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MANAGEMENT PLAN 2011

ZONE SUBSTATIONS

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1. PURPOSE

The purpose of this document is to describe, for Zone Substations and associated assets:

- Aurora's approach to asset management, as reflected through its legislative and regulatory obligations and Network Management Strategy;
- The key projects and programs underpinning its activities for the period from 2012/13 to 2016/2017; and
- Forecast CAPEX and OPEX, including the basis upon which these forecasts are derived.

2. STRATEGY

The objective of the Network Management Strategy is:

To minimise cost of supply to the customer whilst:

a. Maintaining network performance;

b. Managing business operating risks; and

c. *Complying with regulatory, contractual and legal responsibilities.*

3. SCOPE

The assets covered by the Zone Substations Management Plan are urban and rural zone substations including the power transformers, switchgear, associated auxiliary equipment, earthing systems and enclosures.

4. DESCRIPTION OF THE ASSETS

4.1 Asset Family

The assets in Aurora's urban and rural zone substations covered by the Zone Substation Thread and Management Plan are:

1. **Power transformers** to reduce or increase voltage;
2. **Switchgear and associated auxiliary equipment** (battery and battery charger, SCADA and protection equipment etc) to provide isolation, disconnection and connection of the sub-transmission and distribution systems in order to maintain supply to the customer;
3. **Earthing system** for personnel and public safety and the correct operation of protection equipment; and
4. **Enclosures** to provide a safe, secure and weatherproof place for the zone substation equipment.

Following assets are excluded from the asset family:

- Connecting outgoing feeders both overhead and underground;
- Connecting incoming feeders both overhead and underground; and
- Mobile generators for emergency purposes.

4.2 Zone Substations and Power Transformers

Zone substations are established where significant bulk load points exist and there is a need to further distribute the capacity requirements of customer loads at high voltage (HV). This type of asset class forms a key component in the distribution system requiring close monitoring and regular maintenance.

Zone Substations contain large power transformers, switchgear, an earthing system, protection and control devices, which are contained in purpose built enclosures for security and the prevention of unauthorised access.

The zone substations range in size (connected MVA) from 2 MVA to 90 MVA with out going HV feeders ranging from only one feeder up to 16 feeders. Appendix A provides details on the rating and age of the zone substation power transformers.

As at August 2010, there are 18 zone substations within the distribution system – these are further divided into ten urban zone substations and eight rural zone substations. Trial Harbour zone substation whilst in a rural location is more similar to an urban zone substation in design and hence included in urban zone category. The Distribution System Planning Report 2010 (reference 1) indicates there will be up to three additional new zone substations installed in Aurora’s network by the end of financial year 2012.

The urban zone substations, except Trial Harbour, are located within the greater Hobart area and are supplied by dedicated sub-transmission feeders. The urban zone substations take supply at a voltage of 33 kV and step these voltages down to a distribution voltage of 11 kV. Redevelopment and upgrade work was completed during the 2003 pricing determination period to establish all Hobart urban zones substations as 33/11 kV stations instead of a combination of 22/11 kV and 33/11 kV.

Trial Harbour zone substation is located on the west coast of Tasmania and is supplied by a 66/44 kV line. The zone substation steps the voltage down to a distribution voltage of 22 kV.

The rural zone substations are located throughout rural areas and are also supplied from sub-transmission-type feeders. However, these feeders are also used as rural distribution feeders, distributing load to customers along their route to the zone substation.

The rural zone substations take supply at voltages of 44 kV, 33 kV and 22 kV and step down these voltages to standardised local distribution high voltages of 22 kV and 11 kV, with the exception of the Wayatinah zone substation, which steps the voltage up from 11 kV to 22 kV, and Tods Corner zone substation, which steps up the voltage from 6.6 kV to 22 kV.

4.3 Switchgear and Associated Auxiliary Equipment

Zone substation switchgear consists of circuit breakers, switch-fuses and isolator-switch devices. They are primarily used to provide isolation, disconnection or connection of the sub-transmission incoming feeders and the outgoing distribution feeders. Appendix B provides further details of the zone substation switchgear.

A protection system contains protection relays and protection devices to identify faults in the system and isolate the system automatically to minimise the damage to equipment and maintain public safety. Operation of protection systems is critical to provide the electricity in a safe and reliable manner.

Supervisory Control And Data Acquisition (SCADA) contains intelligent electronic equipment and devices to provide valuable data regarding the condition of the system and site equipment to a centralised control room. This also enables remote system operation from a centralised control room.

Batteries and battery charger systems are required to provide the backup DC supply to critical equipment such as protection and SCADA systems and switchgear in case of interruption of normal AC supply.

4.4 Earthing System and Enclosures

The integrity of the earthing system is paramount for maintaining operational personnel and public safety and for correct operation of protection equipment. The fault level, protection clearing time and site soil resistivity dictates the extent of earthing required.

Security and prevention of unauthorised access to a highly dangerous area is of paramount concern with zone substations, especially when located close to populated areas.

Zone substation enclosures are purpose-built for each zone substation and may be a building, fence or combination of the two. The enclosures are designed for safety and security and, in the case of building-types, to provide a weatherproof environment for the equipment.

These enclosures may also provide noise mitigation and a more aesthetically pleasing site as per current industry practice.

4.5 General Condition of Equipment

Periodic inspections and routine maintenance programs indicate that the switchgear and enclosures are in good condition. However, the majority of the switchgear is more than halfway through its expected life, increased condition monitoring may be required in the future.

Transformer oil tests (Refer 7.2.3) indicate that the urban zone substations are all in good condition. Transformer oils tests have indicated several problems with the rural zone substation transformers as summarised in Table 1.

Table 1: Transformer Oil Test Results

Site	Problems
Gretna	Transformers have high moisture levels The acidity and interfacial tension are approaching unacceptable limits. Furan analysis indicates worse than expected aging. (Decommissioning planned 2015/16, reference 1)
Hamilton	T2 2-FAL results indicate accelerated ageing (Out of service – decommissioned in 2010/2011)
New Norfolk	T1, T2, T3 and T4 have high moisture levels T1, T2, T3 and T4 have high acidity and display signs of ageing Furan analysis indicates worse than expected aging. Replacement proposed in 2016/ 17
Richmond	T1 and T2 have high moisture levels T2 has high acidity and displays signs of ageing T2 furan analysis indicates worse than expected aging. Replacement proposed in 2016/ 17
Tod's Corner	T2 and T3 have high moisture levels (Energised but not much load, Kept for back up supply, Rebuilt proposed in 2020, reference 1)
Wayatinah	T2 has high acidity and interfacial tension is approaching unacceptable limits. Replacement in process (2011/12)
Westerway	Transformers have PCB results above 2ppm The acidity and interfacial tension are approaching unacceptable limits. Decommissioning proposed in 2013/14 (reference 1)
Zeehan	T1, T2 and T4 show indications of arcing T4 has high moisture levels T1 and T2 have PCB levels above 2ppm (Out of service – to be decommissioned 2011/2012)

5. AGE PROFILE

The age profile data of Aurora's zone substations assets was compiled using Aurora's Replacement Capex Expenditure Model (reference 13) and can be found in Appendix C to Appendix F.

The age profiles reveal a cluster of assets below 10 years of age and a second cluster above 40 years old. This reflects the initial installation of the assets in the 1950s and the upgrade and redevelopment of the urban zones in the mid 1990s. A number of the assets, particularly those at rural zones, are either approaching or are at the end of their nominal asset life and require more frequency condition monitoring to reduce the risk of in service failure.

Unplanned outages that affect whole zone substations are rare.

6. FACTORS INFLUENCING ASSET MANAGEMENT STRATEGIES

The principle factors influencing asset management strategies are classified as per objectives set out in Section 2:

6.1 Minimising Cost of Supply to the Customers

- 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; and
- Capturing adequate information on the assets to facilitate informed decision making.

6.2 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) is very long; and
- By identifying trends in asset performance to target future likely failures.

6.3 Managing Business Operating Risks

- Ensuring adequate fencing and protection of building enclosures at all zone substations 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 are suitably secured and earthed;
- Ensuring adequate monitoring and inspection activities cover legislative compliance obligations and duty of care safety obligations; and
- Ensuring all risks are identified and have adequate management plans integrated into the business' practices.

6.4 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 Aurora's Safety, Health and Environment policies (reference 1).
- Ensuring confined space entry signage and records are (refer Section 7.2.8) in accordance to AS 2865: 2009, Confined spaces and workplace health and safety regulations 1998 (reference 2).
- Ensuring installations of assets (including earthing) are compliant to:
  - AS 2067: Substation and high voltage installations exceeding 1kV a.c. (reference 3);
  - AS1940: The storage and handling of flammable and combustible liquids, Appendix H (reference 4);
  - Electricity Network Association (ENA) guidelines;
  - Building Code of Australia (reference 5):
    a. Protection of Openings C3.5 Doorways in firewalls.
    b. Part E1, Fire fighting equipment.
    c. 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.
    d. Part E4 Emergency lighting, Exit signs and warning systems.
- Ensuring inspection and monitoring are compliant to:
  - AS 1851 Maintenance of fire protection system and equipment (reference 6);
  - AS/NZS 2293.2 Emergency evacuation lighting for buildings – Inspection and maintenance (reference 7); and
  - Code of Practice for the Management and Control of Asbestos in Workplaces [NOHSC:2018 (2005)] (reference 8).

