Asset Management Plan

Structures and Busbars

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Authorisations

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Review cycle	2.5 Years	

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").

The approval of this document is the responsibility of the General Manager, Strategic Asset Management.

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

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

Record of revisions

Section number	Details
All sections	*Re-write from Transend format into TasNetworks format and update of data.*

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1 Purpose

The purpose of this asset management plan is to describe for structures and busbars and related assets:

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

2 Scope

This document is TasNetworks asset management plan for its population of extra high voltage (EHV) and high voltage (HV) structures and busbars for a ten year rolling planning period. The objective of this plan is to minimise business risk by achieving reliable asset performance at minimal life-cycle costs.

3 Strategic Alignment and Objectives

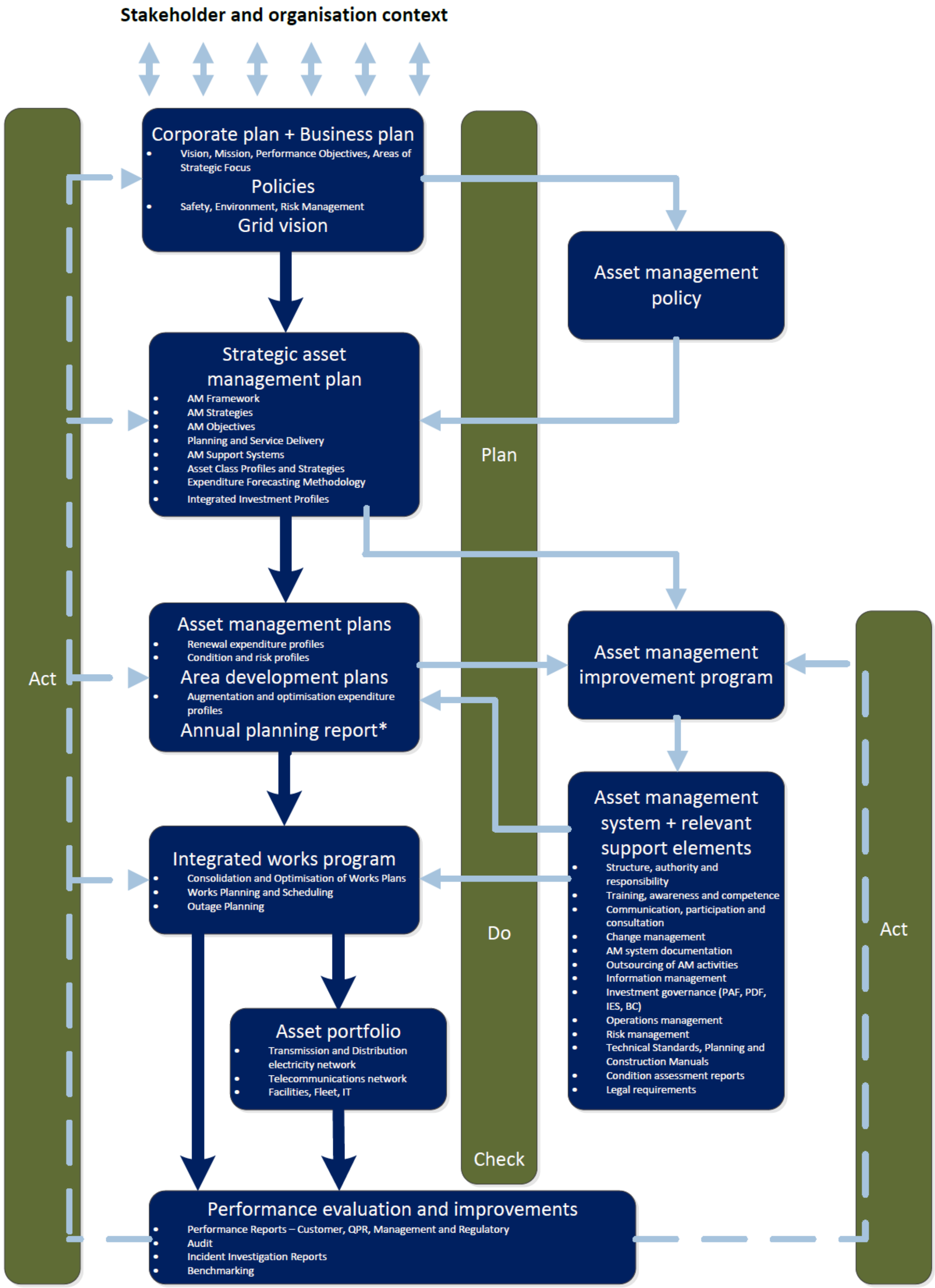
This asset management plan has been developed to align with both TasNetworks Asset Management Policy and Strategic Objectives. This management plan describes the asset management strategies and programs developed to manage the structures and busbars, with the aim of achieving these objectives.

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

The asset management policy and strategic objectives are outlined within the Strategic Asset Management Plan. Figure 1, from the Strategic Asset Management Plan, 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.

4 Asset Information Systems

4.1 Systems

TasNetworks maintains an asset management information system (AMIS) that contains detailed information relating to the structures and busbar population. AMIS is a combination of processes, technology and people applied to provide the essential outputs for effective asset management, such as:

- Reduced risk;
- Enhanced transmission system performance;
- Enhanced compliance, effective knowledge management;
- Effective resource management; and
- Optimum infrastructure investment.

It is a tool that interlinks asset management processes through the entire asset life cycle and provides a robust platform for extraction of relevant asset information.

Normally, substation asset defects are recorded directly against the asset registered in the asset management information system (WASP). Since substation structures are not held within WASP, structures defects cannot be directly reported. Instead, recorded defects against structures can be analysed through TasNetworks business intelligence reporting system to gain an understanding of the magnitude of asset defects.

Any identified defects may be detailed further during the development of a substation condition assessment reports (CAR) which will aid in the decision to perform any abnormal or upgrade work associated with post insulators.

It is noted that a new Asset Management system (SAP) will be commissioned early in 2018 to replace WASP.

4.2 Asset Information

The following AMIS standards provide additional information relevant to Structure and Busbars.

- R17017 WASP Asset Register – Data Integrity Standard –Structure/Tower
- R17087 WASP Asset Register – Data Integrity Standard – Support Structure
- R17120 WASP Asset Register – Data Integrity Standard – Busbar
- R17116 WASP Asset Register – Data Integrity Standard – Bay Conductor

4.2.1 AM8 Condition Data

An initiative within the Asset Performance and Strategy team was completed in 2016 to review key asset condition and maintenance regimes to assess their capability for asset condition being the basis for setting spending priorities. This initiative was referred to as AM8.

Condition based assessments provide a quantitative means to assess asset condition, their risk and failure probabilities and a basis to justify mitigation measures. Condition assessments are used to produce risk indices for assets and / or asset classes and provide a basis for asset expenditures.

Condition data is gathered through asset inspection and maintenance activities and is used along with defect, failure and performance data to formulate asset management strategies. Condition assessment relies on asset knowledge capable of being modelled using numerical analysis.

