20 March 2017

Rainer Korte
Executive Manager
Asset Management
ElectraNet Pty Ltd

Our ref: 0911288
Your ref:

RE: ElectraNet synchronous condenser asset life review

Dear Rainer

GHD has been engaged by ElectraNet to provide advice regarding the appropriate standard life for synchronous condensers to support efficient asset management decisions and the development of capital expenditure proposals and budgets that reflect the economic life of these assets for the purposes of ElectraNet's forthcoming revenue determination which will take effect on 1 July 2018.

The scope of assets to be assessed is limited to synchronous condenser equipment, and excludes any civil infrastructure, such as support structures and buildings.

The key issues considered in assessing an appropriate asset life include:

- Equipment manufacturer advice and recommendations on design life
- Synchronous condenser asset lives adopted by other Australian and international electricity utilities
- Australian Taxation Office current ruling on effective life of depreciating assets
- Obsolescence of equipment and implications for the availability of maintenance support from vendors
- Publicly available data from other industry sectors on synchronous condenser replacement cycles

1 Introduction

The transmission network in South Australia is experiencing a significant increase in the volume of connection of low inertia generation development which have displaced traditional synchronous generators.

Traditional generators, due to their rotating mass, provide inertia to the power system which allows the transmission network to operate in a secure manner. In recent years, transmission networks are experiencing a change in this inertia component compounded by:

- Changes in generation mix being connected including renewable generation (solar, wind and behind the meter rooftop solar PV)
- A decrease in conventional generation (either being shut down or having a reduced utilization)

The transmission network in South Australia is a relatively long distributed network, with areas of low short circuit ratio where the connection of generators poses a potential risk to power system security. This is due to minor power system faults potentially causing the tripping of generators, and therefore the power system becoming insecure.

To address these issues, Network Service Providers (NSP's) have typically managed power system security by installing dynamic reactive plant including synchronous condensers or constraining the operation of generators.

Synchronous condensers are used by network service providers where the electrical network requires support to manage:

- Reactive compensation
- Voltage support
- System inertia
- Low short circuit ratios

2 Assets included in review

Synchronous condensers comprise a number of major equipment components. These include:

- Main rotating plant, such as rotating exciters
- Secondary systems

These components can be replaced over a period of time and are subject to replacement/refurbishment cycles.

This review excludes consideration of site infrastructure asset groups which include but are not limited to buildings or enclosures.

3 National Electricity Rules

Clause 6A.6.3 (b)(1) of the National Electricity Rules[1] discusses the calculation of depreciation of transmission network assets, and states that the depreciation schedules "*… must depreciate using a profile that reflects that nature of the assets or category of assets over the economic life of that asset or category of assets.*"

An electricity transmission utility may adopt the manufacturer's design life or the expected economic life of the assets for depreciation purposes, where the design life or the expected economic life of the asset may reflect the minimum life that most of the assets are expected to remain in service.

[1] http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules Version 88, January 2017

4 Recent AER decisions

In its draft decision[2] for Powerlink, the Australian Energy Regulator (AER) stated "*… the same asset types should have the same standard asset life applied across TNSPs, taking into account any environmental or operational factors that may impact on the expected useful life of the asset*"[3]

Table 1 summarises the current regulatory depreciation schedules for electronic secondary system assets for selected electricity transmission utilities, based on information from recent regulatory decisions.

Table 1 Comparison of secondary system asset lives

Utility	Assets	Standard Asset Life (years)	Comments
ElectraNet	Substation secondary systems - electronic	15	Existing asset category
AusNet Services	Secondary systems	15	Accepted in AER draft decision Jul 2016
Powerlink	Substations secondary systems	15	Accepted in AER draft decision Sep 2016
TasNetworks	Protection & Control – short life	15	Accepted in AER draft decision Nov 2014
TransGrid	Secondary systems	15	Accepted in AER draft decision Nov 2014

For the purposes of this review, we are satisfied that adopting a 15-year asset life for the secondary systems for synchronous condensers is consistent with other Australian electricity transmission utilities.

There are no common asset categories across the electricity transmission utilities for reactive plant. AusNet Services has a specific broad asset category for reactive plant, which includes synchronous condensers, capacitor banks and Static VAR Compensators, to which they have assigned a 40-year asset life. This was accepted by the AER in their draft decision of July 2016.[4]

2 AER, *Draft Decision Powerlink transmission determination 2017-18 to 2021-22: Attachment 5 – Regulatory depreciation*, September 2016

3 Ibid., section 5.4.1, p. 12

4 AER, *Draft Decision AusNet Services transmission determination 2017-18 to 2021-22: Attachment 5 – Regulatory depreciation*, July 2016, section 5.4.2, table 5.4, p. 30

5 Taxation rulings

The current taxation ruling TR2016/1[5] from the Australian Taxation Office (ATO), effective 1 July 2016, represents the view of the ATO concerning the effective life of depreciating assets. This ruling discusses the methodology used by the Commissioner of Taxation in determining the effective asset life for calculating depreciation in accordance with the provisions of the *Income Tax Assessment Act 1997*.