7. SPECIFIC ISSUES AND MANAGEMENT PLAN

7.1 Treatment Trade-offs

7.1.1 Preventative Corrective Maintenance versus Reactive Corrective Maintenance

Failures of most of the equipment in zone substations have the potential of serious or catastrophic damage to both zone substation equipment and to nearby areas, as well as a substantial impact on reliability. Due to the critical nature of these assets, reactive corrective maintenance is avoided where possible due to the generally high costs involved. Preventative corrective maintenance programs represent a cost effective alternative.

7.1.2 Planned Asset Replacement versus Reactive Asset Replacement

Similarly to Section 7.1.1, a reactive asset replacement program does not represent an attractive alternative to planned asset replacement. Waiting times for replacement zone substation equipment can be in excess of six months, depending on the availability of supply and manufacture, and significantly more expensive than planned asset replacement.

Aurora's urban zone substations supply high density urban, commercial and CBD communities where extended periods of outages are unacceptable. The distribution system has adequate connectivity to reconfigure the network in the event of a zone substation failure but the extent to which supply can be restored is restricted by the current load on the network. However, due to the significant reliability and system security risk leaving the distribution system in these contingency arrangements for extended periods of time pose, reactive asset replacement is avoided where possible.

The use of a temporary mobile generation substation while an asset is out of service is also possible. Aurora's current mobile generator would be undersized for this purpose but leasing arrangements are in place to source additional units as required.

7.1.3 Non Network Solutions

Zone substations are a fundamental requirement of the network with limited alternatives. System loading and security usually drive the need for new zone substations. Demand side management such as smart meters and ripple control serve to defer but not fully remove the need for investment.

7.2 Preventative Maintenance

7.2.1 Visual Inspections

Each zone substation is visited once every six months to conduct a visual inspection of the site. The aim of the visual inspection is to ensure that all signage is intact, there is no damage to the substation enclosure and to carry out a visual inspection of the equipment. The frequency is based on the manufacturer's recommendation for the different equipment and Aurora's previous experience regarding the enclosures and signage etc.

7.2.2 Load Check

Aurora monitors load on all the urban zone substations through the SCADA system. Most of the transformers are run well below the full continuous load capacity to ensure that the total substation load is maintained under the firm capacity of the substation.

Integrity checks of the SCADA systems are conducted every six months in conjunction with the visual inspection at all urban zones.

7.2.3 Transformer Load Monitoring and Oil Testing

Factors that affect the ageing of power transformers are high temperatures and the state of the transformer oil, in particular moisture ingress. The temperature of a transformer is a function of the transformer loading and the cooling of the transformer, thus it is important that transformer loads are monitored continuously.

Load Monitoring

Aurora monitors load on all the transformers through an online Feeder Load Reporting System. Most of the transformers are run well below the full continuous load capacity to ensure that the total substation load is maintained under the firm capacity of the substation.

Oil Testing

Regular testing of oil samples from transformers is important to monitor the moisture content of the transformer oil and the gas content as well to capture any indication of any internal problems, such as partial discharge, overheating or arcing, within the transformer tank.

Therefore the aim of the transformer oil-testing program is to test the power transformer oil to:

1. Detect signs of ageing and deterioration of the transformer oil by measuring a number of physical and electrical properties of the oil; and
2. Monitor for fault conditions and operational problems in the transformer by performing dissolved gas analysis.

Transformer oil sampling and testing is undertaken annually for the urban zone substation and every two years for the rural zone substation power transformers as per recommendations from manufacturer. The results of the oil testing indicate whether more frequent testing is required on specific transformers if issues are detected.

The oil samples are sent to an external NATA certified laboratory for testing and analysis.

7.2.4 Thermal Inspections

The aim of the thermal inspections is inspect all accessible equipment to detect any hot spots, which may be an indicator of a developing failure.

Thermal inspections are conducted once every two years at each zone substation site. This work is contracted out to an external service provider, as Aurora does not have the capability to do these inspections in-house.

More frequent thermal inspections may be required at particular sites in the event of abnormal test results.

This work is conducted at the same time as the partial discharge testing (refer Section 7.2.5).

7.2.5 Partial Discharge Testing

The aim of the partial discharge testing is to detect any partial discharge, which may be an indication of problems with the insulation and an indicator of a developing failure.

Partial discharge testing of the switchgear is conducted once every two years at each zone substation site. More frequent partial discharge testing may be required at particular sites in the event of abnormal test results.

This work is conducted at the same time as the thermal inspections (refer Section 7.2.4).

7.2.6 66kV Disconnector, Fault Throw Switch and Trial Harbour Road Yard Inspection

The aim of these inspections is to ensure the equipment is in a serviceable condition.

As this equipment is relatively new and Aurora has little experience with this type of equipment, it is maintained as per the manufacturer's recommendations.

Aurora is currently assessing whether there is the in-house capability to carry out this work or whether it will be contracted out.

7.2.7 Asbestos and Asbestos Inspections

Aurora is required to comply with Workplace Health and Safety and Regulations 1998 and the Code of Practice for the Management and Control of Asbestos in Workplaces [NOHSC: 2018 (2005)] (reference 8) with regards to the management of sites containing asbestos.

The zone substations constructed prior to 1980 are likely to contain asbestos.

These sites include:

- Bellerive;
- Claremont (old buildings only);
- Derwent Park;
- Geilston Bay;
- New Town; and
- Sandy Bay.

Equipment that may contain asbestos includes switchboards, metering panels, roof lining, conduits and doors.

The aim of periodic asbestos inspections is to ensure that the information in Aurora's asbestos register is correct and all on-site labelling is in place and period risk assessments are undertaken to manage the risk of asbestos exposure.

These inspections are undertaken every four years by qualified personnel and are conducted at the same time as the confined space inspections (refer Section 7.2.8).

7.2.8 Confined Space Inspections

The aim of the confined space inspections is to ensure that the information contained in the confined space register is correct and all on-site labelling is in place.

The definition of a confined space is contained in Schedule 1 of the Workplace Health and Safety Regulations 1998 (reference 14).

An inspection was undertaken in 2010 to identify confined spaces within Aurora's sites. The following assets were classified as confined spaces as part of the audit:

- The cable trenches in the urban zone substations; and
- The oil containment tanks at the urban zone substations, including Trial Harbour zone substation.

Safe entry into confined spaces to perform work is governed by the requirements of AS 2865:2009 and is called up as a direct reference in the Workplace Health and Safety Regulations 1998.

These inspections are undertaken every four years and are conducted at the same time as the asbestos inspections (refer Section 7.2.7).

7.2.9 Emergency and Exit Lighting Inspections

Substation buildings can 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 volume1 (Part E4 Emergency lighting, Exit signs and warning systems).

Aurora has emergency lighting installed in all its urban zones including Trial Harbour zone substation although some of the older urban zone substations do not meet current standards with regards to exit lights, which poses a risk to operator safety.

The maintenance requirements for emergency lighting in zone substation buildings are specified in AS/NZS 2293.2 Emergency evacuation lighting for buildings – Inspection and maintenance (reference 6).

The emergency and exit lighting at each urban zone substation is inspected every six months, as required by AS/NZS 2293.2. This work is scheduled at the same time at the visual inspections.

7.2.10 Fire and Exit Door Inspections

The installation of fire doors and doorways in firewalls are governed by the requirements of the BCA Volume 1 Protection of Openings C3.5 Doorways in firewalls.

The requirements for the maintenance of fire doors are set out in AS1851 Maintenance of fire protection systems and equipment (reference 6).

The older urban zone substations do not meet current standards with regards to fire doors and emergency exits, which poses a risk to operator safety.

The fire and exit doors at each urban zone substation are inspected every three months, as required by AS 1851.

7.2.11 Switchgear Maintenance

The aim of switchgear maintenance is to ensure the equipment is in a serviceable condition.

The switchgear in zone substations is maintained on a six-year cycle, based on manufacturer’s recommendations and the performance of the equipment.

7.2.12 Circuit Breaker Timing Tests

The aim of circuit breaker timing tests is to detect any developing issues in the mechanical tripping systems.

These tests are conducted as part of the switchgear maintenance prior to the switchgear being taken out of service to enable the ‘first trip’ to be captured, as this provides the most useful information as to the condition of the circuit breaker timing.

7.2.13 Transformer Maintenance and Inspection

The aim transformer maintenance and inspection is to conduct electrical testing to provide additional information on the condition of the transformers.

