# AMS – Victorian Electricity Transmission Network

## Asset Life Evaluation

# Public

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# 1 Introduction

This paper documents the lives assigned to electricity transmission assets in Victoria including:

- Transmission lines[1], power cables and associated easements and access tracks
- Terminal stations, switching stations, communication stations and depots including associated electrical plant[2], buildings and civil infrastructure
- Protection, control, metering and communications equipment
- Related functions and facilities such as spares, maintenance and test equipment
- Asset management processes and systems such as System Control and Data Acquisition (SCADA) and asset management information systems (including MAXIMO)

More specifically, asset lives relate to the electricity transmission sites and facilities:

- Listed in the Network Agreement between SP AusNet (then PowerNet Victoria) and VENCorp (then the Victorian Power Exchange) 1994
- Listed in 1994 Connection Agreements between SP AusNet and connected parties largely consisting of generators, direct connect customers and distributors
- Listed in various supplementary network and connection agreements, detailing SP AusNet's unregulated transmission assets
- Illustrated on SP AusNet's system diagram T1/209/84

[1] 500 kV, 330 kV, 275 kV and 220 kV transmission lines and cables
[2] 500 kV, 330 kV, 275 kV, 220 kV, 66 kV and 22 kV switchgear and transformers

This document excludes the assets and infrastructure owned by generators, exit customers and other companies providing transmission services within Victoria.

This document provides an overview of the method used in determining asset lives and the assessed lives for the various assets. Additional information on the asset lives and life assessment factors is provided in the relevant detailed plant strategy documents. This document contains indicative useful lives intended to be used as a high level summary. Useful lives may vary on a per asset basis where more specific information is available.

For more detailed useful life and unit replacement cost information please see: Technical Useful Lives - V1.xls.

## 1.1 Responsibility

Asset Strategy & Planning is responsible for assigning, reviewing and updating the expected asset lives annually and in conjunction with each regulatory reset submission.

The assignment of asset lives shall take into account changes that may have occurred in the various life drivers, identified in Appendix 1 of this document.

## 1.2 Requirement

Asset lives provide an input to asset management decisions. In order to evaluate which combination of asset management options, i.e. maintenance, condition monitoring, refurbishment or replacement provides the least life cycle cost for the required performance level, it is necessary to have an assessment of the remaining life of the assets. Without these assigned lives, an asset manager can only determine the least cost solution to overcome the immediate problem. This can often lead to lost opportunities to improve the overall life cycle costs and failure to realise the benefits offered by a new technology.

By assigning asset lives to the various significant station assets, a strategy for the switchyard or station can be developed and this helps ensure that capital funds are not wasted on replacement of assets which may become redundant or require reconfiguration within a relatively short time.

Asset lives are also one of the factors used to identify specific assets that require more detailed assessment. Age is not the determinate for asset life or replacement. However, it is a useful proxy for asset condition and can provide a first level filter for assessing assets. Condition assessments from routine maintenance activities or specific assessment programs, fault and defects reports, are more important filters for detecting potential performance limitations and optimising work and outage programs.

Asset lives are also useful in modelling future asset replacement activity and capital expenditure requirements to enable financial and physical resource planning. These forecasts can also highlight the need for levelling of the capital expenditure programs to avoid inefficient variations in financial and physical resources.

## 1.3 Effective Asset Life

In the context of this document, the *effective asset life* is defined as that period of time that an asset continues to be of technical and economic use. Within its effective life an asset can be relied upon to consistently perform the required function with the required availability and outputs. Also pertinent is that the required inputs remain within predictable and manageable levels.

As the requirement for a particular asset and its associated functional performance may change over time, depending on a number of factors, this definition includes the consideration of technical and non-technical criteria such as economics and regulatory influences.

Estimates of the asset life will vary throughout the lifecycle of the asset, depending on changes in the contribution of the various life drivers.

The effective asset lives of the transmission network assets have been assessed by internal specialists for each asset class on a generic equipment type basis and takes into account their specialist knowledge gained over time relative to that asset type and condition, maintenance and performance information for each asset type.

The asset life drivers and influences that are considered when assessing the effective life of an asset are included in Appendix 1.

Each asset has been assigned "*Earliest*" and "*Latest*" lives, which represent the 5% and 95% percentile of the expected asset replacement life. These earliest and latest asset lives take into account the normal range that may occur in asset lives due to the expected range of operational and environmental conditions and efficient asset refurbishment and replacement projects for co-located assets.