A number of observations were concluded as part of the review including the need to obtain condition data consistently across all asset types and in electronic form. The need for storage and collection would align with other business initiatives such as the AGILIS project.

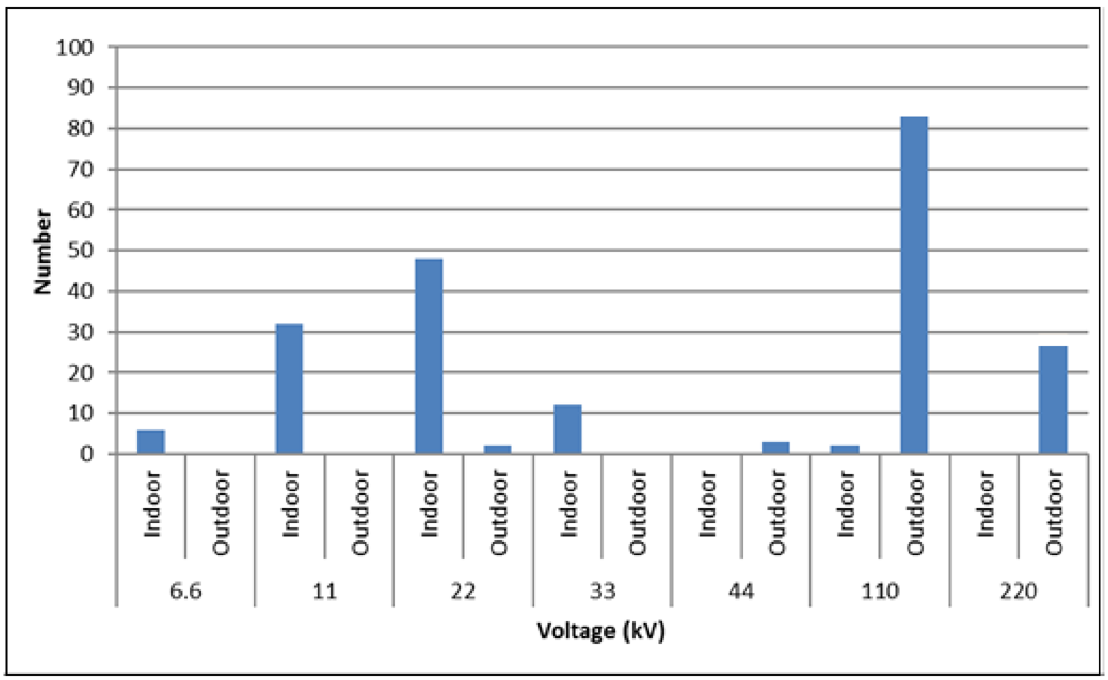
5 Description of the Assets

Structures and busbars are an essential part of the transmission system. A variety of structures are used, including large steel based structures for supporting outdoor electrical busbars, lightning protection assets or terminating transmission lines. Numerous other smaller support structures for post insulators, instrument transformers, disconnectors, circuit breakers and other primary equipment are used.

Busbars are the medium through which the electrical current is passed and includes the conductor, insulator connectors associated with main busbars, bay connections and dropper connections.

TasNetworks has 211 busbars in service. Outdoor busbars consisting of 27 at 220 kV, 82 at 110 kV, 3 at 44 kV and 2 at 22 kV. The remaining busbars in service consist of two indoor gas insulated switchgear (GIS) at 110 kV and the remainder being indoor metal clad switchgear at high voltage levels. Figure 2 presents the population of busbars categorised by voltage level and grouped between indoor and outdoor installations.

Figure 2: Busbars population



5.1 Structure Types

Bus support structures have evolved from lattice towers to tubular steel. Smaller support structures also use a number of designs including concrete, lattice steel and tubular steel. TasNetworks has standardised on steel supports for instrument transformers and the like.

TasNetworks has standardised on support structures for both EHV Voltage and Current Transformers; to:

- Be hot dipped galvanised, constructed of tubular steel and be of at least 300 mm diameter;
- Be of a height specified within the project specifications;
- Conform to AS 1554, AS 1627 and AS 4100 for steel structures and welding; and
- Comply with the requirements of TasNetworks Substation Civil Infrastructure standard,

Further standardisation of structures is given in TasNetworks General substation requirements standard which includes:

- In particular the pedestals must have a maximum deflection limit of H/125 (H= Height of the structure) when subjected to the most critical design loading conditions.
- Towers and pedestals used to support outdoor power equipment must be made of galvanised steel, or of an equivalent material.
- That any projected horizontal component must be above 2500 mm to avoid personnel hazards.

5.2 Busbar Types

Busbars have evolved from using slack strung copper conductors to aluminium conductors and now solid tubular aluminium busbars. For outdoor substations, TasNetworks has standardised on hard drawn tubular busbar, stranded copper or aluminium alloy busbar. In addition, TasNetworks has standardised on the use of ‘Uranus’ type all aluminium conductor (AAC/1350) for stranded busbars. There is however, a number of other conductors still in use, all with varying diameters requiring separate spares holdings. Table 1 shows the stranded conductor types that are still in use in TasNetworks substations. The following gives reference to TasNetworks direction towards standardisation from the EHV System Standard:

“For outdoor substations, hard drawn tubular busbar or stranded aluminium alloy busbar shall be used. For stranded aluminium alloy busbars “Uranus” type 1350 All Aluminium Conductor (ACC) must be used.”

Table 1: Standard conductors in use in substations

Conductor Name/ Stranding	Conductor type
61/.125	AAC
MAYBUG (37/4.09)	AAC
TAURUS	AAC / 1350
URANUS	AAC / 1350
VENUS	AAC
GOAT	ACSR
19/.083	HDC
19/.092	HDC
37/.080	HDC
37/.103	HDC

Table 2 details the various types of solid tubular busbar in use in TasNetworks substations.

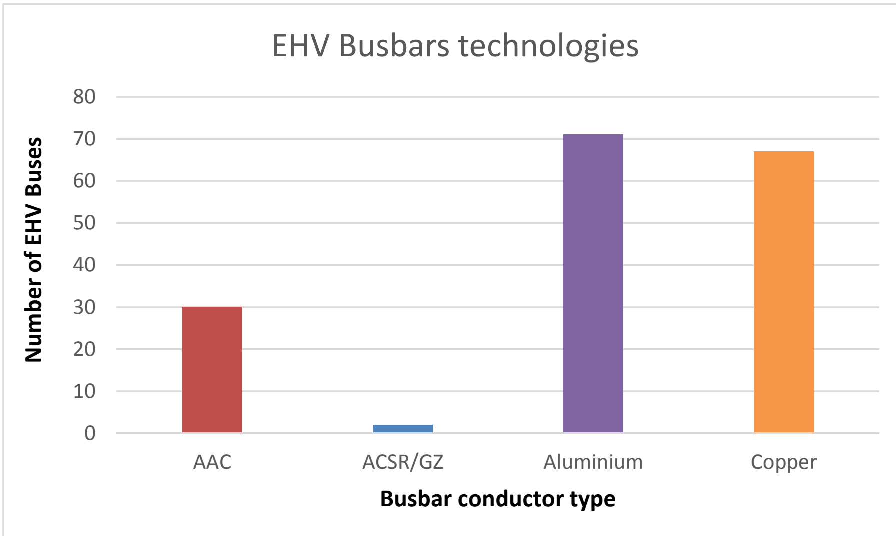
Table 2: Solid tubular busbars in use in substations