Transformer periodic maintenance and inspection is conducted on a six-year cycle as per manufacturer's recommendations.

7.2.14 Tapchanger Maintenance

The aim of tapchanger maintenance is to ensure that the equipment is in a serviceable condition.

Transformer tap changing equipment accounts for a substantial proportion of transformer failures. As it is estimated within the industry that the annual cost ratio of preventative maintenance programs versus emergency maintenance and equipment replacement is 1:3, specific maintenance of tap changers is recommended.

The tapchangers in zone substations are maintained on a two-year cycle, based on manufacturer's recommendations and the performance of the equipment.

7.2.15 Protection and SCADA

The aim of the protection and SCADA routine maintenance is to ensure the equipment is in a serviceable condition.

The equipment is maintained on a two-year cycle as per manufacturer's recommendations. This work is contracted out to an external service provider as Aurora does not have the capability to do this testing in-house.

The current contract, which commenced in 2009/10, covers additional activities such as:

- Fault and emergency response;
- Fault investigation and rectification;
- SCADA and protection drawing management (including management of changes or alterations);
- Asset repair; and
- Other minor work.

7.2.16 Earthing System Injection Testing

The aim of earthing system injection testing is to ensure the integrity of the earthing system.

The earthing of the zone substations is required to ensure personnel and public safety and the correct operation of protection equipment in the event of system faults and external events such as lightning.

Maintenance of the earthing resistance below a certain value is of prime importance for both correct protection operation and safety of the public. Earthing of zone substation is specifically important, as there are so many other distribution assets, which depend and refer back to substation earthing for effective earths.

Earth potential rise (EPR) is the rise in voltage of earth (including all the metallic enclosures attached to earth) during a fault clearance period. Therefore, this is very important parameter in the assessment of public risk and has to be within limits as per Energy Networks Association (ENA) EG1-2006 Substation Earthing Guide (reference 15). ENA also recommends a risk-based approach to earthing designs based on ENA EG-0 Power System Earthing Guide Part 1: Management Principles (Version 1) – May 2010 (reference 16).

External service providers conduct these tests once every ten years, as Aurora does not have the capability to conduct this specialised testing.

7.2.17 Batteries and Battery Chargers

Batteries and battery chargers are critical in the correct operation of the protection and control systems within zone substations.

The batteries are designed to supply full load backup for protection and control system for continuous eight hours in the event battery charger failure.

Battery and battery charger maintenance is to ensure the equipment is in a serviceable condition.

This work is undertaken on a twelve-month cycle and is contracted out to an external service provider, as Aurora does not have the capability to do this testing in-house.

7.2.18 Fire Panel and Smoke Detector Maintenance

Substation buildings can be deemed a class 8 building as part of the BCA. The installation of fire detection and alarm systems is governed by the requirements of the BCA volume1 (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) (reference 5).

The requirements for the maintenance of fire systems are set out in AS1851 Maintenance of fire protection systems and equipment (reference 6).

The fire panels and smoke detectors at each urban zone substation are inspected every month, as required by AS 1851.

7.2.19 Fire Extinguisher Maintenance

Substation buildings can be deemed a class 8 building as part of the BCA and as a requirement of this the fire fighting system shall comply with BCA volume 1 Part E1 ‘Fire Fighting Equipment’ (reference 5).

To comply with the BCA, Aurora has fire extinguishers installed in all urban zone substations.

The requirements for the maintenance of fire extinguishers are set out in AS1851 Maintenance of fire protection systems and equipment (reference 6).

The fire extinguishers at each urban zone substation are inspected every six months, as required by AS 1851.

7.2.20 Transformer Deluge System Testing – East Hobart only

The transformers at East Hobart Zone Substation are fully enclosed, so a deluge system was installed to enable fires to be extinguished in the event of a fire in a transformer enclosure.

The requirements for the maintenance of fire systems are set out in AS1851 Maintenance of fire protection systems and equipment (reference 6).

The deluge system at East Hobart Zone Substation is maintained every 12 months as required by AS 1851.

7.2.21 Building and Enclosures and Civil Maintenance

Third party damage and vandalism can be an issue with zone substation buildings and enclosures.

As parts of these sites are outdoors there are also issues with weed and vegetation growth that require ongoing attention.

Therefore periodic civil maintenance program is to ensure the safety, cleanliness and security of the substations are maintained and to conduct maintenance tasks such as weed spraying, vermin control, painting and other minor building maintenance activities.

Sites are visited four times per year for the purpose of civil maintenance.

7.3 Reactive Maintenance

7.3.1 Minor and Major Asset Repairs

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

7.4 Non Demand Replacement

7.4.1 Battery Replacement Program

Zone substation batteries are estimated to have a 10-year asset life and are managed through an ongoing program of battery replacement.

7.4.2 Oil-filled Circuit Breakers

The metal-clad switchgear within urban zone substations are indoor and installed within building-type enclosures. They are either air-insulated or oil-insulated.

The consequence of an explosion of oil-filled switchgear is much greater than modern air-insulated vacuum-interrupter switchgear. This poses a greater risk to operator safety. Additionally, this type of switchgear presents an environmental risk and has greater maintenance costs because of the oil.

Varying environments such as damp conditions (condensation build up), dust, pollution and insects and vermin can degrade the performance of the switchgear and lead to partial discharge and ultimately switchgear failure. Loose connections, high resistance joints, corrosion and overloading can also lead to equipment failure.

Currently Sandy Bay, New Town and Derwent Park zone substations contain oil filled switchgear.

To remove the risks posed by oil filled switchgear Aurora has a program in place to replace all oil-filled switchgear with insulated vacuum-interrupter switchgear in zone substation sites by 2016.

In addition to removing the risks associated with the oil-filled switchgear, this program will enhance the remote operation capability of these sites, as the replacement circuit breaker truck will be fitted with motor spring charging and will improve operator safety with the installation of blast proof enclosure doors.

Replacement for Sandy Bay zone substation's switchgears was proposed in 2011/12 but due to capital and budget constraints the replacement has been deferred to 2012/13. New Town and Derwent Park zone substation's switchgears are proposed to be replaced in 2013/14 and 2014/15 respectively.

Although the primary driver of the program is safety and risk, this program shall also reduce operational expenditure under routine maintenance of circuit breaker. Maintenance cost of air insulated vacuum circuit breakers is cheaper in comparison to oil circuit breakers.

7.4.3 Power Transformers Urban Zones

As transformers age, they become noisier and Aurora have had noise complaints from customers in the vicinity of Claremont and Geilston Bay zone substations. Testing at these sites has indicated that they do not comply with the lowest noise limits for a transformer of that size as per AS 2374 Part 6 1994: Power Transformers – Determination of Transformer and Reactor Sound level (reference 17). A noise barrier wall has been installed at Geilston Bay zone substation to treat the issue.

Approximately 40% of the urban zone substation transformers are over 40 years old, with several approaching 50 years old. Although oil testing indicates that in general these transformers are in good condition for their age but a few have started showing signs of deteriorating condition.

Aurora has a program in place to replace the oldest of these transformers installed at Claremont, Derwent Park and Geilston Bay zone substations in the next ten years, based on noise compliance issues and oil testing results (reference 12).

Transformer replacement at Claremont and Derwent Park zone substations are proposed for the 2012 pricing determination period in 2013/14 and 2014/15. Transformers at Geilston Bay zone substation are proposed for the 2017 pricing determination along with oil containment installation (refer Section 7.4.5).

7.4.4 Power Transformers Rural Zones

The oil testing of the rural transformers indicates they are in poor condition (Table 1) and need replacing. Although there is a program in place to remove or redevelop a number of Aurora's rural zone substations, which is managed by the Network Development team, not all rural zones will be addressed through this program.

Aurora has a program in place to replace the transformers at Richmond and New Norfolk zone substations in 2016/17. The program could be required to be brought forward in the event of any transformer failure.

7.4.5 Oil Containment

Power transformers contain mineral insulating oil for both electrical insulation of the internal components and cooling.

AS 2067: Substation and high voltage installations exceeding 1kV a.c., Clause 6.7.11 (reference 3) requires that every high voltage installation containing equipment with more than 500 litres of a liquid dielectric such as transformer oil, shall have provision for containing the total volume of any possible leakage and meet the overall objectives of AS 1940 The storage and handling of flammable and combustible liquids, Appendix H (reference 4).

Currently all urban zone substations contain oil containment except Bellerive and Geilston Bay zone substations. The rural zone substations do not have any oil containment.

The oil containment at Geilston Bay zone substation shall be installed at the same time as the transformer replacements during the 2012 pricing determination. The oil containment issue at the rural zone substations shall be addressed based on the future requirement of the substations and the risk associated at each individual site.