Due to the consequences of failure to supply energy, transmission assets are generally planned and managed to lower failure frequencies than in distribution businesses where failures affect smaller numbers of end users for shorter periods. This is clearly demonstrated by the differences in the planning criteria adopted for most transmission networks compared with distribution networks. Very few transmission network assets can be efficiently managed with "run to failure" strategies.

Accordingly, transmission asset refurbishment and replacement is focussed on avoiding significant probabilities of failure for an asset fleet or high probabilities of failure for an individual asset.

## 1.4 Remaining Life

T transmission assets generally have long lives. In particular, a line tower could be regarded as having an indefinite live provided sufficient preventative maintenance and focussed re-furbishment is performed on its constituent elements.

However there is some risk that some long life transmission assets may become redundant before their technical life has been reached. The currently identifiable factors that are likely to shorten the effective life of these assets include changes in generation location, load profile, technology, environmental policies and societal concerns regarding overhead transmission lines.

For example, the development of highly efficient combined cycle generation and other alternative generation technologies suitable for embedded generation, the possible introduction of stricter environmental policies designed to reduce greenhouse gas emissions, the development of high temperature conductors and superconductors and increased societal concerns regarding electromagnetic fields could result in significant changes to future transmission networks.

While it is possible that significant asset stranding could occur prior, it has been assumed that the asset lives can be reviewed at each regulatory reset and the latest information on potential stranding taken into account at that time. Where an asset stranding is identified, the affect on the life of the assets shall be taken into account in the life assessment.

## 1.5 Grouping

The lives assigned to the assets have been assessed at a level that is considered to be the lowest practical grouping of assets for replacement purposes.

In some circumstances some minor assets within a group may need to be replaced and in these instances it is preferable to use a system spare in a "like for like" replacement to overcome immediate issues so that a complete group replacement can be implemented at a later date.

Where some assets from a group retirement have some residual life, the assets will be either kept as spares, or wherever economical, used to replace deteriorating assets in other groups. This is practical for some current transformers, capacitor voltage transformers and disconnectors but is generally not economic for circuit breakers due to the high cost of installation. The redeployment of these assets will help to maximise the benefits of the capital expenditure program by ensuring the technological and efficiency benefits of group asset replacements are realised wherever possible.

# 2 Station Primary Assets

These assets include station switch bay equipment, transformers and reactors, synchronous condensers, diesel generators, static VAR compensators, capacitor banks, and the general station infrastructure such as the station civil works, roads, fencing, lighting, fire services, water reticulation, buildings and associated services and AC supplies.

The following table (Figure 1) provides a summary of the circuit breaker technologies employed in the Victorian electricity transmission network and the years in which purchase specifications were issued for each technology type and voltage.

| Technology Type | Voltage | Specification Years | Notes |
|---|---|---|---|
| **Air Blast** | 200kV | 1950 to 1967 | |
| | 500kV | 1967 | |
| **Bulk Oil** | 22kV | 1950 to 1963 | Outdoor |
| | 22kV | 1942 to 1950 | Indoor switchboard |
| | 66kV | 1949 to 1967 | |
| | 220kV | 1950 To 1967 | |
| **Minimum Oil** | 22kV | 1979 | |
| | 66kV | 1955 to 1982 | |
| | 220kV | 1949 to 1980 | |
| **$SF_6$ Air Insulated** | 66kV | 1982 onwards | |
| | 220kV | 1979 onwards | |
| | 275kV, 330kV | 1983 onwards | |
| | 500kV | 1978 onwards | |
| **Gas Insulated Switchgear** | 220kV | 1972 | Indoor |
| | 500kV | 1978 and 1980 | Outdoor |

Figure 1 – Circuit breaker technologies

The actual service date of some circuit breakers may be significantly later than the specification year as in some instances deliveries were taken for up to five years after the specification year.

Asset lives have been assigned at a switch bay level as this has proven to be a practical replacement grouping. The life of the elements in the group have been based on the life of the particular type of circuit breaker within that group.