Description	Tube type
3" x ¼" Bar	HDC
4" x ¼" Bar	HDC
60 x 10 Bar	HDC
32mm OD x 3.25mm Tube	HDC
60mm OD x 5.5mm Tube	6101 T6 AL
100mm OD x 4mm Tube	6101 T6 AL
100mm OD x 5mm Tube	6101 T6 AL
100mm OD x 6mm Tube	6101 T6 AL
100mm OD x 10mm Tube	6101 T6 AL
140mm OD x 8mm Tube	6101 T6 AL
160mm OD x 10mm Tube	6101 T6 AL
65 nb Tube	GMS

Condition monitoring results for each of the types can vary substantially as different design and construction methods are used for each type. Condition monitoring results for structures and busbars are often subjective so overly descriptive or analytical condition monitoring is not effective.

The quantity of each type of TasNetworks busbars population is shown in Figure 3.

Figure 3: EHV busbars technology profile (as at June 2017)



5.3 Age Profile

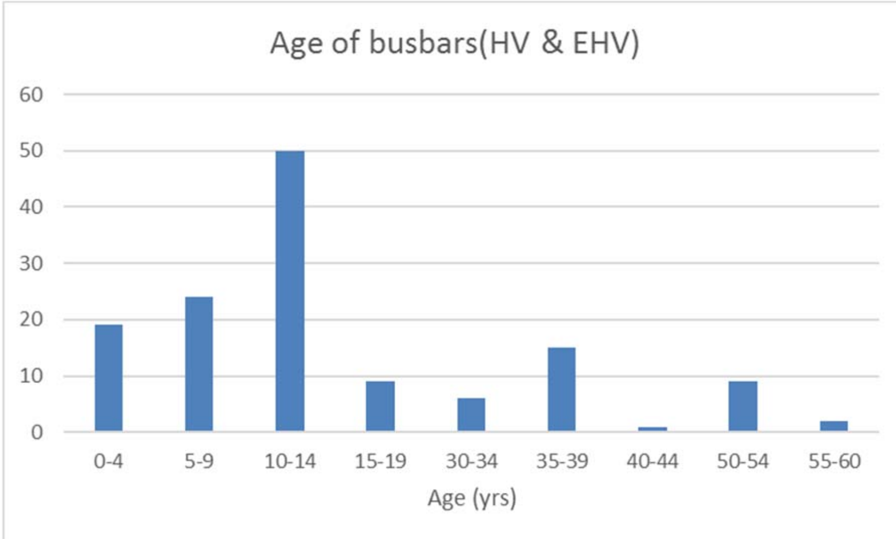
The average age of TasNetworks busbars population is 25 years as at June 2017. Substation commissioning age is used as an indication of structures system age, the current substation median commissioning age is 46 years.

The capital plan and future structure and busbar replacements are predominantly aimed at replacement due to poor condition and obsolete design. Age is not a primary driver for replacement and only serves as an indicator of the degradation materials may have been exposed to. Such degradation of materials and/or deterioration of structure and busbar integrity are confirmed through preventive condition monitoring techniques.

Structures and busbars systems are considered to be part of a substation switch-bay and have an average service life of 45 years as defined by Sinclair Knight Merz (SKM) in its ‘Assessment of proposed asset lives for Transend Regulatory Asset Classes’.

The age profile for TasNetworks structures and busbars population is shown in Figure 4.

Figure 4: Busbars age profile (as at June 2017)



6 Standard of Service

6.1 Technical Standards

To address potential design issues, TasNetworks has developed a prescriptive standard specification for the design and installation of structures and busbars. The specification requires installations to be designed and tested to Australian and international standards. The prescriptive technical specification encourages some standardisation of design which also addresses population type issues.

6.2 Performance Objectives

To mitigate the risk of inadequate quality control during manufacturing, TasNetworks requires manufacturers to have AS/NZ ISO 9001 accreditation and conform to its requirements.

6.3 Key Performance Indicators

TasNetworks undertakes two broad classes of performance monitoring, namely internal and external performance monitoring.

6.3.1 Internal Performance Monitoring

TasNetworks monitors structures and busbars systems for major faults through its incident reporting process. The process involves the creation of a fault incident record in the event of a major failure that has an immediate impact on the transmission system (eg causes an immediate trip of a transmission circuit or element). The fault is then subjected to a detailed investigation that establishes the root cause of the failure and recommends remedial strategies to reduce the likelihood of reoccurrence of the failure mode within the population. Reference to individual fault investigations reports can be found in TasNetworks reliability incident management system (RIMSys).

For structures and busbar failures that do not initiate a transmission system event, such as minor failure or defects, corrective costs and action can be tracked using TasNetworks business intelligence tool.

6.3.2 External Performance Monitoring

TasNetworks participates in various formal benchmarking forums with the aim to benchmark asset management practices against international and national transmission companies. Key benchmarking forums include:

- International Transmission Operations & Maintenance Study (ITOMS); and
- Australian and New Zealand chief executive officer's benchmarking forum, which provides information to the Electricity Supply Association of Australia (ESAA) for its annual industry performance report.

In addition, TasNetworks works closely with transmission companies in other key industry forums, such as CIGRE (International Council on Large Electric Systems), to compare asset management practices and performance.

6.3.2.1 ITOMS Benchmarking

The industry benchmarking of the structures and busbars asset categories are not covered as a specific category measure in ITOMS activities.

Although structures and busbars are not a specific measure in the ITOMS study, external benchmarking activities and industry forums show that the performance of TasNetworks is consistent with other transmission companies when comparing service, performance and asset management practices.

6.3.2.2 ESAA Benchmarking

TasNetworks reporting to the ESAA covers transmission network data of system minutes unsupplied, energy delivered and transmission circuit availability. For ESAA benchmarking, network data is limited to transmission circuits.

7 Associated Risk

7.1 Risk Management Framework

TasNetworks has developed a Risk Management Framework for the purposes of assessing and managing its business risks, and for ensuring a consistent and structured approach for the management of risk is applied.

The Risk Management Framework requires that each risk event is assessed against all of the following consequence categories:

- Safety and People
- Financial
- Customer
- Regulatory Compliance
- Network Performance
- Reputation
- Environment and Community

An assessment of the risks associated with the structures and busbars has been undertaken in accordance with the Risk Management Framework. For each asset in this class the assessments have been made based on:

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

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

7.1.1 Condition

The condition assessment, maintenance practices and spares holdings for structures and busbars have been revised where appropriate to sustain or improve reliability and optimise transmission system performance. The adoption of innovative asset management techniques and the introduction of newer assets, requiring reduced maintenance, aim to realise a gradual reduction in operational costs.