7.4.6 Removal Of Redundant Assets

Aurora's Network Development team are managing a program to remove or redevelop a number of the rural zone substations. As part of this strategy, Hamilton Zone Substation and Zeehan Zone Substation were taken out of service with Hamilton Zone Substation decommissioned in 2010/11 and Zeehan Zone Substation to be decommissioned in 2011/12.

The removal of all the assets from Hamilton Zone Substation is proposed for the 2012 pricing determination in 2013/14. The removal was scheduled earlier but could not be completed due to other priority works and budget constraints.

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8. REVIEW OF HISTORICAL PRACTICES

Aurora's asset management practices on 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, Aurora believes the practices of condition based renewal, driven by asset inspection and maintenance practices are providing well-founded decision making.

Due to the critical nature of this asset class, frequent maintenance is required to defer unnecessarily early capital expenditure. Aurora believes that the existing frequency of maintenance is reasonable and that the practices are capturing the issues appropriately.

Capital expenditure has been low historically due to adequate performance and condition of the equipment, however, this will change going into the future with the deteriorating condition of some of the assets and increase safety and environmental risks from the oil filled assets.

9. PROPOSED OPEX PLANS

Aurora is satisfied that its current practices are performing adequately. In-service failures are rare and the assets are achieving and exceeding their expected service life. It is proposed to continue with the current asset management practices, but with the some additional expenditure due to an increase in routine maintenance.

Inspection levels and routine maintenance program shall continue at current levels (Table 2) due to the critical nature of these assets and the need to ensure their reliable operation.

Nominal increase is proposed for future operational expenditure due to an increase in routine maintenance (Table 2). This increase is due to the addition of two urban zone substations in 2007 and 2008 and is estimated to increase further with the addition of new zone substations in the 2012 pricing determination.

Table 2: OPEX for period between 2007/08 and 2016/17 financial years ($)

Work Program	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Inspection	46,328	53,000	72,995	93,344	101,344	107,077	104,655	103,599	102,060	91,592
Maintenance	138,375	427,771	112,163	203,320	224,320	344,343	351,399	339,589	352,864	358,831
Repair	115,061	77,512	55,980	50,144	50,144	85,434	83,063	82,079	80,581	80,001
Actual $$	299,764	558,282	241,138							
Proposed	447,401	402,044	423,253	346,808	375,808	536,853	539,117	525,267	535,506	530,424

10. PROPOSED CAPEX PLANS

The following values were obtained using Aurora's Capex Model (reference 13). Using the estimated life expectancy feature of the model for this asset category, the following envelope of renewal investment is required over the following 20 years to maintain the asset class at a stable Remaining Life Expectancy (RLE).

Figure 1 shows the outputs of Aurora's capital expenditure model for zone substations, taking into account condition, risk and age. The model forecasts capital investment of $31.8 M over the next regulatory period.

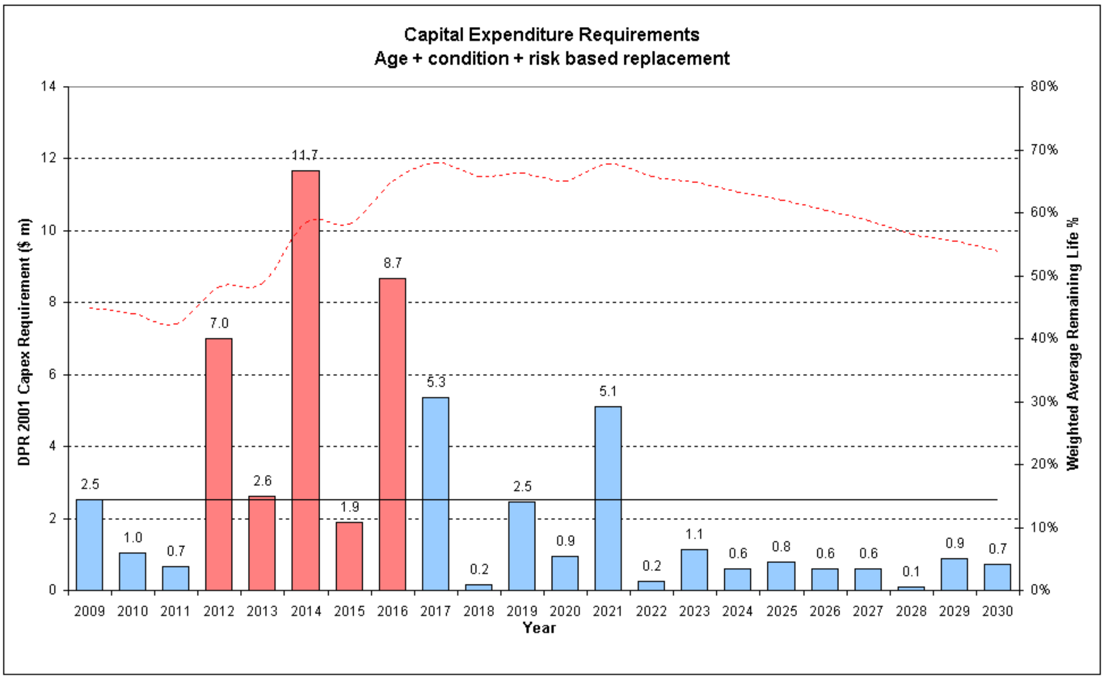

Figure 1: Forecast CAPEX Expenditure From PB Model ($M)

When c onsidering t he bot tom up drivers f or as set r eplacements based on current condition data, field failure rates and prudent risk management, Aurora proposes that the above envelope can be discounted to the proposed levels of capital ex penditure in Table 3 without representing ex cessive risk or s ervice level c onsequence t o c onsumers. B oth these areas w ill be m onitored carefully to ensure these assumptions remain valid.

Table 3: CAPEX for period between 2007/08 and 2016/17 financial years ($)

Work Program	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Replacement	5,296	31,704	142,518	660,000	2,200,000	2,063,882	3,334,980	3,345,000	50,000	2,025,000
Actual	5,296	31,704	142,518							
Proposed	43,946	9,000	4,832,318	660,000	2,200,000	2,063,882	3,334,980	3,345,000	50,000	2,025,000

11. CAPEX – OPEX TRADE OFFS

The o perating ex penditure pr ograms are es sential for i dentifying assets the require r eplacement for c ondition-based r easons. An example of t his i s t he routine oil t esting o f z one s ubstation transformers t o d etect s igns o f ag eing and deterioration of the transformer oil. The results of the oil test can be used to m onitor t he condition o f t he t ransformer an d i dentify when c apital expenditure is required.

There i s a p ositive r elationship b etween t hese t wo c ategories i n t hat r egular inspection programs gather continuous condition information of the assets to better t arget as set r eplacements and i dentify any as set t rends. M aintenance and r epair ac tivities a lso de fer t he r equirement for c apital expenditure and increase the likelihood of achieving a reasonable service life from the asset.

12. ASSET MANAGEMENT INFORMATION

Aurora maintains records of underground assets through the periodic routine testing and inspection programs providing the following information. The equipment details and attributes are predominantly recorded within FRAMME / WASP. These being the two integrated asset management systems, however there are smaller data-sets in MS Access and Excel that currently store other information relating to the asset and its condition.

Recorded information includes:

1. Identification number (unique identifier)
3. Location / site / geographical details
4. Asset / equipment details (size, make, model, type, rating, installed date)
5. Ancillary equipment details (such as make, model, type, rating, Installed date)
6. Equipment attributes and operational numbering
7. Operational details (connectivity, protection & equipment settings / ratings, etc)
8. System performance details (reliability, causes, power quality recorded data etc)
9. System monitoring information / data (load – cyclic, maximum demand, load balance)
10. Asset condition data and remaining residual life (general and limited)
11. Oil condition, contamination levels
12. Age of asset and components, installed / refurbished date
13. Age of related equipment
14. Unit rates or agreed costs i e inspection, treatment refurbishment and replacement costs
15. Maintenance details / action
16. Maintenance program progress, and
17. Maintenance history (general and limited).

13. MANAGEMENT PLAN MONITORING

A review of management plans will be conducted at the end of each financial year to measure the performance of this plan against the expected outcomes and to identify any gap. Also, sometimes changes are required in works or expenditures to address any important emerging issues (not considered earlier or estimated wrongly). Any changes, if required, shall be made and recorded accordingly in appropriate approved manner for future reference.

14. RESPONSIBILITIES

Maintenance and implementation of this management plan is the responsibility of the Asset Engineer – Substations and Underground.

Approval of this management plan is the responsibility of the Asset Performance and Information Manager.

