For the period from 2024/25 to 2028/29 an increase from eleven to sixteens site per annum will be required.

The replacement program is predominantly focused on the oil filled switchgear as the failure rate of this type of switchgear has increased in recent years, with 80 per cent of the failures being from this type of switchgear, yet it only represents 10 per cent of the switchgear population. This increased failure rate has been attributed to the lengthy service life of the equipment and resultant deterioration in condition that has resulted. The insulating medium due to its combustibility has the potential to result a catastrophic failure which is resulted in an elevated risk of harm to members of the public and operational personnel. As at May 2017 there are currently 180 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 results in a reduction of operational costs as modern switchgear requires less frequent and less intrusive maintenance, which allows the maintenance frequency to be extended from four to eight years. The replacement from oil filled to air/gas switchgear also allows for added functionality such as remote controlling.

### **7.7.6 Replace ground mounted low voltage switchgear (RELSW)**

There are two components to this replacement program:

- Replacement of low voltage switchgear
- Replacement of low voltage switchboards

Each of these programs is described in the following sections.

#### **7.7.6.1 Replacement of low voltage switchgear**

Some of the low voltage switchgear in older substations presents an elevated risk to operational personnel due to the presence of asbestos. In many instances this equipment can be safely managed, but in instances where the asbestos containing materials are deteriorating and becoming hazardous the equipment is replaced. The asbestos is present in the arc chutes of the Nilsen circuit breakers.

A replacement program began in 2007 to replace the switchgear in these substations.

There are currently twenty five substations remaining in the network where asbestos is present in the switchgear with the Nilsen circuit breakers containing asbestos in their arc chutes.

Switchgear replacement is also undertaken on switchgear that is deemed to be in poor condition and may present either a safety risk to operational personnel or impact to network reliability.

To manage these risks the rate of replacement for the switchgear has been set six sites per annum.

#### **7.7.6.2 Replacement of low voltage switchboards**

In many of the older substations on the network the low voltage switchboards are a 'live front' configuration i.e. the live components of the switchboards are not covered. The live front low voltage switchboards 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.

To manage this risk a cost effective solution has been to cover the front of the switchboards. This solution prevents inadvertent contact with live components for the switchboard, but it does not reduce the risk to operational personnel when they need to access the switchboard e.g. fuse replacement.

Where the design of the switchboard or access requirements may still present an unacceptable safety risk they are considered for complete replacement. Based on this criterion approximately five switchboards will be replaced per annum.

### **7.7.7 Safety and environment in ground mounted substations (SIGMS)**

The management of issues and risk in substation associated with safety and the environment are undertaken under the SIGMS program. There are five subprograms under this program, with these being:

- Replacement/refurbishment of building substation doors
- Replacement of locks at substations

#### **7.7.7.1 Replacement/refurbishment of building substation doors.**

Where the doors on substations are deemed to be in poor condition they are replaced prior to their being a risk to the security of the substation or unauthorised entry occurring.

To minimise the risk associated with fire in the majority of building substations the substations are designed to contain an internal fire for a minimum of two hours. To achieve this all external substation doors are required to be fire rated. Where external doors are identified at building types substations that are not fire rated they are replaced under this program. Where the doors are fire rated, but there are deficiencies that do not achieve compliance with the standard, rectification work is undertaken.

An audit was undertaken on all the building substations to determine the condition of external substation doors and identify any areas where work was necessary to achieve compliance. Of the 368 building substations on the network, the doors are approximately one third of them require either remedial work or complete door replacement to achieve compliance with the standard.

Under this program work is undertaken on the doors at approximately twenty substations per annum.

### **7.7.7.2 Replacement of locks and locking mechanisms on substations**

Where locks and locking mechanisms on substation doors are defective they are replaced to maintain the security of the site and minimise the risk of exposing the public to energised electrical equipment.

The program is predominantly focused on the locking mechanism used on the block wall kiosks as the design is such that doors have been found to not be securely retained, with some instances of doors coming open. The replacement locking mechanism uses a dead latch arrangement that is more secure.