The ATO has determined the effective life of a depreciating asset by estimating the period it can be used by an entity for a taxable purpose or for producing income:

- assuming it will be subject to wear and tear at a rate that is reasonable for the Commissioner to assume
- assuming it will be maintained in reasonably good order and condition
- having regard to the period within which it is likely to be scrapped, sold for no more than scrap or abandoned

The factors used in consideration of the effective lives include:

- physical life of asset
- engineering information
- manufacturer's specifications
- industry use of the asset
- use of asset by different industries
- level of repairs and maintenance
- industry standards
- experience of users of the asset
- retention periods
- obsolescence
- scrapping or abandonment practices
- leasing periods (where applicable)
- economic analysis of useful period
- conditions in any secondary trading market

Table 2 summarises a selection of the published effective lives for power generation assets that are similar to equipment associated with synchronous condensers.[6]

Table 2 ATO power generation asset depreciation schedule

Category	Sub-category	Asset	Effective Life (years)
Power generators	Co-generation	Gas turbine generators	30
		Steam turbine generators	30
		Control & monitoring systems	15
		Miscellaneous assets	30
	Combined cycle	Gas turbine generators	30
		Steam turbine generators	30
		Control & monitoring systems	15
		Miscellaneous assets	30

[5] ATO, *TR2016/1 Taxation Ruling Income tax: effective life of depreciating assets*, 29 June 2016

[6] Ibid., asset categories 26110 to 26400, pp. 164-8

Category	Sub-category	Asset	Effective Life (years)
Power generators	Gas turbine	Gas turbine generators	30
		Control & monitoring systems	15
		Miscellaneous assets	30
	Thermal	Steam generators	30
		Steam turbine generators	30
		Control & monitoring systems	15
		Miscellaneous assets	30

5.1.1 Main rotating plant

Fundamentally, a synchronous condenser is a synchronous generator operating without the shaft being connected to any other plant, but spinning freely. It supports network voltage by providing reactive power compensation and additional short circuit power capacity.

Whilst the ATO does not specifically include synchronous condensers as an asset type, it does assign effective economic lives to power generation primary assets, including steam/gas turbine generators. We consider steam turbine generators as being the closest representative asset type to synchronous condenser main rotating plant. These assets have an effective life of 30 years, and therefore we consider that this ruling implies that the effective economic life for rotating plant similar to synchronous condensers has a 30-year effective life.

5.1.2 Secondary systems

The depreciation schedule in Table 2 shows control and monitoring systems associated with power generation assets have an effective economic life of 15 years.

Under the Electricity supply section, the ATO nominates an effective life of 12½ years for a broad asset category defined as “control, monitoring, communications and protection systems”.[7] We consider that this is an average effective life, given that telecommunication assets within this ruling predominately have an effective life of 10 years, and secondary and protection systems typically have a 15-year effective life.

For the purposes of this review, we have relied upon this taxation ruling as an indicative guide to support our assessment of a 15-year asset life for the secondary systems.

6 Industry experience

6.1 AusNet Services

There were previously three synchronous condensers on the Victorian transmission network located at Brooklyn, Fishermans Bend and Templestowe Terminal Stations which were built during the 1960s.

[7] Asset categories 26110 to 26400, p. 167

These synchronous condensers were considered to have a technical life[8] of between 40 and 50 years, with major refurbishments required after 20-25 years.

AusNet Services and AEMO agreed in October 2016 that it was prudent to retire, rather than replace, these three synchronous condensers on the transmission network. These assets were in extremely poor condition and studies confirmed that their replacement would not have provided a net market benefit.

Since the agreement to retire the synchronous condensers, all three units have failed due to their poor condition. Given that the synchronous condensers were due to be retired by 1 April 2017, AusNet Services and AEMO agreed that it was not efficient to repair and return the synchronous condensers into service.

Whilst the synchronous condensers were in-service for approximately 50-60 years, AusNet Services was required to undertake periodic major refurbishments to achieve this operational life, and noted in its 2007 Asset Management Strategy that the synchronous condensers were not achieving their annual availability targets due to their poor condition and on-going refurbishment requirements.[9]

6.2 Transpower

Transpower has 10 synchronous condensers in operation. Eight of the synchronous condensers have been assessed as being necessary for the continued secure operation of the New Zealand power system and principally the HVDC between the North and South Islands.

The fleet of synchronous condensers was installed between 1955 and 1965 and are expected to remain in service until 2035. Therefore, these units will have had an in-service life of 70-80 years before they are planned to be decommissioned.[10] However, to achieve this in-service life, all of the synchronous condensers required major refurbishment expenditure in the 1990s, including new stator windings and re-insulated rotor coils, new cooling systems and a complete replacement of gas management and monitoring equipment. This implies that the assets have an effective asset life of approximately 30 years before major works are required to extend their in-service life or achieve planned economic life.