15. REFERENCES

1. Aurora Safety, Health and Environment Policies
2. AS 2865: 2009, Confined spaces and workplace health and safety regulations 1998
3. AS 2067: Substation and high voltage installations exceeding 1kV a.c.
4. AS1940: The storage and handling of flammable and combustible liquids, Appendix H
5. Building Code of Australia
6. AS 1851 Maintenance of fire protection system and equipment
7. AS/NZS 2293.2 Emergency evacuation lighting for buildings – Inspection and maintenance
8. Code of Practice for the Management and Control of Asbestos in Workplaces [NOHSC:2018 (2005)].
9. Distribution System Planning Report 2010 (NW30118740) & Planning Sheet Zone Subs (DM#30157885)
10. AS/NZS 2293.2 Emergency evacuation lighting for buildings – Inspection and maintenance
11. AS1851 Maintenance of fire protection systems and equipment
12. Oil Data Analysis (DM # 10197528)
13. CAPEX Expenditure Model for Zone Substations (DM # 30160068)
14. Workplace Health and Safety Regulations 1998
15. Energy Networks Association EG1-2006 Substation Earthing Guide
16. Energy Networks Association EG-0 Power System Earthing Guide Part 1: Management Principles (Version 1) – May 2010
17. AS 2374 Part 6 1994: Power Transformers – Determination of Transformer and Reactor Sound levels

Appendix A Power Transformers Details

Table 4 Urban Zone Substation Power Transformers

Substation	Designation	Ratio	Manufacturer	Rating	Year of Manufacture
Bellerive	T1	33/11kV	Wilson	15/22.5	1971
Bellerive	T2	33/11kV	Wilson	15/22.5	1971
Cambridge	T1	33/11kV	Wilson	15/20	2008
Cambridge	T2	33/11kV	Wilson	15/20	2008
Claremont	T1	33/11kV	Wilson	15/22.5	1969
Claremont	T2	33/11kV	Wilson	15/22.5	1969
Derwent Park	T1	33/11kV	Wilson	15/22.5	1964
Derwent Park	T2	33/11kV	Wilson	15/22.5	1964
East Hobart	T1	33/11kV	ALSTOM	20/30	2004
East Hobart	T2	33/11kV	ALSTOM	20/30	2004
East Hobart	T3	33/11kV	ALSTOM	20/30	2004
Geilston Bay	T1	33/11kV	Wilson	15/22.5	1964
Geilston Bay	T2	33/11kV	Wilson	15/22.5	1964
New Town	T1	33/11kV	AREVA	15/22.5	2005
New Town	T2	33/11kV	ALSTOM	15/22.5	1999
Sandy Bay	T1	33/11kV	ALSTOM	20/30	2004
Sandy Bay	T2	33/11kV	ALSTOM	20/30	2004
Sandy Bay	T3	33/11kV	ALSTOM	20/30	2004
Sandy Bay	T4	33/11kV	Wilson	15/22.5	1967
West Hobart	T1	33/11kV	ALSTOM	20/30	2001
West Hobart	T2	33/11kV	ALSTOM	20/30	2001
West Hobart	T3	33/11kV	ALSTOM	20/30	2001
Trial Harbour Rd	T1	66/44/22kV	Areva	20MVA (44kV)	2007
Trial Harbour Rd	T2	66/44/22kV	Areva	20MVA (44kV)	2007

Table 5 Rural Zone Substation Power Transformers

Substation	Designation	Ratio	Manufacturer	Rating	Year of Manufacture
Gretna	T1	22/11kV		1	1971
Gretna	T2	22/11kV		1	1971
Hamilton	T1	22/11kV	London	0.5	1953
Hamilton	T2	22/11kV	London	0.5	1953
Hamilton	T3	22/11kV	London	0.5	1953
Hamilton	T4	22/11kV	London	0.5	1953
New Norfolk	T1	22/11kV	EE	2.5	1960
New Norfolk	T2	22/11kV	EE	2.5	1960
New Norfolk	T3	22/11kV	EE	2.5	1960
New Norfolk	T4	22/11kV	EE	2.5	1960
Richmond	T1	22/11kV	EE	2.5	1960
Richmond	T2	22/11kV	EE	2.5	1960
Tods Corner	T1	6.6/22kV		3	1971
Tods Corner	T2	6.6/22kV		3	1971
Wayatinah	T1	11/22kV	Electric Plant*	1	1950
Wayatinah	T2	11/22kV	Electric Plant	1	1950
Wayatinah	T3	11/22kV	Electric Plant	1	1950
Wayatinah	T4	11/22kV	BGE	1	1948
Westerway	T1	22/11kV	Wilson	1	1962
Westerway	T2	22/11kV	Wilson	1	1962
Zeehan	T1	44/22kV	Standard Waygood	2.5	1972
Zeehan	T2	44/22kV	Standard Waygood	2.5	1972
Zeehan	T3	44/22kV	Wilson	2.5	1980
Zeehan	T4	44/22kV	Westralian	2	1963
Zeehan	T5	44/22kV	Westralian	2	1963

Appendix B Urban Zone Substation Switchgear Details

Table 6 Urban Zone Substation Switchgear

Substation	Manufacturer	Installation Date
Bellerive	Reyrolle LMT	1971
Cambridge	ABB Uni Gear type ZS1	2008
Claremont	AREVA HWX	2006
Derwent Park	Reyrolle LMT	1964
East Hobart	ALSTOM HWX	2004
Geilston Bay	Reyrolle LMT	1964
New Town	Reyrolle LMT	1966
Sandy Bay	Reyrolle LMT	1967
West Hobart	ALSTOM HWX	2001
Trial Harbour	AREVA	2007

Table 7 Rural Zone Substation Switchgear

Substation	Manufacturer	Installation Date
Gretna	OYT	1971
Hamilton	OYT	1953
New Norfolk	Nulec	2001
Rcihmond	Nulec	2003
Tods Corner	OYT	1971
Wayatinah	Scarpa	1950
Westerway	OYT	1962
Zeehan	OYT	1972

Appendix C Transformer Age Profiles

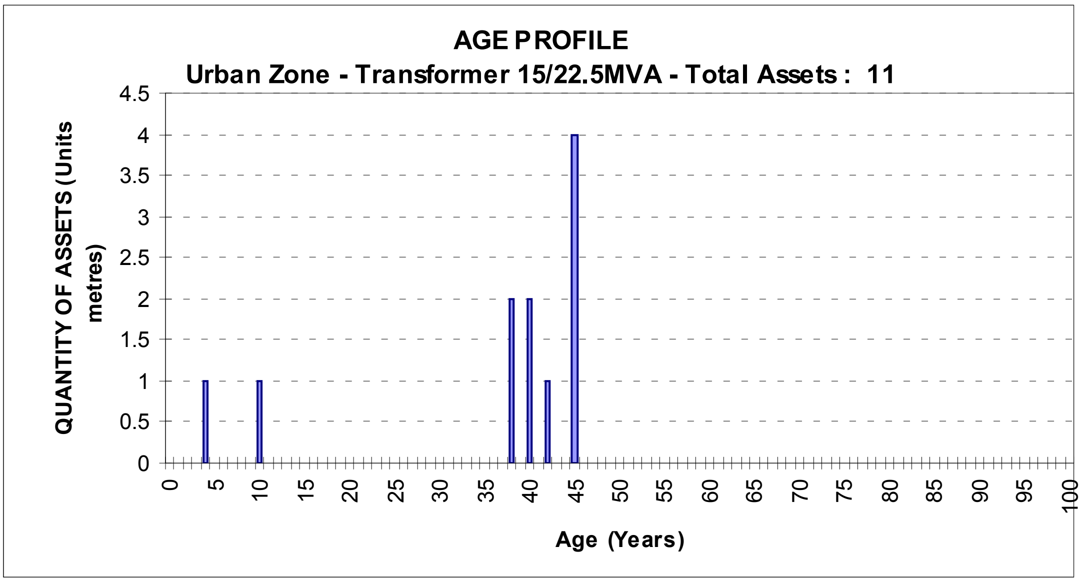

Figure 2 Urban Zone Substation Transformer Age Profile (15/22.5 MVA)

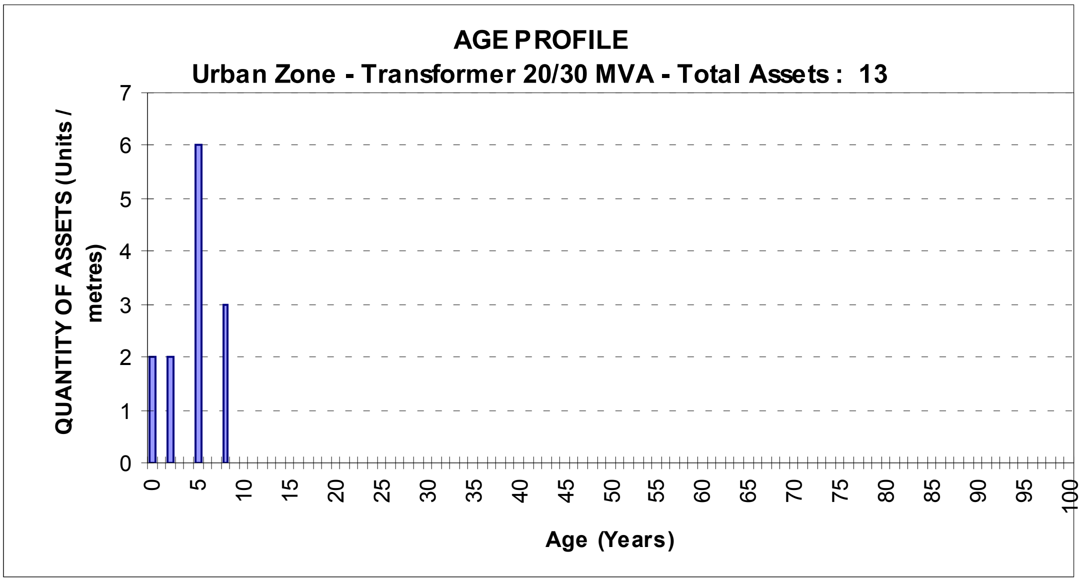

Figure 3 Urban Zone Substation Transformer Age Profile (20/30 MVA)