### **7.7.7.3 Removal of asbestos from substation**

Historically asbestos containing materials (ACM) were used in some of the equipment installed in substations e.g. light and power boards and meter boards. The safety risks associated with exposure to ACMs are managed through a routine inspection program and work practices.

Where the material has deteriorated to a state where there is an elevated risk e.g. the material approaches a 'friable' condition it is replaced. Typically replacement of the material at one substation per annum is required.

### **7.7.7.4 Upgrades to oil containment systems**

Historically building type substation where not built with an oil containment system installed. The risks from an oil spill were managed through routine inspections, but with the equipment aging the risk of an oil spill occurring increases. The greatest risk is from the transformers.

To manage and reduce this risk in substations, where transformers are being replaced consideration is given to the use of dry type transformers. Where this is not achievable and conventional oil filled transformers are to be used a risk assessment is undertaken to determine if an oil containment system should also be installed.

Where the consequences of an oil spill present a safety or environmental risk that cannot be adequately managed through other means an oil containment system is installed. To minimise the cost, and where possible, the existing cable trenches within the substation are used for the containment system.

**Table 8: Annual asset replacement volumes**

| Classification                              | Annual volume |
|---------------------------------------------|---------------|
| Replace ground mounted substations (REGMS)  |               |
| Replacement of ground mounted substations   | 22-25         |
| Building refurbishments                     | 2             |
| Fault replacement                           | As required   |
| Replace HV switchgear (REHSW)               |               |
| Replacement of high voltage switchgear      | 10-12         |
| Fault replacement                           | As required   |
| Ground mounted LV Switchgear (RELSW)        |               |
| Replacement of low voltage switchgear       | 6             |
| Replacement of low voltage switchboards     | 5             |
| Replace ground mounted transformers (REGTF) | 11            |

## 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<sup>1</sup>.

## 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 SF<sub>6</sub> switchgear (ARDSO)

To comply with legislative requirements for the disposal of redundant equipment containing SF<sub>6</sub>, TasNetworks is required to comply with National Environment Protection Measures and the Environmental Management Pollution Control Act 1994.

Equipment containing SF<sub>6</sub> 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<sub>6</sub> 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.

<sup>1</sup> Spares Management Strategy – Distribution Substations R247679

TasNetworks is required to report the loss and disposal of SF<sub>6</sub> in accordance with the National Greenhouse and Energy Reporting Act 2008. This process is managed by TasNetworks' Environmental Management team.

Disposal of SF<sub>6</sub> 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 oil testing                           |
|                                    |                                                                              | Asbestos inspection                               |
|                                    |                                                                              | Confined space inspection                         |
|                                    |                                                                              | Civil maintenance                                 |
| Non-routine maintenance            | Asset repair (ARDSR)                                                         | Minor and major asset repairs                     |
|                                    |                                                                              | Graffiti removal                                  |
| Reliability and quality maintained | Upgrade ground mounted substation earthing (REGA)                            | Upgrade ground mounted earthing systems           |
| Regulatory obligations             | Address safety or environmental issues in ground mounted substations (SIGMS) | Replace substation locks                          |
|                                    |                                                                              | Address asbestos issues                           |
|                                    |                                                                              | Address confined space issues                     |
|                                    |                                                                              | Address fire standards compliance issues          |
|                                    |                                                                              | Address oil containment issues                    |
| Replacement                        | Replace ground mounted substations (REGMS)                                   | Replacement of ground mounted substations         |
|                                    |                                                                              | Building refurbishments                           |
|                                    |                                                                              | Fault replacement                                 |
|                                    | Replace high voltage switchgear (REHSW)                                      | Replacement of switchgear                         |
|                                    | Replace ground mounted low voltage switchgear (RELSW)                        | Replace LV switchgear                             |
|                                    |                                                                              | Replace LV switchboards                           |
|                                    | Replace ground mounted transformers (REGTF)                                  | Replacement of transformers                       |
| Spares management                  | System spares management (RMSSM)                                             | Management of spares                              |
| Disposal                           | Asset repair (Other) (ARDSO)                                                 | Recovery and disposal of redundant SF6 switchgear |

## 8. Program delivery

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.