The condition of structures relates to their ability to provide mechanical support to primary substation equipment.

The condition of busbars relates to their ability to carry current to connected circuits in TasNetworks substations.

Condition assessment of structures and busbars is based on the following key considerations:

- Technical and design;

- Reliability;
- Physical condition;
- Maintenance;
- Safety; and
- Environment.

A variety of condition assessment methods are used to determine structures and busbars condition. The methods include, among others:

- Thermographic inspection; and
- Various visual inspection techniques.

Structures and busbars condition is determined using a combination of the condition monitoring methods, with emphasis being placed on the method/s employed depending upon the installation. For example, solid busbars use a different design and construction principle than strung busbars, resulting in different failure modes and the need for different condition assessment methods. The preventive maintenance criteria adopted enable a collective and thorough approach to determine the condition of the structures and busbars population.

TasNetworks has purchased a 'Corona Camera' device for detecting insulation breakdown causing corona discharge. This type of camera has been included as part of a suite of substation test equipment.

Details of the condition assessment methodologies are included in Appendix B – Condition Assessment Methodologies.

7.1.1.1 Structures Condition Assessment

An assessment of the condition of any structure is escalated to be conducted by a suitable qualified corrosion engineers. At present the 44 kV structure at Rosebery Substation has been identified as requiring further analysis and is targeted for replacement.

Future assessments, together with routine preventive maintenance inspections and condition monitoring results provides details of any need of remedial work or replacement at relevant substations.

7.1.1.2 Busbars Condition Assessment

A more detailed assessment of the condition of the busbar and conductors population is provided in Appendix C and D. Overall condition monitoring results for the population indicates that all units are in acceptable condition.

A number of older busbars designs are constructed from either copper or steel reinforced conductors. These types of conductors were typically installed using bolted fittings which are more susceptible to hot joints as compared to the modern compression type connections, which TasNetworks has standardised on.

7.1.2 Consequence of Failure

A major mechanical failure of a structure or busbar has been identified as a key risk for the structures and busbars class as it has the potential to impact on safety and transmission system performance, particularly when failed components fall onto primary transmission equipment.

A mechanical failure of an element of the Structures population could result in loss of supply, dependent on the electricity system element it is supporting. This could result in failure of primary equipment in the case of a support structure failure, or the loss of a bus circuit in the case of a bus support structure. The resultant short circuits and fault outages pose a safety risk to nearby personnel and may cause loss of supply to customers.

A mechanical failure of an element of the Busbars population would likely result in loss of supply to multiple circuits connected to the electrical system at that bus. The resultant short circuits and fault outages pose a safety risk to nearby personnel and may cause loss of supply to customers.

Larger outdoor bus support structures are designed in accordance with ENA C(b) 1 Guidelines for the design and maintenance of overhead distribution and transmission lines. The C(b) 1 document covers wind loading criterion for support structures and has undergone a number of changes in recent years.

Whenever a structure undergoes a change in use, whether it is replacement of conductors, addition of conductors or addition of structural elements such as lightning protection, the structure must be evaluated against the modern standard. The significant changes include the management of higher wind and maintenance loadings. Often the result will be the addition of more steelwork in the structure for added strength. The exact amount of steel required is unknown until design completion and can add significant cost to a relatively simple project.

7.1.3 Probability of Failure

The predominant causes of a structures and busbars failure or defect include:

- Inadequate quality control during manufacture and active service (which can affect random units or batches of units of a proven design) including general quality, poor welding, and corrosion;
- Design faults, including electrical, choice of materials used in construction and mechanical failure; and
- Incorrect assembly or poor workmanship

7.2 Special Operational and Design Issues

7.2.1 Operational Issues

There are currently no specific operational issues relating to structures and busbars.

7.2.2 Design Issues

Structures and busbar design issues are key elements in developing an asset management strategy for the population. Design considerations have been separated into specific structure and busbar categories and are detailed below.

Structure design is an important factor that can influence both asset and transmission system performance levels. In addition, design issues have a direct impact on maintenance practices and expenditure. Common design issues across TasNetworks structures population include:

- Corrosion of structures and associated components due to stray earth currents;
- Corrosion of structures and associated components due to exposure to salt laden winds;
- Corrosion of structures and associated components due to exposure to pollution; and
- Changes to design standards.

Busbar design is an important factor that can influence both asset and transmission system performance levels. In addition, design issues have a direct impact on maintenance practices and expenditure. Common design issues across TasNetworks busbar population include:

- Use of outdoor high voltage (HV) busbars susceptible to poor performance;
- Corrosion of busbar conductors and associated components;
- Poor condition and subsequent corona discharge of insulator strings;
- High resistance joints, particularly in bolted clamps; and
- Use of fittings and lack of access suitable for live-line works.

Replacement of busbars is generally condition based. Awareness of issues such rising fault currents should be taken into account regarding busbars.

7.3 Summary of Risk

Structures and busbars must be selected to provide reliable service for its expected 50 year life. The major issues identified in the review of the structures and busbars population include the following:

- Poor condition of insulators;
- Use of outdoor HV busbars;
- High resistance joints and use of bolted connections;
- Corrosion of the Structures and busbars population; and
- Exposure to high levels of pollution (both industrial and salt-laden winds) at specific sites can result in deterioration of lattice type structures.

TasNetworks has not experienced any major failures of structures or busbars in the past ten years, including failures relating to:

- Electrical failure (hot connections) of connection such as bolted fittings, palms and compression joints; and
- Mechanical failures of structures and busbars.

Minor defects have been actioned before any major failure could occur, as a result of the strict preventive and inspection regime adopted.

8 Management Plan

8.1 Historical

Historically, management of structures and busbars have been undertaken based primarily on condition and condition assessments. This will be continued into the future through inclusion of a Condition Based Risk Management (CBRM) program which aligns with direction provided in TasNetworks Strategic Asset management Plan (SAMP).

8.2 Strategy

The management strategies adopted to mitigate the risks associated with structures and busbars are monitored on an ongoing basis to ensure they are effective and relevant to achieving TasNetworks risk management objectives. Practices are reviewed on a regular basis taking into account:

- Past performance;
- Manufacturer's recommendations;
- Industry practice (derived from participation in technical forums, benchmarking exercises and discussions with other transmission companies); and
- The availability of new technology.

Failures within structures and busbars may cause serious or catastrophic damage to the assets, so allowing failures to occur represents a real risk to the surrounding infrastructure.

To reduce the risk of structure and busbar failure, TasNetworks has adopted the following specific strategies to address the predominant causes and consequences of failure.

8.2.1 Routine Maintenance

There is a fundamental requirement for TasNetworks to periodically inspect the assets to ensure 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.

8.2.2 Routine Maintenance versus Non Routine Maintenance

Failures within structures and busbars may cause 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, so a preventative corrective maintenance program represents a cost effective alternative to a reactive corrective maintenance program.