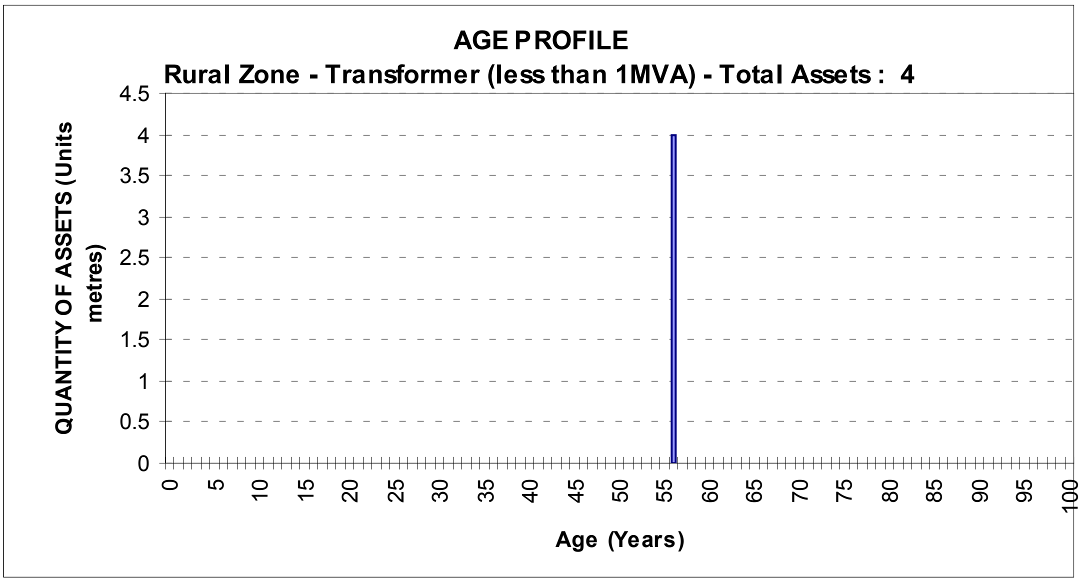

Figure 4 Rural Zone Substation Transformer Age Profile (less than 1 MVA)

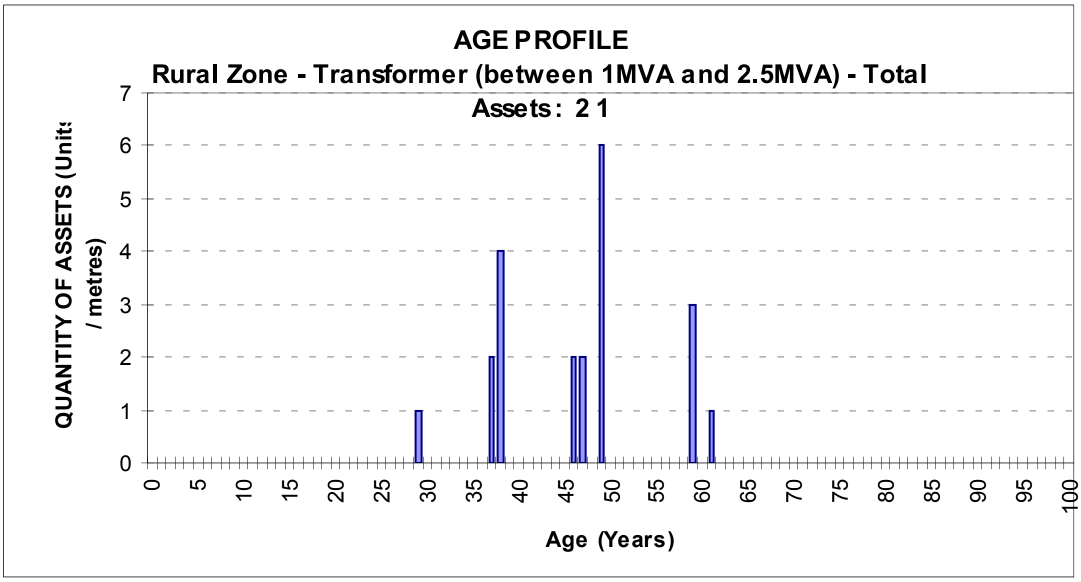

Figure 5 Rural Zone Substation Transformer Age Profile (1 to 2.5 MVA)

Appendix D Switchgear Age Profiles

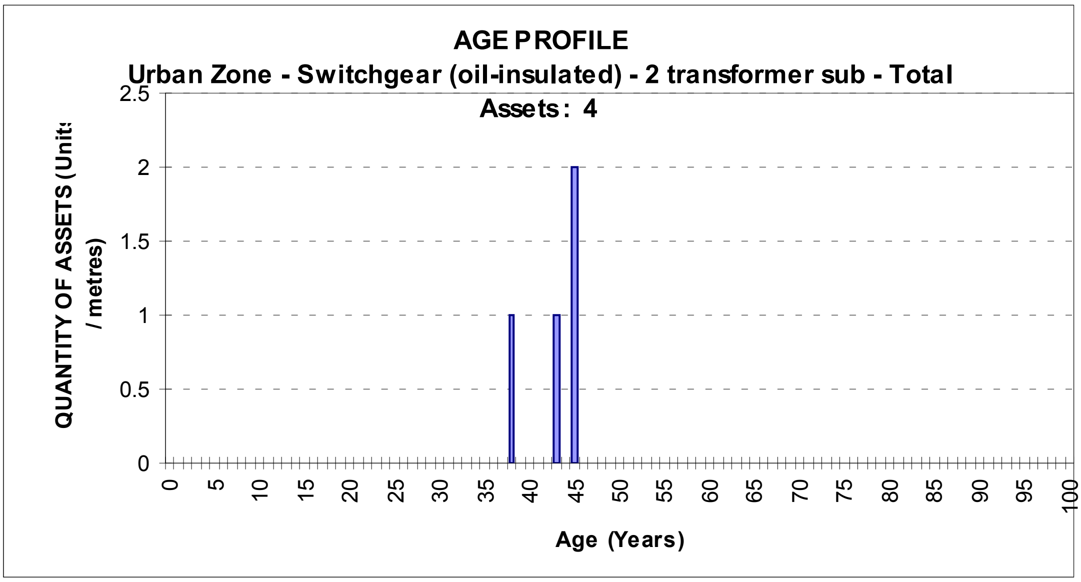

Figure 6 Urban Zone Substation Switchgear Age Profile (Oil-insulated, two transformer substations)

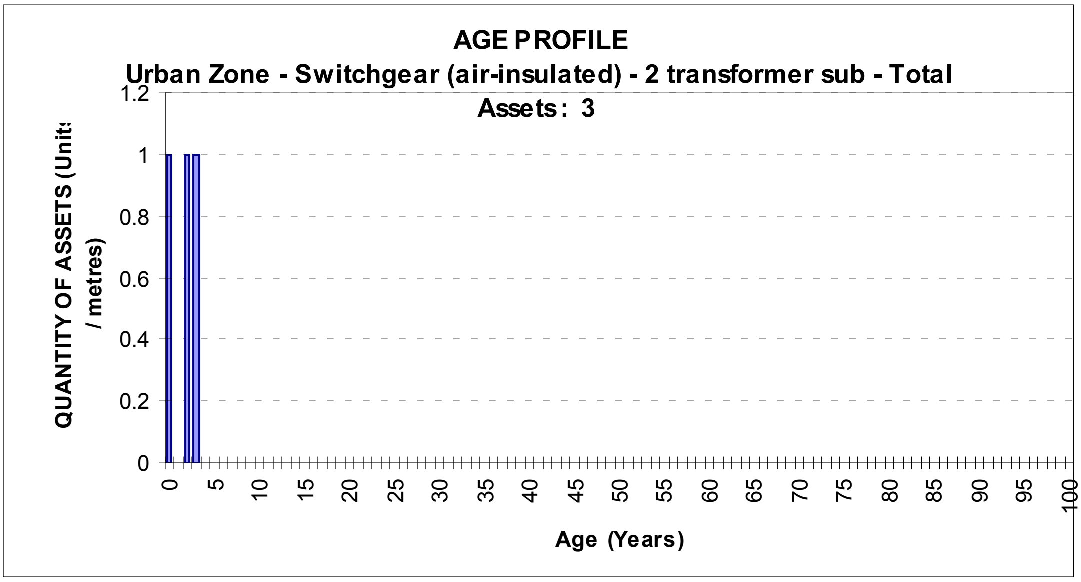

Figure 7 Urban Zone Substation Switchgear Age Profile (Air-insulated, two-transformer substations)