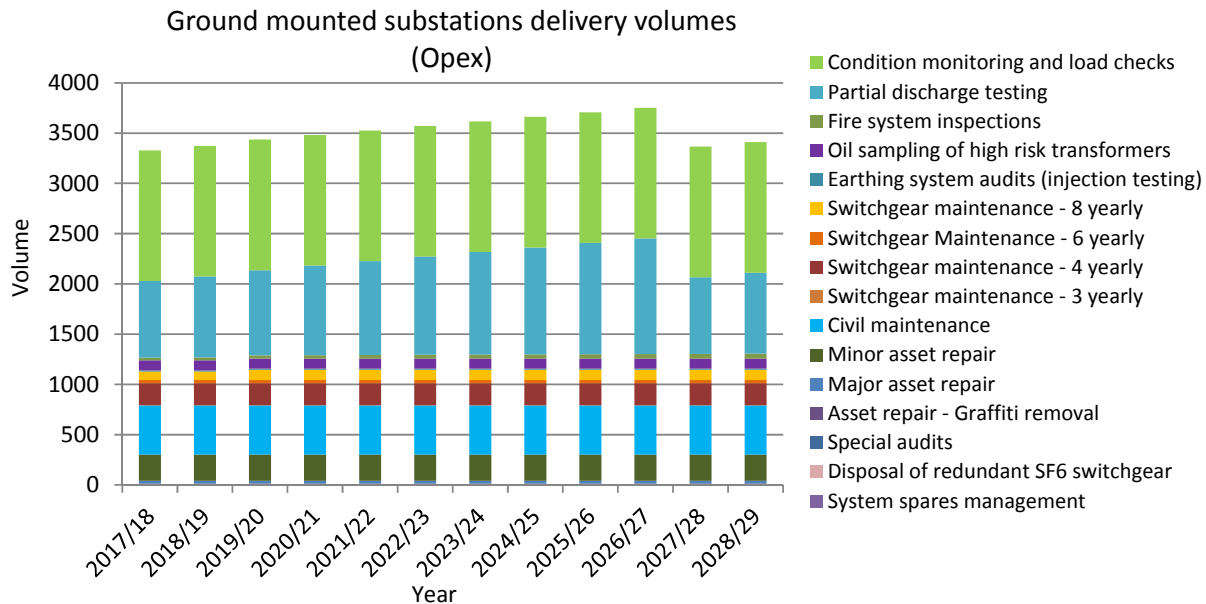
### 8.1 Proposed Opex plan

The operational programs identified in this management plan are necessary to manage the operational and safety risks and maintain network reliability in compliance with business objectives.

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.

Due to the critical nature of these assets and the need to ensure their reliable operation the current routine maintenance programs will continue at their current frequency.