8.2.3 Refurbishment

Where structures and busbars are removed from the network in good operating condition by activities such as capacity and power quality drivers, these assets are assessed for redeployment back into the network where such refurbishment is deemed to be an economic proposition.

8.2.4 Planned Asset Replacement versus Reactive Asset Replacement

Replacement is generally only preferred when this is a more economic proposition compared to ongoing maintenance costs over the estimated remaining service life of the asset. These are identified from the maintenance and inspections activities and feed into the list of proposed capital expenditure projects for prioritisation. All corrective works are performed on a ‘do and charge’ basis.

8.2.5 Non Network Solutions

The role of the structures and busbars generally cannot be cost effectively substituted via upgrading other infrastructure on the network.

8.2.6 Network Augmentation Impacts

TasNetworks requirements for developing the transmission system are principally driven by five elements:

- Load forecasts;
- New customer connections;
- New generation projects;
- System security criteria; and
- National Electricity Rules (NER) compliance.

Details of planned network augmentation works can be found in TasNetworks Tasmania Regional Plans, which are updated on a 2.5 year cycle.

Proposed network augmentation projects identified in the Tasmania Regional Plans that requires the installation or upgrade of structures and busbars will have a minimal impact on the population when considering asset management. Additional costs associated with new installations as part of network augmentation projects will have minimal impact on the projected operational expenditure.

8.3 Routine Maintenance

Previous preventive maintenance practices of structures and busbars consisted of ground based thermographic and visual inspections.

The revised condition assessment and maintenance practices for structures and busbars are shown in Table 3. Based on condition monitoring data, the frequency of maintenance intervals may increase towards the end of a structure or busbar life. In the event that increased maintenance levels are required, the decision to replace the unit may be justified depending on the impact on preventive maintenance expenditure and transmission system performance.

Table 3: Condition monitoring and preventive maintenance practices

Task	Frequency
Structures	
Visual inspections (Ground based)	Quarterly
Half cell testing (Direct buried steel Structures only)	After 20 years of service and every six years thereafter
Detailed condition assessment	As required
Busbars and conductors	
Thermographic inspections (Ground based)	Every six months
Visual inspections (Ground based)	Quarterly
Electronic capturing of condition data#	In conjunction with programs

The proposed additional line item is to be released post the AJILIS project.

In order to maximise the potential benefits of the revised maintenance practices, the development and implementation of the following specific programs is recommended.

8.3.1 Condition assessment procedures

To date, substation structures and busbars systems have typically undergone a ground based visual inspection by the substation operator during periodic inspection of the substation site/s. The ground based nature of these inspections limits the operators ability to see all components of the structures and busbars. In addition, no formal guidance is provided on what aspects of condition should be reported.

The Engineering and Asset Services - Substations group will implement condition monitoring methodologies as used by the Engineering and Asset Services - Transmission Lines group for assessing the condition of transmission line conductors and Structures. The methods and techniques consist of guidelines showing photos of reportable asset condition and how to define them. The common use of these methods and techniques also enables a consistent approach to be applied in the asset management information system (AMIS).

TasNetworks will continue to develop the inspection methodologies for the differing lightning protection types and will undergo regular review and enhancement.

8.3.2 Aerial condition assessment

Helicopters are used extensively for inspecting and determining condition of transmission line assets. TasNetworks will investigate the feasibility of using planned, helicopter based structure and busbar inspections in substations. The aerial based inspections will complement the ground based inspections, however significant factors such as safety of helicopter crews, proximity to major assets and environmental hazards such as nuisance noise to nearby residents all need to be considered. It is noted that at present helicopters are not allowed to fly at low level over switchyards as they need an emergency landing area below and to the side. The use of unmanned aerial vehicles may be a future option that will be investigated and a component amount has been included in the 2019-24 regulatory submission for this purpose.

8.4 Non Routine Maintenance

Minor and major asset defects that are specifically identified during asset inspections and routine maintenance or through other ad-hoc site visits, are prioritised and rectified as per the recommendations set out in TasNetworks condition assessment report and general asset defects management process.

The methodology used to develop and manage non routine maintenance is adjusted to meet the option analysis completed specific for the defect to meet the performance criteria set out in TasNetworks risk framework, with the objective to return to service and prevent asset failure.

8.5 Reliability and Quality Maintained

8.5.1 Standardisation

TasNetworks has standardised on the use of Uranus type conductor and solid busbar of a nominated outside diameter in TasNetworks substations. It is preferred to use twin Uranus conductors on sites where higher current ratings are required. Glass type insulators are preferred for strung busbar installations. Compression fittings are also used as standard.

TasNetworks has standardised on the use of tubular steel design for instrument transformer pedestals. TasNetworks also prefers the use of internal metal clad switchgear for HV busbars to reduce the risk of faults arising from windblown debris and/or wildlife interaction.

The standardisation of design of equipment significantly reduces spares requirements.

8.6 Regulatory Obligations

There are no specific compliance requirements for structures and busbars.

8.6.1 Service Obligations for Network Assets

TasNetworks service target performance incentive scheme (STPIS), which has been produced in accordance with the Australian Energy Regulator’s (AER’s) Electricity TNSPs STPIS publication, is based on plant and supply availability. The STPIS includes the following specific measures relevant to transmission network assets:

- Plant availability:
    - Transmission line circuit availability (critical and non-critical); and
    - Transformer circuit availability.
- Supply availability:
    - Number of events in which loss of supply exceeds 0.1 system minute; and
    - Number of events in which loss of supply exceeds 1.0 system minutes.

Details of the STIPIS scheme and performance targets are managed by TasNetworks Asset Performance group and are listed in TasNetworks Corporate and Business plans.

8.6.2 Service Obligations for Non-regulated Assets

8.6.2.1 Hydro Tasmania

TasNetworks has a Performance Incentive (PI) scheme in place with Hydro Tasmania under its Connection and Network Service Agreement (CANS 2) for connection assets between the two companies. The PI scheme includes connection asset availability which can be impacted by

TasNetworks substation assets. An overview of Hydro Tasmania PI scheme and performance targets can be found in the Connection Agreement.

8.6.2.2 Tamar Valley Power Station (TVPS)

TasNetworks has a PI scheme in place with Tamar Valley Power Station (TVPS) under its Generator Connection Agreement for connection assets between the two companies. The PI scheme includes the connection asset availability measure. An overview of TVPS PI scheme and performance targets can be found in the Connection Agreement.

8.6.2.3 Major Industrial Direct Customer Connections

TasNetworks have a number of direct connections to major industrial customers through EHV and HV substations. The following sites have asset category assets providing these direct connections:

- Boyer Substation (6.6 kV);
- George Town Substation (220 kV & 110 kV);
- Huon River Substation (11 kV);
- Newton Substation (22 kV);
- Port Latta Substation (22 kV);
- Que Substation (22 kV);
- Queenstown Substation (11 kV);
- Risdon Substation (11 kV);
- Rosebery Substation (44 kV); and
- Savage River Substation (22 kV);

The individual connection agreements describe the level of service and performance obligations required from the associated connection assets.