For the New Zealand electricity transmission network, no alternative was identified which could provide the network support similar to the current synchronous condensers which would allow the HVDC link to continue to operate. This includes when the upgrade to the HVDC interconnector was recently carried out. System redundancies allow for the loss of a synchronous condenser with only a minor impact on power system capability. Transpower has considered that the synchronous condensers cannot be replaced by another reactive plant device and have chosen to keep them in service.

There is a comprehensive maintenance plan established for each of the major components. Due to the differences in the types of machines there are differences in maintenance approaches including maintenance regime and spare holdings. Each of the synchronous condensers has incurred another major refurbishment as recently as 2011/12.

---

[8] SP AusNet, *Asset Management Strategy 2008-09 to 2013-14*, February 2007, section 7.6, p. 70

[9] Ibid.

[10] Transpower, *ACS Reactive Power Fleet Strategy*, document no. TP.FS 32.01, October 2013, p. 12

Spare parts have been retained from the replacement and upgrades for use on the other synchronous condensers if and when required. However, due to the rarity of failure, only a few spares have been found necessary to hold.

This included the replacement of:

- re-insulation of windings
- cooling towers
- control systems

6.3 Equipment manufacturer/supplier

ABB offers module-based synchronous condenser packages, with the active components customised to suit project-specific requirements. These modules include all of the equipment to be complete units, such as condenser cooling, lube oil supply, auxiliary power distribution, and control equipment. In their product brochure[11], ABB notes that "*… some synchronous motors and generators … are still in operation after 40 years.*"

In a related document[12], ABB discusses the maintenance program for high-voltage machines, based on operational data, inspections and maintenance levels previously completed. In the recommended maintenance program for high-voltage machines, ABB suggests that a major refurbishment to restore the machine to a reliable operating condition is conducted at 50% of the estimated lifetime of the asset, or after approximately 12 years in service. This implies an effective operational life of 24 years, which is consistent with anecdotal evidence received from ABB that the asset life of their synchronous condensers is considered to be 25-30 years.

6.4 Maintenance requirements

With regards to the maintenance requirements for synchronous condensers, these devices have a similar type of high-voltage insulation as a HV generator or power transformer, and as such will likely incur the same level of degradation in this thermal insulation over time as a power transformer. Based on maintenance data available to ElectraNet, this suggests an estimated/indicative life of 30 years.

In addition, the cooling system for a synchronous condenser is not as thermally efficient as a power transformer forced cooling system and has the potential for higher thermal stresses and hot spots; and a synchronous condenser will be subjected to high mechanical stresses due to vibration for rotating components, potentially accelerating the degradation of the insulation.

Using the standard asset life for power transformers of 45 years nominated by ElectraNet as a guide, it is reasonable to expect that synchronous condensers would have a shorter asset life due to its operating conditions, and given it is rotating plant as opposed to static plant.

---

11 ABB, *Product note: Synchronous condensers for voltage support in AC systems*, March 2013

12 ABB, *Maintenance of High Voltage Machines: Four level maintenance program*

7 Recommendation

Synchronous condensers are large rotating machines that provide highly flexible reactive power for voltage control and dynamic support for the transmission system, and have a wide range of ancillary equipment to start, stop, control, monitor, and protect the operation of the machine. Therefore, the asset lives applied to this equipment should separately recognise the major rotating plant and the associated control systems.

Given the limited use of synchronous condensers in Australian transmission networks, there is no common asset life for the major rotating component of synchronous condensers that has been adopted in recent AER regulatory decisions for electricity transmission utilities. However, there is a consistent use of 15 years as the asset life for control and monitoring equipment.

Recent depreciation schedules published by the ATO allocate asset lives to power generation assets, without specifically addressing synchronous condensers. The taxation ruling allocated 30-year asset lives to rotating plant that is similar to synchronous condensers, and 15 years to control and monitoring systems.

Advice from ABB suggested that their synchronous condensers were considered to have an asset life of 25-30 years, with some of their machines having achieved 40 years' in-service. This advice is consistent with maintenance experience from ElectraNet with regards to the degradation of thermal insulation in related assets, with an indicative asset life of 30 years being considered appropriate.

In-service experience for AusNet Services in Victoria and Transpower in New Zealand shows that extended operational life for synchronous condensers requires major refurbishment work after approximately 25-30 years in service, and that the ongoing maintenance requirements for the rotating plant are expensive and extensive, including the replacement of major components such as rotors, insulation, cooling systems and control equipment.

Therefore, it is our view that the standard asset life for the main rotating plant component of a synchronous condenser should be 30 years, and 15 years for secondary systems associated with synchronous condensers, recognising manufacturer/supplier advice, the field experience of electricity transmission utilities and current industry standards.

Regards

GHD Pty Ltd

David Bones
Executive Manager
07 3316 3979

cc Brad Parker
Network Planning Manager

Colleen Luck
Business Development Advisor / Bushfire Liaison Coordinator