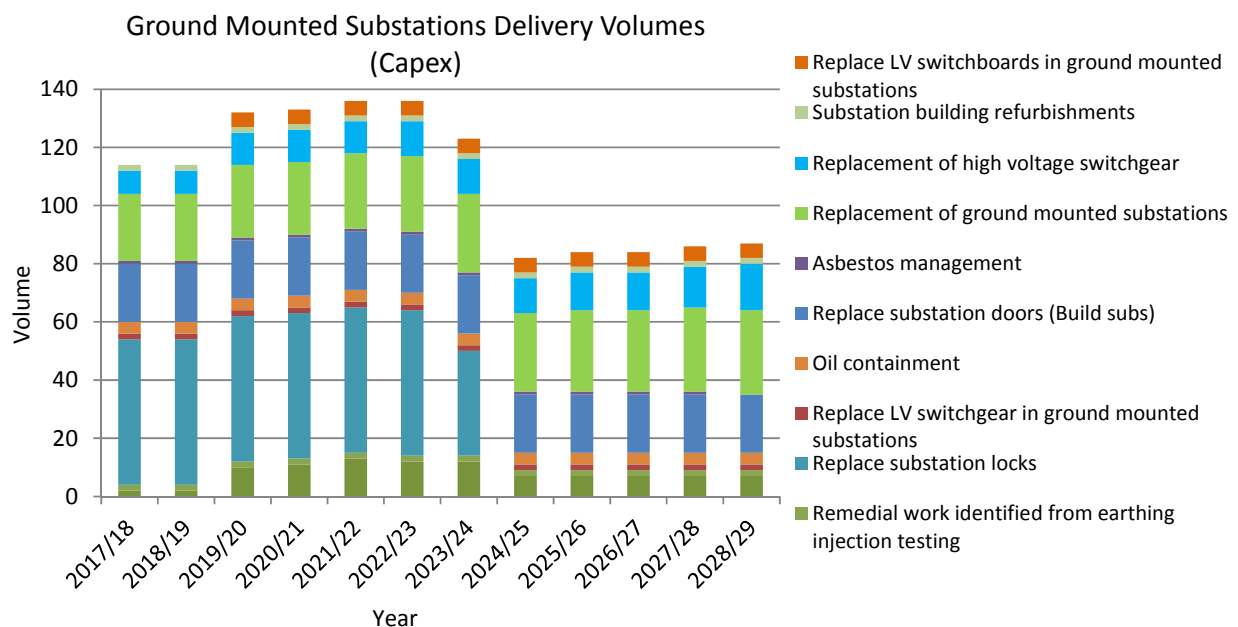


**Figure 9: Total Opex delivery volumes, with forecast to the 2028/29 financial year**

## 8.2 Proposed Capex delivery 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.

Due to the increasing number of ground mounted substation equipment reaching end of life over the next ten years an increase the rate of replacement is required over the period from the 2019-20 to 2023-24 financial years. This increase has resulted in increased expenditure for some of the capital programs. The increase in assets reaching end of life is due to the increased number of substations installed through the 1960s and 1970s. The details are provided in Section 5.

**Figure 10: Total Capex delivery volumes, with forecast to the 2028/29 financial year**

### **8.3 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 Leader.

## **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:

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

## 11. Appendix A – Prioritisation tables

### 11.1 Substation prioritisation

**Table 14: Enclosure safety/security prioritisation matrix**

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

**Table 15: Fire suppression system installation prioritisation**

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

**Table 16: Earthing testing prioritisation**

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

**Table 17: Oil-containment prioritisation rating**

| 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      |

## 11.2 Switchgear replacement prioritisation

**Table 18: Switchgear replacement prioritisation rating**

| Criteria          | State                             | Rating         |
|-------------------|-----------------------------------|----------------|
| Reliability area  | Critical infrastructure           | 4              |
|                   | High density commercial           | 2              |
|                   | Urban                             | 1              |
|                   | High density rural                | 0              |
| Customer count    | Between 250 and 200               | 5              |
|                   | Between 199 and 150               | 4              |
|                   | Between 149 and 100               | 3              |
|                   | Between 99 and 50                 | 2              |
|                   | Less than 50                      | 1              |
| Sensitivity       | With 50 metres of a school        | 2              |
|                   | With 50 metres of a park          | 1              |
| Switchgear type   | English Electric OLX              | 4              |
|                   | GEC DDFC                          | 4              |
|                   | Reyrolle JK                       | 4              |
|                   | Reyrolle LMT                      | 3              |
|                   | Reyrolle JKSS                     | 3              |
|                   | Statter                           | 3              |
|                   | Hazemeyer MD4                     | 2              |
|                   | Fluokit                           | 2              |
|                   | Other switchgear types            | 0              |
| Age of switchgear | Age of switchgear from 0-60 years | Scale from 0-6 |

### 11.3 Transformer replacement prioritisation

**Table 19: Transformer replacement - Safety prioritisation rating**

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

**Table 20: Transformer replacement - Condition prioritisation rating**

Condition prioritisation rating = Condition x (Reliability area + customer count)

| Condition        | State                     | Rating           |
|------------------|---------------------------|------------------|
| Reliability area | Critical infrastructure   | 4                |
|                  | High density commercial   | 2                |
|                  | Urban                     | 1                |
|                  | High density rural        | 0                |
| Customer count   | Between 250 and 200       | 5                |
|                  | Between 199 and 150       | 4                |
|                  | Between 149 and 100       | 3                |
|                  | Between 99 and 50         | 2                |
|                  | Less than 50              | 1                |
| Condition        | Inspection + Oil analysis | Scale 0-5 (Poor) |