8.7 Replacement

To address design, condition and performance risks associated with the structures and busbars population, continuation of the Structures and busbars replacement program is recommended.

The following section provides details of the recommended replacement program for the structures and busbars population.

8.7.1 Structures Replacement

Structures tend to be replaced as required by declining condition due to corrosion. Where required structure replacements are integrated with other capital works.

Replacement of structures in the current and future revenue reset period has been integrated with other capital works.

8.7.2 Busbars Replacement

Busbars tend to be replaced as required by declining condition due to aging of copper conductors. Where required busbar replacements are integrated with other capital works.

Replacement of busbars in the current and future revenue reset period has been integrated with other capital works.

8.8 Program Delivery

The needs assessment and options analysis for undertaking an asset management activity is documented in the Investment Evaluation Summary for that activity.

The delivery of these activities follows TasNetworks end to end (E2E) works delivery process.

8.9 Spares Management

TasNetworks carries small amounts of busbar spares including any fittings and conductors that are not easily and locally obtained. Structures spares are not covered by the System Spares Policy.

From the System Spares Policy:

"This covers all overhead high voltage conductors within the substation boundary including stranded and solid busbars and conductors (droppers) for connection from the bus structure to the individual assets (for example circuit breakers or transformers).

Sufficient conductors of each type will be available to replace the longest continuous length of the conductor in service. Sufficient fittings will also be available for the connection and termination of each conductor type

For low level aluminium bus structures, spares should be kept as required to maintain the integrity of the bus and to ensure the minimum down time should repairs be necessary."

8.10 Technical Support

Other operational costs which are not able to be classified under the above categories are allocated to technical support. These tasks include:

- System fault analysis and investigation;
- Preparation of asset management plans;
- Standards management;
- Management of the service providers;
- Training;
- Group management; and
- General technical advice.

8.11 Disposal Plan

Prior to disposing of decommissioned structures and busbars and their associated components, they will be reviewed to determine their suitability for system spares in accordance with TasNetworks System Spares Policy.

Disposal of equipment will be adhered to in accordance with relevant standards and procedures.

8.12 Summary of Programs

Tables 4 and 5 provide a summary of all of the programs/projects described in this management plan.

Table 4: Summary of EHV Circuit Breaker OPEX programs / projects

Work Program	Work Category	Work Category	Project/Program
Routine Maintenance	CMBCE	Corrective maintenance	S561- SUBs- Structures Maintenance (note also detailed in substation site infrastructure AMP)
	CMBCE	Corrective maintenance	S017-SUBS-Corrective-Busbar/Conductor EHV
	PMSBI	Preventative maintenance	S301-SUBS-Structures Inspection (note also detailed in substation site infrastructure AMP)

Table 5: Summary of EHV Circuit Breaker CAPEX programs / projects

Work Program	Work Category	Project title	Project/Program details
Capital	RENSB	Rosebery Substation 44 kV gantry/bus replacement	To replace the 44 kV gantry and bus work at Rosebery Substation in conjunction with the 44 kV switchgear.
	PSCSB	Substation on-site condition monitoring inspection tools (portable)	Investigate potential for use of and implement as needed: 1. DRONE technology as a tool for asset condition inspection. Outcome could be to procure 2x DRONE for use South and North with potential roll-out into overhead lines. (note also detailed in substation site infrastructure AMP)
	RENSB	Substation gantry/bus renewal work (corrosion control)	Undertake a condition review of all terminal substations to identify if any are in need of remedial works on gantry or external bus work typically due to corrosion. One station already identified is Rosebery Substation. Allowance to provide corrosion control on bus-work and landing gantries or replace if required, at various substations. Several substations to be further reviewed include: • Rosebery 110 kV and 44 kV. • Farrell 220 kV and 110 kV. • Emu Bay 110 kV (bolts). • Savage River 110 kV (Franklin Rods) • Wesley Vale 110 kV (Franklin Rods) • George Town 220 kV F1 & G1 landing gantries. Waratah tee (operating rods and tower cross-arms) (note also detailed in substation site infrastructure AMP)

9 Financial Summary

9.1 Proposed OPEX Expenditure Plan

Requirements for operating expenditure are a function of the defined periodic condition monitoring regimes, defined maintenance requirements and expected minor and major site infrastructure works.

In the event that increased maintenance levels are required, the decision to replace equipment may be justified depending on the impact on preventive maintenance expenditure and transmission system performance.

The developed works plan is held and maintained in the works planning tool in AMIS. It contains details such as planning dates, task types, specific assets and planned costs.

The planned costs for each differing task type are derived from either unit rates from Contractors or averaged historical costs. The development and application of the planned costs are described in Engineering and Asset Services operational expenditure planning methodology.

9.2 Proposed CAPEX Expenditure Plan

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

A comprehensive capital investment plan has been developed to address the design and performance issues associated with the structures and busbars population and to improve transmission system performance.

The plan presents a replacement program for the period 2019 to 2029 only for the program identified at this time. The replacement program will mitigate the business risks presented by the existing structures and busbars population and reduce future maintenance costs.

9.3 CAPEX – OPEX trade offs

The operating expenditure programs are essential for identifying assets that require replacement for condition-based reasons. There is a positive relationship between these two categories in that regular inspection programs gather continuous condition information of the assets to better target asset replacements and identify any asset trends. Maintenance and repair activities also defer the requirement for capital expenditure and increase the likelihood of the asset operating for as long as possible within the network.

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:

TasNetworks documents:

1. WASP Asset Register – Data Integrity Standard –Structure/Tower R17017
2. WASP Asset Register – Data Integrity Standard – Support Structure R17087
3. WASP Asset Register – Data Integrity Standard – Busbar R17120
4. WASP Asset Register – Data Integrity Standard – Bay Conductor R17116
5. System Spares Policy R517373
6. AM8 Asset Condition Review – project report June16 FINAL R503361

Technical requirements for Structures and busbars are detailed in the following standards/specifications:

7. D03/4697 Extra High Voltage Systems Standard
8. D02/148 General Substation Requirements Standard
9. D10/72320 Installation Inspection Guideline – Substations
10. D01/7216 TasNetworks Substation Civil design and construction standard
11. EHV Voltage Transformer Standard, Issue 4.0 November 2011, TasNetworks Networks.
12. EHV Current Transformer Standard, Issue 6.0 November 2011, TasNetworks Networks
13. Extra High Voltage System Standard, Issue 5.0 February 2012, Section 4.5.1, TasNetworks Networks

Other standards and documents:

14. Sinclair Knight Merz, ‘Assessment of Economic Lives for Transend Regulatory Asset Classes’, 2013. R192773
15. Australian Standard AS 1554 Structural steel welding
16. Australian Standard AS 1627 Metal finishing – preparation and pre-treatment of surfaces
17. Australian Standard AS 4100 Steel structures