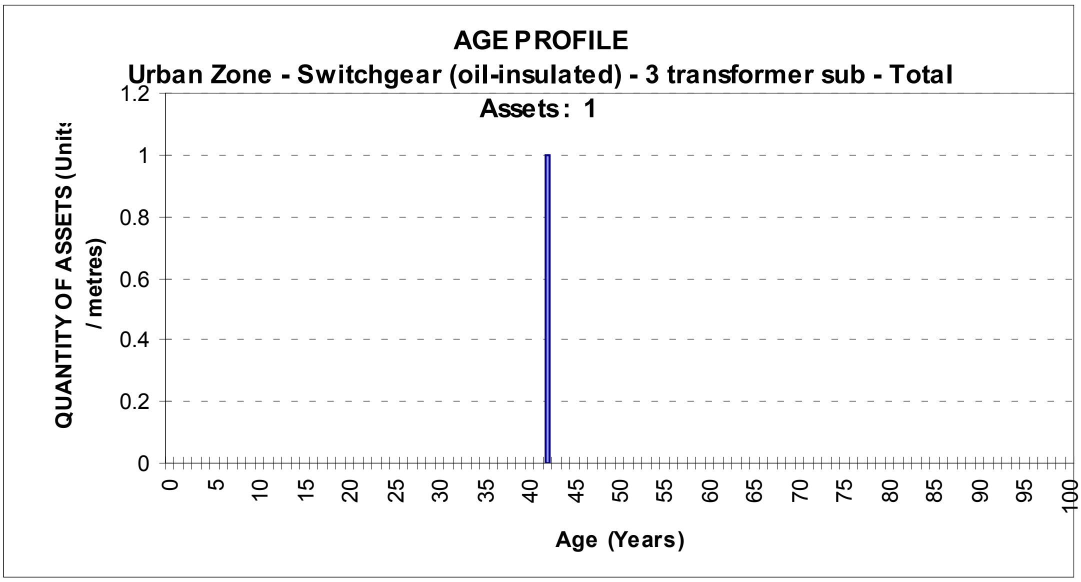

Figure 8 Urban Zone Substation Switchgear Age Profile (Oil-insulated, three-transformer substations)

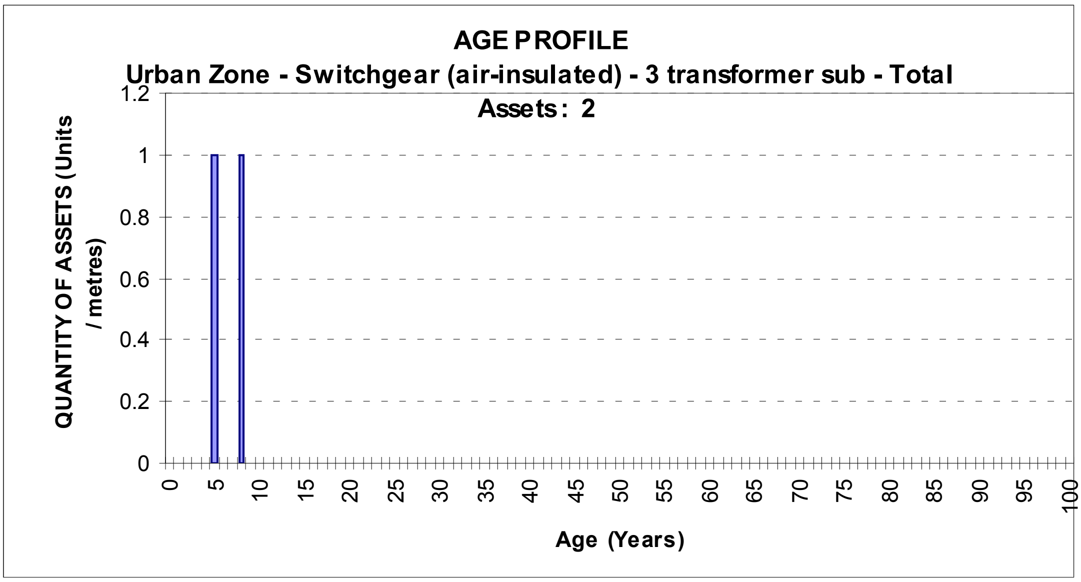

Figure 9 Urban Zone Substation Switchgear Age Profile (Air-insulated, three-transformer substations)