A summary of the asset lives is provided in the Table below (Figure 2)

| Asset Category | Asset Type | Earliest | Expected | Latest | Technical |
|---|---|---|---|---|---|
| AIS Switchbay – Air Blast CB | [redacted] | 40 | 43 | 45 | 55 |
| | [redacted] | 40 | 43 | 45 | 55 |
| | [redacted] | 40 | 45 | 50 | 55 |
| | [redacted] | 40 | 43 | 45 | 55 |
| AIS Switchbays - Minimum Oil CB | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-65 |
| | [redacted] | 45 | 48 | 50 | 42-65 |
| | [redacted] | 44 | 46 | 50 | 42-65 |
| | [redacted] | 35 | 40 | 45 | 42-65 |
| AIS Switchbay Bulk Oil CB | [redacted] | 40 | 43 | 45 | 42-60 |
| | [redacted] | 40 | 45 | 50 | 42-60 |
| | [redacted] | 40 | 45 | 50 | 42-65 |
| | [redacted] | 45 | 48 | 50 | 42-65 |
| AIS Switchbay SF6 CB | [redacted] | 35 | 40 | 45 | 42-55 |
| | [redacted] | 35 | 40 | 45 | 42-55 |
| | [redacted] | 35 | 40 | 45 | 42-55 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-60 |
| | [redacted] | 35 | 40 | 45 | 42-65 |
| | [redacted] | 35 | 40 | 45 | 42-65 |
| | [redacted] | 35 | 40 | 45 | 42-65 |
| AIS Disc bay | All | 35 | 45 | 55 | |
| Metal Enclosed Switchgear | [redacted] Bulk Oil Indoor | 50 | 53 | 55 | |
| | 220kV SF6 Dead Tank Outdoor | 40 | 45 | 50 | |
| Switchbay (AIS) – Reactive | Capacitor switch | 15 | 20 | 25 | |
| | Reactor switch | 15 | 20 | 25 | |

| Asset Category | Asset Type | Earliest | Expected | Latest | Technical |
|---|---|---|---|---|---|
| GIS Bays | 500kV Outdoor[3] | 35 | 40 | 45 | |
| | 220kV Indoor | 45 | 50 | 55 | |
| Current Transformers – single phase, oil insulated | [redacted] | 27 | 33 | 39 | 45 |
| | [redacted] | 36 | 42 | 48 | 45-50 |
| | [redacted] | 40 | 47 | 54 | 30-45 |
| | [redacted] | 24 | 30 | 37 | 30-45 |
| | Other | 38 | 44 | 50 | 30-50 |
| Capacitor Bank | Pre 1970 | 35 | 40 | 45 | 40 |
| | Post 1970 | 30 | 35 | 40 | 40 |
| Synchronous Condenser | Machine w/o refurbishment | 32 | 34 | 35 | |
| | Auxiliary Equipment | 32 | 34 | 35 | |
| | Refurbished (rotor, auxiliaries and stator re-wedge) | 45 | 47 | 50 | |
| SVC's | Primary Equipment | 35 | 40 | 45 | 40 |
| | Auxiliary Equipment | 15 | 20 | 25 | 40 |
| Shunt Reactors | Individual reactors have an assessed life within this range. | 30 | 35 | 45 | 45 |
| Power Transformers | Individual transformers have an assessed life within this range | 40 | 50 | 60 | 45 |
| Diesel Generator | All | 35 | 40 | 45 | 20 |
| Station Infrastructure | Bench and general civil works | 60 | 70 | 80 | |
| | AC Supplies | 40 | 45 | 50 | |
| | Buildings | 40 | 45 | 50 | |
| | Other Infrastructure | 40 | 45 | 50 | |

Figure 2 – Station Primary Assets

# 3 Line And Cable Assets

These assets include the overhead power lines up to the first rack structure in the terminal station and HV and EHV power cables both in and external to the stations. A summary of the assets is included in the table below (Figure 3):

| Voltage | Towers | Circuit km | Service Year Range |
|---|---|---|---|
| 500 kV | 3,209 | 1,516 | 1968 to 1985 |
| 330 kV | 1,763 | 739 | 1959 to 1978 |
| 275 kV | 184 | 157 | 1988 |
| 220 kV | 7,452 | 4,009 | 1954 to 1985 |
| 66 kV | 220 | 142 | 1967 to 1983 |

Figure 3 – Transmission Lines

[3] Subject to successful refurbishment works identified in the AMS 10-62

Underground cables are employed at 220kV, 66kV and 22kV. The majority are of the earlier paper/oil type but recent installations use XLPE insulation.

The majority of insulators used are porcelain “cap and pin” disc with some using glass construction. Dampers were installed on later lines to control conductor vibration and fatigue.