11 Appendix A – Summary of Programs and Risk

Description	Work Category	Risk Level	Driver	Expenditure Type	Residual Risk
S017-SUBS-Corrective-Busbar/Conductor EHV	CMBCE	Medium	Customer Financial Safety	Opex	Low
S561- SUBs- Structures Maintenance (note also detailed in substation site infrastructure AMP)	CMBCE	Medium	Customer Financial Safety	Opex	Low
S301-SUBS-Structures Inspection (note also detailed in substation site infrastructure AMP)	PMSBI	Medium	Customer Financial Safety	Opex	Low
Substation on-site condition monitoring inspection tools (portable) (note also detailed in substation site infrastructure AMP)	PSCSB	Medium	Customer Financial Safety	Capex	Low
Rosebery Substation 44 kV gantry/bus replacement (incorporates switchgear)	RENSB	Medium	Customer Financial Safety	Capex	Low
Substation gantry/bus renewal work (corrosion control) (note also detailed in substation site infrastructure AMP)	RENSB	Medium	Customer Financial Safety	Capex	Low

12 Appendix B – Condition Assessment Methodologies

A variety of condition assessment methods are available to determine Structures and busbars system condition. The methods include:

- Visual inspection; and/or
- Electrical testing.

Visual inspection

Visual inspections of structures and busbars occur in two ways, the first being regular, walking, site inspections carried out by the substation operator, the other being aerial inspection in conjunction with transmission line aerial inspections.

A feasibility study into aerial based visual inspections of substation structures and busbars will be conducted.

The Engineering and Asset Services - Transmission Lines Group has a suite of condition monitoring documents which both ground and air based inspection team report against. The documents separate structure and conductor condition into five reportable categories, with priority 1 reports requiring action within five days, priority 3 requiring action within 12 months and priority 5 requiring no action.

By utilising the transmission line inspection documents, a consistent approach is applied when reporting structure and busbar defect conditions in AMIS.

Thermographic inspection

Thermographic inspection of TasNetworks substations are performed by NATA qualified contractors on an annual basis. The site is systematically examined and includes conductors, fittings and terminations on all equipment including indoor and outdoor switchgear.

The test detects hot spots created by high resistances in which current flows; therefore the test is affected by the amount of current flowing in device. The thermal camera is calibrated to the ambient temperature at the time of testing; however in cases where high ambient temperatures and low current flows exist, the test can be less meaningful.

Thermographic inspections are used to detect abnormal conditions and often a first indication of potential failure for current carrying components like busbars and conductors.

Half cell testing

Copper sulphate half-cell tests are carried out on grillage (direct buried steel) foundations. The test measures the voltage created between the tower and surrounding ground. Foundations with test results with a voltage more positive than -650 mV indicate that zinc galvanised coating has been consumed in places, and that corrosive action is occurring between iron and the solid. Corrosion of the iron causes strength degradation of the steelwork and is the real problem for the structure, not the loss of galvanising.

Half-cell results indicate if zinc or steel corrosion is occurring, but do not reliably indicates the degree of corrosion activity. A sample must be selected for excavation for final inspection to correlate the half-cell results. One leg per site will be exposed to confirm the half-cell results.

Half-cell tests are not satisfactory for foundation tests where coatings (like denso tape, paint or concrete) inhibit the electrolytic corrosion process.

Excavation of a foundation for inspection disturbs the corrosion process/micro environment and is unlikely to be exactly the same after reinstatement. But, calibration of half-cell readings is difficult without an excavation sample. Excavation, however, aerates the site and may accelerate the corrosion after re-instatement. Therefore it is important to minimise the number of exploratory excavations.

13 Appendix C – Busbars Assessment

TasNetworks does not keep a detailed register of individual components of a busbar. Recent substation inspections performed indicate that all busbars are in an acceptable condition.

Conductors

Some conductors, particularly older copper type, have failed at mechanical loads well below their designed maximum probably as a result of annealing and vibration damage. Internal corrosion of ACSR/GZ conductors and midspan joints will reduce their strength, resulting in conductors breaking.

Copper and ACSR conductors are typically associated with older sites and were installed using bolted fittings. Bolted fittings are susceptible to creating high resistance joints and should be replaced with modern compression fittings.

Insulators

Insulators used in substations, for strung buses, come in three main types, being glass, porcelain and composite polymer. Each type is in use in TasNetworks sites and each has differing properties.

Glass and porcelain insulators offer flexibility in that they are strung together to make up the creepage distance required, whilst composites tend to come in a single, light weight and rigid unit.

Composites are known for their superior pollution performance and it is recognised that porcelains tend to offer better pollution performance than glass, especially in fluorine environments. However each type is susceptible to insulator degradation.

Insulator degradation can occur in many ways:

- pin corrosion associated with aggressive marine/industrial environments;
- pollution by airborne contaminants that degrade the surface of the insulator discs;
- electrical puncture caused by lightning, cement growth or age;
- pieces of insulation broken out by rifle fire, lightning or other causes;
- superficial scorching usually caused by flashover; and
- design or manufacturing faults of some relatively new porcelain makes.

A routine detailed condition monitoring regime is required to detect any of the above defects.

Another major difference between the types is the ongoing condition monitoring requirement. It is possible for an internal defect on both porcelain and composite insulators to go undetected until failure, which can often result in mechanical failure and dropping of the conductor. Glass discs are pre-stressed which means that any electrical or mechanical defect will result in the glass shed shattering and falling whilst maintaining its physical integrity. When a glass disc shatters, the cap and pin do not normally separate ensuring the live conductor does not fall. A shattered glass disc is easily spotted by an aerial or ground based inspection, but pin corrosion or hair line fractures are not.

TasNetworks will standardise on the use of glass insulators throughout its substations.

Porcelain disc insulators are installed at Boyer Tee and Rosebery substations and will be replaced in conjunction with other planned capital works at the site.

Polymeric composite insulators are installed at George Town, Norwood and Hadspen substations. They were recently installed as part of redevelopment projects and it is not economically viable to replace them. They will be carefully monitored and consideration will be given to undertaking infrared and corona discharge inspections together with specific visual inspections to ensure they remain suitable for service.

Assembly fittings

Corrosion occurs on busbar conductor assembly fittings as a result of environmental conditions and age. This causes loss of metal and with constant movement of the conductor from wind, causes wear on the fittings leading to failure.

These should be changed as required based on condition as determined from normal inspections or in association with a fitting change of the insulator assembly.

Environmental

There are no known specific environmental issues associated with substation busbars structures at this time.

Lightly mechanically loaded bus span insulators can from time to time emit excessive radio frequency noise due to arcing between insulator discs. This may cause interference to telecommunications, and to radio and television reception. Routine site inspections normally identify this audible phenomenon.

Environmental considerations with respect to substation structures have mainly involved the visual amenity of neighbouring properties. Landscaping and screening using native vegetation installed at commissioning will be maintained.