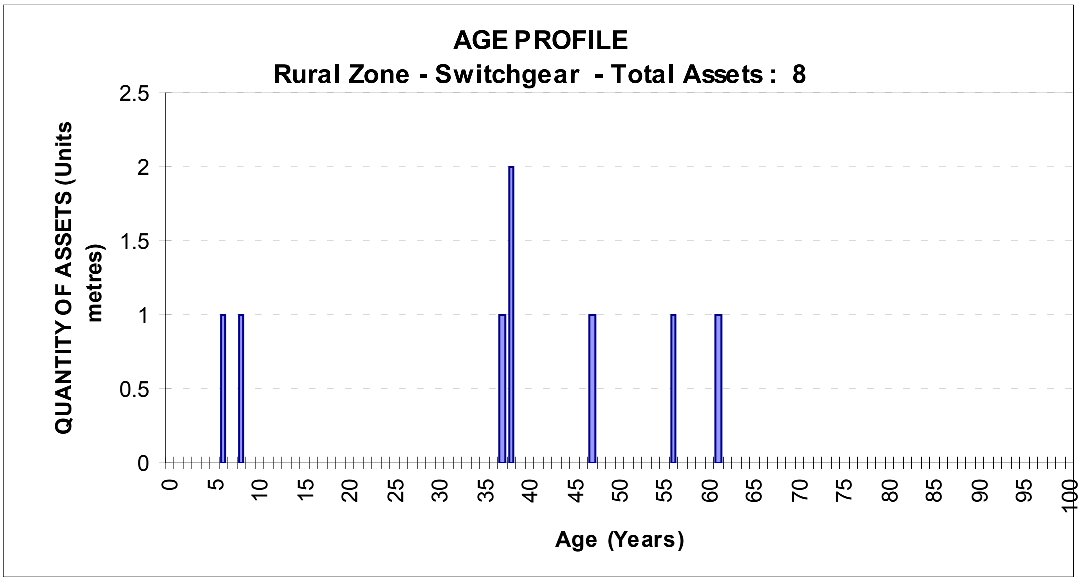

Figure 10 Rural Zone Substation Switchgear Age Profile

Appendix E Protection and SCADA Age Profiles

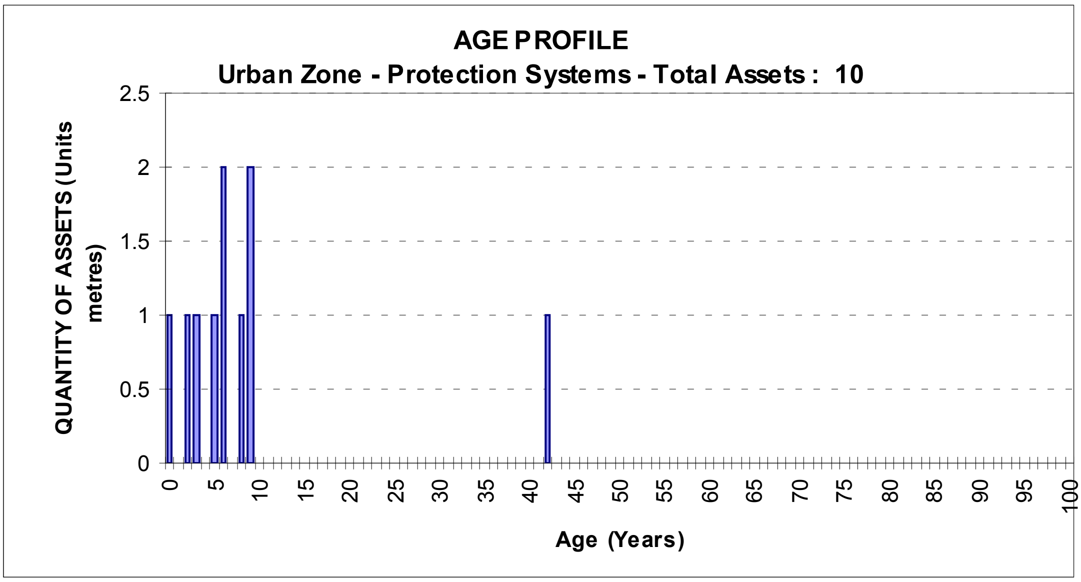

Figure 11 Urban Zone Substations Protection Systems Age Profile

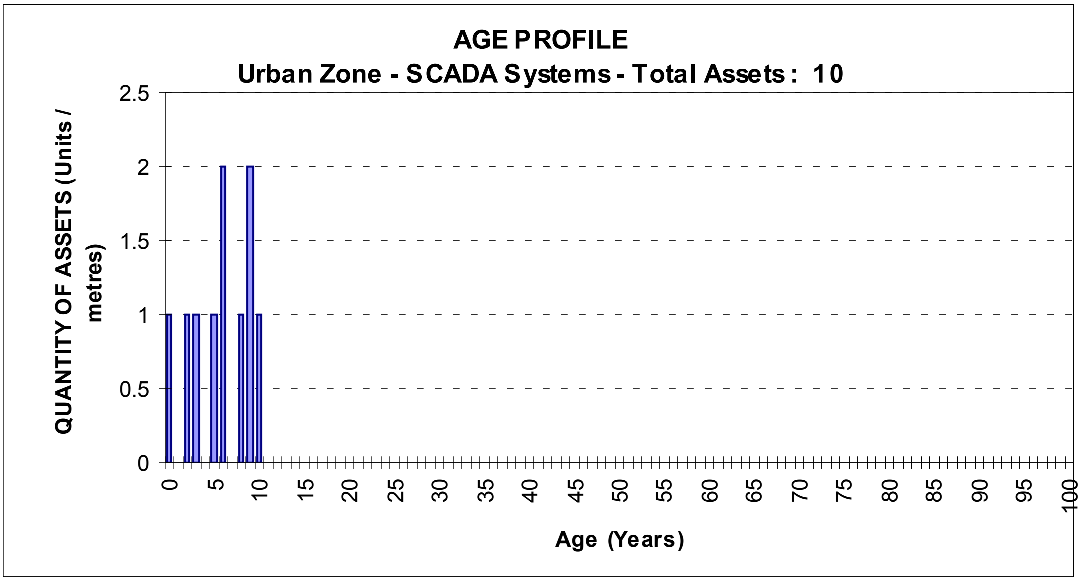

Figure 12 Urban Zone Substations SCADA Systems Age Profile

Appendix F Auxiliary Systems and Infrastructure Age Profiles

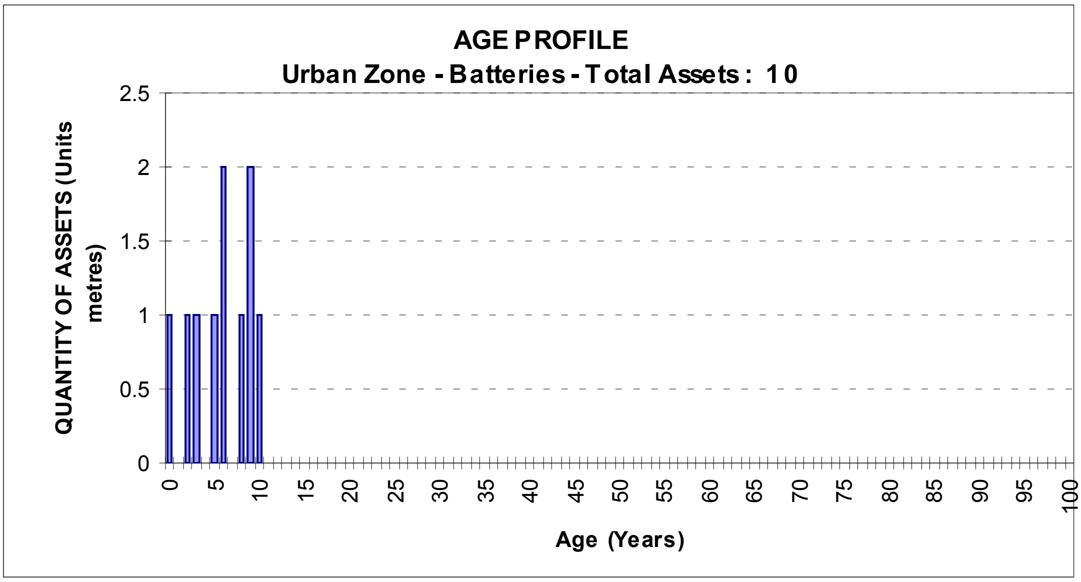

Figure 13 Urban Zone Substations Battery Systems Age Profile

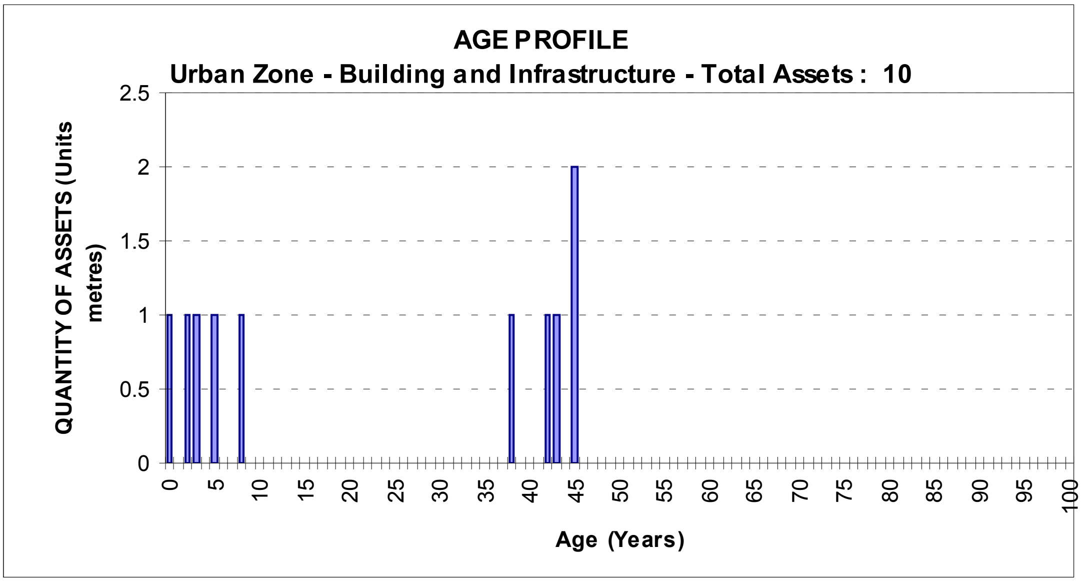

Figure 14 Urban Zone Substations Building and Infrastructure Age Profile

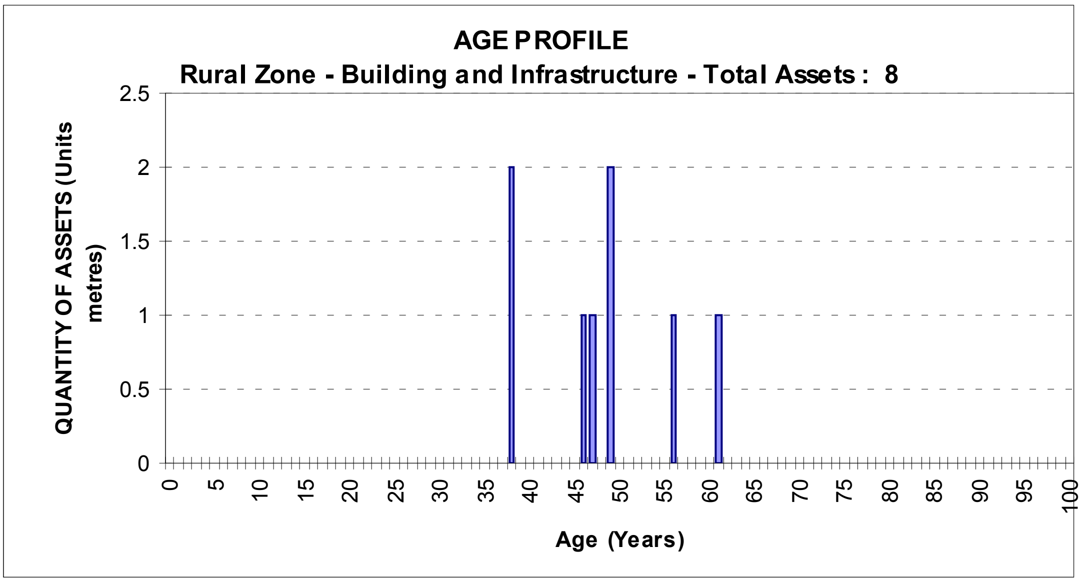

Figure 15 Rural Zone Substations Building and Infrastructure Age Profile