Victoria’s transmission lines were built in a generally benign environment with a few areas affected by industrial or marine atmosphere. At [redacted] tower painting commenced approximately 18 years after construction, due to rapid zinc loss and onset of rust, in an aggressive marine environment. In other areas it has been found necessary to replace corroded conductor and ground wire adjacent to isolated industrial sites.

The lives assigned for the various line components are detailed below. These reflect the figures for the broad population excluding extreme short lives, associated with Portland environment. The insulator lives also represent the broad population.

Asset lives, where appropriate, will be assigned to specific sections of a line if the design, condition or environment of the section will result in a significantly different life of that section compared to other line sections.

The lives of the various components of the lines have been reviewed and a significant increase in line refurbishment programs (particularly line insulators) are forecast for the next decade to manage the increasing risk of energised conductors falling to ground over public roads or in bushfire risk areas. A program is planned to retrofit conductor vibration dampers to older transmission lines to ensure ACSR conductors achieve their expected lives.

The following table (Figure 4) summarises line and cable asset lives.

| Asset Category | Earliest | Expected | Latest | Technical |
|---|---|---|---|---|
| Insulators – [redacted] | 35 | 40 | 45 | 30-90 |
| Insulators – Ceramic | 40 | 50 | 60 | 30-90 |
| Insulators – Polymeric | 20 | 30 | 40 | 30-90 |
| Fittings (including dampers & spacers) | 40 | 60 | 70 | 30-80 |
| Steel Overhead Ground wire | 40 | 50 | 65 | 30-80[4] |
| ACSR Conductor (& ground wire) | 35 | 60 | 70 | 30-804 |
| Towers | 60 | 70 | 85 | 60-1004 |
| HV and EHV Power Cable | 40 | 60 | 70 | 30-804 |

Figure 4 – Line and Cable Assets

# 4 Protection And Control Assets

These assets include the protection and control equipment associated with the primary assets, station general control, monitoring and alarms, and SCADA systems and the control centre master SCADA system. The protection asset lives have been based on the life of the primary protection scheme, as the practical unit of replacement is a protection scheme.

The lives have been assessed for relays of the same generic technology type. The range in the generic type lives will take into account the variation that is expected to occur in the lives of individual

[4] These assets are specific to Corrosion Zone

manufacturers types of the generic technology group. A summary is included in the following table (Figure 5) below.

| Asset Category | Asset Type | Earliest | Expected | Latest |
|---|---|---|---|---|
| Protection & Control Scheme | (A1) Electro-mechanical with continuous moving parts e.g. RI | 22 | 29 | 34 |
| | (A2) Electro-mechanical with occasionally moving parts | 26 | 32 | 36 |
| | (A3) Electro-mechanical with electro-magnetic operation | 29 | 35 | 39 |
| | (B2) Analogue electronic based mainly on solid state discrete components | 18 | 24 | 28 |
| | (B3) Analogue electronic device using discrete components & integrated circuits | 17 | 23 | 27 |
| | (C1) Hybrid analogue/digital device (analogue measuring and signal comparators and digital logic) no serial connectivity minimal self monitoring | 12 | 19 | 23 |
| | (C2) Hybrid analogue/digital device (analogue measuring and signal comparators and digital logic) with serial connectivity and comprehensive self monitoring | 13 | 21 | 25 |
| | (D1) Digital device incoming signals converted to digital form | 13 | 19 | 23 |
| Station Control Platform | Analogue | 30 | 35 | 45 |
| | Screen based (1st generation PC Based) | 10 | 14 | 16 |
| | Integrated digital platform | 10 | 14 | 16 |
| Energy Metering | 1st generation units | 6 | 10 | 12 |
| SCADA | Station RTUs (B2) Analogue electronic based mainly on solid state discrete components | 18 | 24 | 28 |
| | Station RTUs (B3) Analogue electronic device using discrete components & integrated circuits | 19 | 23 | 29 |
| | Station RTUs (D1) Digital device incoming signals converted to digital form | 13 | 19 | 23 |
| Control Centre | Master SCADA system | 10 | 12 | 15 |
| | Host computer equipment | 2 | 3 | 5 |
| DC Supplies | Batteries (pasted plate) | 13 | 15 | 16 |
| | Home lighting | 4 | 5 | 7 |
| | Battery Chargers (Early Analogue) | 20 | 24 | 30 |
| | Battery Chargers (Digital Control) | 10 | 15 | 20 |

Figure 5 – Protection and Control System assets

# 5 Communication Assets

These assets include the communications systems at the terminal stations and remote communication sites; the associated copper and optical fibre cable links, optical ground wire, communications switchboards and associated monitoring and management systems.