14 Appendix D – Substations Structures & Busbars Audit

Table 6: Substation busbar & structure information

	Site	Owner	Busbar Type	Bus Structure Type	Equipment Structures	Remarks
1	Arthurs Lake	TasNetworks	Strung AAC	Lattice Steel		Upgraded in 2013, outdoor HV Bus
2	Avoca	TasNetworks	Strung Copper	Lattice Steel	Lattice and Tubular Steel	Re-strung in period 09-14
3	Boyer	TasNetworks	Strung AAC	Lattice Steel	Tubular Steel	Some discolouration on structures, industrial site
4	Bridgewater	TasNetworks	Strung Twin AAC	Tubular Steel A-frames	Tubular Steel	
5	Burnie	TasNetworks	Strung Twin Copper	Lattice Steel	Lattice Steel	Redeveloped in 14-19 period
6	Chapel Street	TasNetworks	Strung Twin AAC	Lattice Steel	Lattice/Tubular Steel	
7	Creek Road	TasNetworks	Strung Copper	Lattice Steel		Redeveloped to GIS completed in 2014.
8	Derby	TasNetworks	-	Lattice Steel /Tubular Landing Gantries	Tubular Steel	
9	Derwent Bridge	TasNetworks	-	-	-	No Bus
10	Devonport	TasNetworks	Tubular Aluminium	Tubular Steel	Lattice/Tubular Steel	
11	Electrona	TasNetworks	Tubular Aluminium	Tubular Steel	Lattice/Tubular Steel	
12	Emu Bay	TasNetworks	Strung AAC	Lattice Steel	Lattice/Tubular Steel	Some discolouration on structures, industrial site
13	Farrell	TasNetworks	Strung AAC (Twin 220 kV /Single 110 kV)	Lattice Steel / Tubular A-frame landing	Tubular Steel	Discolouration of Gantries
14	George Town	TasNetworks	Tubular Aluminium / Strung AAC	Lattice Steel / Tubular A-frame landing	Tubular Steel	Redeveloped to tubular aluminium busbars. Further investigation may be required of 220 kV F1 & G1 landing gantries
15	Gordon	TasNetworks /Hydro	Strung Twin AAC	Lattice/ Tubular A-frame landing	Tubular Steel	
16	Hadspen	TasNetworks	Tubular Aluminium	Tubular Steel	Lattice/Tubular Steel	
17	Huon River	TasNetworks	-	Wood pole landing gantry	Lattice/Tubular Steel	
18	Kermandie	TasNetworks	Tubular Aluminium	Tubular Steel	Lattice/Tubular Steel	
19	Kingston	TasNetworks	Tubular Aluminium	Tubular Steel	Tubular Steel	Redeveloped to tubular aluminium busbars

			/ Strung AAC			busbars
20	Knights Road	TasNetworks	Strung AAC	Lattice Steel	Lattice/Tubular Steel	
21	Liapootah	TasNetworks /Hydro	Strung AAC	Lattice Steel	Tubular Steel	
22	Lindisfarne	TasNetworks	Tubular Aluminium (220 kV + part 110 kV bus)/ Strung AAC 110 kV	Lattice/Tubular Steel	Lattice/Tubular Steel	
23	Meadowbank	TasNetworks	Strung ACSR	Lattice Steel	Lattice Steel	Redeveloped in 14-19
24	Mornington	TasNetworks	Tubular Aluminium	Tubular Steel	Lattice/Tubular Steel	
25	Mowbray	TasNetworks	Tubular Aluminium	Tubular Steel	Lattice/Tubular Steel	
26	New Norfolk	TasNetworks	Strung Twin AAC	Steel A-frame	Lattice/Tubular Steel	
27	Newton	TasNetworks	Tubular Steel	Tubular Steel	Lattice/Tubular Steel	Redeveloped in 14-19
28	North Hobart	TasNetworks	-	-	Tubular Steel	No EHV Bus
29	Norwood	TasNetworks	Strung AAC	Steel A-frame	Lattice/Tubular Steel	
30	Palmerston	TasNetworks	Strung Twin & Single AAC – 220 kV/ Strung Copper 110 kV	Lattice Steel	Lattice/Tubular Steel	
31	Port Latta	TasNetworks	Strung AAC	Lattice Steel	Lattice/Tubular Steel	Redeveloped in 2017
32	Que	TasNetworks	Strung AAC/ HV Copper Bus	Post Insulator supports	Lattice/Tubular Steel	Outdoor 22 kV Strung Copper Bus
33	Queenstown	TasNetworks	Strung AAC	Lattice Steel	Lattice/Tubular Steel	Undergoing Redevelopment
34	Railton	TasNetworks	Strung AAC	Lattice Steel	Lattice/Tubular Steel	Bus Gantry tower was replaced in 2011 due to corrosion/degradation. Entire structure requires new protective coating and bolts with substrate degradation require replacement.
35	Risdon	TasNetworks	Strung AAC/Indoor GIS	Steel H-Structures	Lattice/Tubular Steel	
36	Rokeby	TasNetworks	-	-	Lattice/Tubular Steel	No EHV Bus
37	Rosebery	TasNetworks	Strung Copper EHV & HV	Lattice Steel	Lattice/Tubular Steel	EHV Bus undergoing redevelopment, replaced with AAC Conductor.

						Outdoor HV Strung Bus
38	Savage River	TasNetworks	Strung Copper	Lattice Steel	Lattice/Tubular Steel	
39	Scottsdale	TasNetworks	Tubular Aluminium	Steel H-Structures	Lattice/Tubular Steel	
40	Sheffield	TasNetworks	Twin Copper & Rigid Aluminium 220 kV/ Twin Copper 110 kV	Steel H-Structures & Lattice Steel	Lattice/Tubular Steel	
41	Smithton	TasNetworks	Rigid Aluminium	Tubular Steel/Post Insulators	Lattice/Tubular Steel	
42	St Marys	TasNetworks	Strung AAC	Tubular Steel/Post Insulators	Lattice/Tubular Steel	
43	St Leonards	TasNetworks	Rigid Aluminium	Tubular Steel/Post Insulators	Lattice/Tubular Steel	Recently Completed New Substation
44	Sorell	TasNetworks	-	-	Lattice/Tubular Steel	No EHV Bus
45	Trevallyn	TasNetworks	Rigid Aluminium	Steel A-frame	Lattice/Tubular Steel	
46	Triabunna	TasNetworks	Strung AAC	Lattice Steel	Lattice/Tubular Steel	
47	Tungatinah	TasNetworks /Hydro	Strung Twin/Single Copper	Lattice Steel	Lattice/Tubular Steel	Undergoing Redevelopment
48	Ulverstone	TasNetworks	Strung AAC	Steel A-frame	Lattice/Tubular Steel	
49	Waddamana	TasNetworks	Rigid Aluminium 220 kV/ Strung AAC 110 kV	Lattice Steel	Lattice/Tubular Steel	
50	Wesley Vale	TasNetworks	Strung AAC	Lattice Steel	Lattice/Tubular Steel	
51	Wayatinah Tee					Review required of operating rods and tower cross-arms