Communications assets generally have a shorter life than protection and control assets using similar technology due to the increasing demands placed on the communications system, changes in regulations and codes and the rapid technological changes.

Assessments were performed for each of the different technologies used for an asset type where the lives are significantly different. For example PLC's were broken down to valve based PLC's as they have achieved longer lives than the expected to be achieved from their digital PLC replacement due to rapid technical obsolesce of modern digital equipment.

| Asset Category | Asset Type | Earliest | Expected | Latest |
|---|---|---|---|---|
| Equipment | Analogue Channel Equipment and associated frames | 5 | 9 | 10 |
| | Digital (SDH & PDH) Multiplex, Channel equipment and associated frames | 6 | 10 | 11 |
| | Digital (DSL) Metallic Line Equipment | 7 | 11 | 12 |
| | Optical (SDH & PDH) Line Equipment (Terminal, repeater & Amplifiers) | 5 | 9 | 10 |
| | New Power Line Carrier | 11 | 15 | 16 |
| | Radio & Antenna Equipment and Associated Feeder Equipment | 6 | 10 | 11[5] |
| | Telephone Exchange Equipment | 6 | 10 | 11 |
| Cables | Underground Metallic | 24 | 35 | 40 |
| | Underground Optical Cable | 29 | 35 | 40 |
| | Optical ADSS Cable | 12 | 18 | 20 |
| | OPGW Cable | 27 | 35 | 40 |
| Remote Site | Towers | 60 | 70 | 85 |
| | Establishment | 40 | 45 | 50 |

Figure 6 – Communication assets

# 6 Strategies

- Embed assets technical Useful Lives in the asset management system against the Equipment Group Identifier (EGI)
- Specify estimated unit replacement costs (P50) for all assets in the asset management system against the Equipment Group Identifier (EGI)

For more detailed useful life and unit replacement cost information please see: Technical Useful Lives - V1.xls

[5] Based on risk of re-allocation of radio frequency spectrum by regulatory authorities

# 7 Appendix 1: Asset Lives And Drivers

The various asset lives that are considered when evaluating the life of an asset are defined below:

- **Design Life:** The life expected to be achieved taking into account the design, materials and manufacture of the asset.
- **Technical Life:** This is the physical life of the asset and this may differ from the design life. It is the life that the asset may reasonably be expected to achieve while still providing an acceptable level of performance.
- **Commercial Life:** The period of time that the asset is sold and marketed by the manufacturer in an un-superseded form.
- **Financial Life:** The life assigned to an asset for the purpose of determining the depreciation of the financial value of a company asset.
- **Economic Life:** The life of an asset at which the asset is no longer able to generate value to the business because of changes in its commercial and economic environment. The economic life can be longer than the technical life if it is possible to economically to extend its life.

The following factors are considered to see how they may shorten or lengthen the life of the asset concerned. This is not an exhaustive list and the impact of these factors will have different weighting depending on the asset concerned.

- **Associated technology changes:** Technological advancement in the marketplace may render the product/system obsolete – i.e. the function of the installed device may be able to be achieved by a more attractive technological solution.
- **Associated changes in functional requirements:** The user requirements may change over time and not be able to be fulfilled by the existing product/system.
- **Market influences:** The life of an asset is impacted by market forces; including changes in supply and demand, pricing, industry standards and legislation and third party influences.
- **Maintainability:** The ability to maintain the product/system in acceptable working order and at an economic cost – includes O & M cost, skills retention etc.
- **Manufacturer support:** The ability of the manufacturer to continue to support the product/system in the marketplace.
- **Compatibility:** The extent to which the installed products/systems remain compatible with other equipment being introduced.
- **Experienced performance:** The “in service” performance of the product/system impacts the user and thus the life of the asset.
- **Environmental/Operational stresses:** Asset life can be affected by operational and environmental conditions. For example, equipment operating in higher temperature or with higher operational duty has a shorter effective life.
- **Legislation, Codes, Licence, Regulatory and Standard changes:** The life of an asset can be severely impacted by changes in government and other external agency requirements.