GHD
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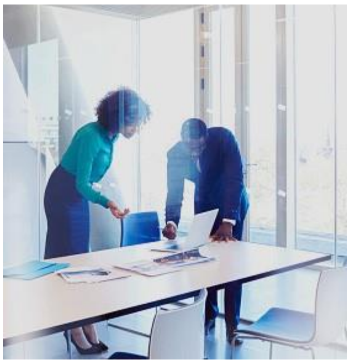


Economic life for ElectraNet synchronous condensers

ElectraNet

28 June 2019

Contents

Figures

Tables

Appendices

1. Scope

ElectraNet is an electricity transmission company in South Australia. It transports electricity locally and interstate over a transmission network which covers an area over 200,000 square kilometres. It also operates and maintains high-voltage substations. ElectraNet is subject to economic regulation via the Australian Energy Regulator (AER).

ElectraNet is preparing to submit an application to the AER for a contingent project for the reinforcement of main grid system strength through the installation of synchronous condensers. ElectraNet engaged GHD Advisory to assist in evaluating the appropriate economic life to apply to these synchronous condenser assets for regulatory depreciation purposes.

We previously provided advice to ElectraNet in March 2017 regarding the appropriate asset life to apply for the primary and secondary components of a synchronous condenser. We found that it was appropriate to apply an asset life of 30 years for the rotating component of a synchronous condenser and 15 years for the secondary systems. In its Draft Decision, the AER accepted the existing 15-year standard asset life applied by ElectraNet for secondary systems, but raised concerns about whether the 30-year life proposed for the primary component reflected the economic life for these assets.

ElectraNet has engaged us to provide further advice on the appropriate life for synchronous condenser assets in light of additional information that is now available on the nature and operation of the assets to be installed. Our review has been limited to the primary component only. This report considers:

- Advice from manufacturer(s) regarding typical economic life for synchronous condenser equipment
- Review of information related to the maintenance of synchronous condensers currently in-service
- Review of Ofgem Project Phoenix and its relevance to the ElectraNet contingent project
- Addressing points raised by the AER in its Draft Decision and subsequent advice

2. Background

The South Australian electricity transmission network has experienced a significant increase in the installed non-synchronous generation capacity which has resulted in the displacement of traditional synchronous generators. To support the security of power supply, traditional synchronous generating systems provide both system strength and inertia through their excitation systems and rotating mass synchronised to the frequency of the power system. Increases in the generation mix from non-synchronous generators and a corresponding decrease in conventional generation have led to reductions in the overall system strength and inertia component provided by traditional generating systems.

As the transmission network in South Australia is characterised by a long-distributed network with areas of low system strength, the connection of non-synchronous generators results in a potential risk to power supply security. This is primarily driven by the risk of power system disburbances potentially tripping the generators. Network Service Providers (NSPs) have typically managed security issues through investments in dynamic equipment, such as SVCs, STATCOMS and synchronous condensers. Synchronous condensers are used by network service providers where the electrical network requires support to manage:

- Low system strength
- System Inertia
- Reactive compensation
- Voltage support

SVCs and STATCOMS only provide reactive compensation and voltage support. Synchronous condensers are comprised of two key components:

1. Primary component, comprising the main stator winding, rotating part, excitation, cooling, lubrication and other balance of plant systems
2. Secondary components, comprising control, protection and monitoring systems.

We understand ElectraNet is delivering a Main Grid System Strength Project, which involves the installation of four high inertia synchronous condensers to address the system strength gap declared by AEMO in South Australia. The units proposed by ElectraNet each include a flywheel to provide increased inertia to satisfy the synchronous inertia shortfall declared by AEMO in South Australia.

The economic evaluation ElectraNet has undertaken showed that installing synchronous condensers is the most efficient and least cost solution in reinforcing system strength and synchronous inertia in the short to medium term.

ElectraNet engaged GHD Advisory to assist in evaluating the appropriate economic life to apply to synchronous condenser assets for regulatory depreciation purposes. We previously provided advice to ElectraNet regarding the appropriate asset life to apply for the primary and secondary components of a synchronous condenser. We found that it was appropriate to apply an asset life of 30 years for the primary components of a synchronous condenser and 15 years for the secondary systems. In its Draft Decision, the AER accepted the 15-year life for secondary systems, but raised concerns about whether the 30-year life for the primary component reflected the economic life for these assets.

ElectraNet has engaged us to provide further advice on the appropriate life for the four proposed synchronous condensers based on more recent information. Our review has been limited to the synchronous condenser primary plant only. We understand that this advice will be used to support a contingent project application to the AER.

2.1 Report content

This report considers the issues raised in the AER's Draft Decision regarding the appropriate economic asset life to apply to the primary component of synchronous condensers. In developing our response, we have considered:

- Advice from manufacturer(s) regarding typical operating life for synchronous condenser equipment
- Review of information related to the maintenance of synchronous condensers currently in-service
- Review of relevant international and industry literature regarding the economic evaluation of refurbishment /replacement decisions for large power plant generators/synchronous generators
- Review of Ofgem Project Phoenix and its relevance to the ElectraNet contingent project.

Where we considered it appropriate, we have included extracts from our previous 2017 advice to support and/or complete our analysis.

This report is structured as follows:

- Section 3 - discussion of the depreciation of transmission assets, including different asset lives and the factors that may impact
- Section 4 - analysis of the ATO depreciation schedule and industry examples of synchronous condenser performance and forecast deployment
- Section 5 - addressing issues raised by the AER regarding particular factors and their potential impact on the economic life
- Section 6 - our recommendations

We understand that this report may be used as part of a broader submission to the AER by ElectraNet as part of its contingent project application. Although some of the arguments advanced in this report may be relevant to the asset lives for synchronous condensers owned by other transmission businesses, our conclusions are based on information that is specific to ElectraNet, the particular plant specification, and the operating environment within which it is expected to operate. This report should not be used to draw conclusions on the appropriateness of asset lives at other infrastructure facilities.

2.2 Disclaimer

This report has been prepared by GHD for ElectraNet and may only be used and relied on by ElectraNet for the purpose agreed between GHD and ElectraNet as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than ElectraNet arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer sections 3 and 4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by ElectraNet and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

3. Depreciation of transmission assets

3.1 Regulatory depreciation of electricity assets

‘Building block’ models are used by Australian regulators to calculate an appropriate annual revenue requirement (ARR) for regulated businesses. ‘Building block’ models determine an ARR that reflects the sum of the underlying cost components faced by a regulated business in providing the regulated service. These cost components reflect an allowance for the return on capital, the return of capital (depreciation), operating expenditure and other cost items, such as taxation or incentive allowances.

The regulatory depreciation allowance enables Australian electricity transmission businesses to recover the upfront investment in transmission assets over their economic life. Regulatory depreciation is calculated by reference to the value of assets which comprise the regulated asset base (RAB), the capital recovery profile of those assets (such as straight line depreciation) and the economic lives of the assets used to provide the transmission service.

3.2 Asset lives

The assumed capital recovery program and the adopted life of the assets that comprise the RAB are important features of the regulatory depreciation allowance. The capital recovery program reflects the time period an asset is expected to efficiently and reliably provide the service for which it was designed. Asset lives also contribute towards the development of appropriate and prudent asset maintenance and replacement regimes, impacting operating and capital expenditure forecasts over a regulatory control period.

The asset lives adopted for regulatory depreciation purposes are important to ensure the regulatory regime promotes:

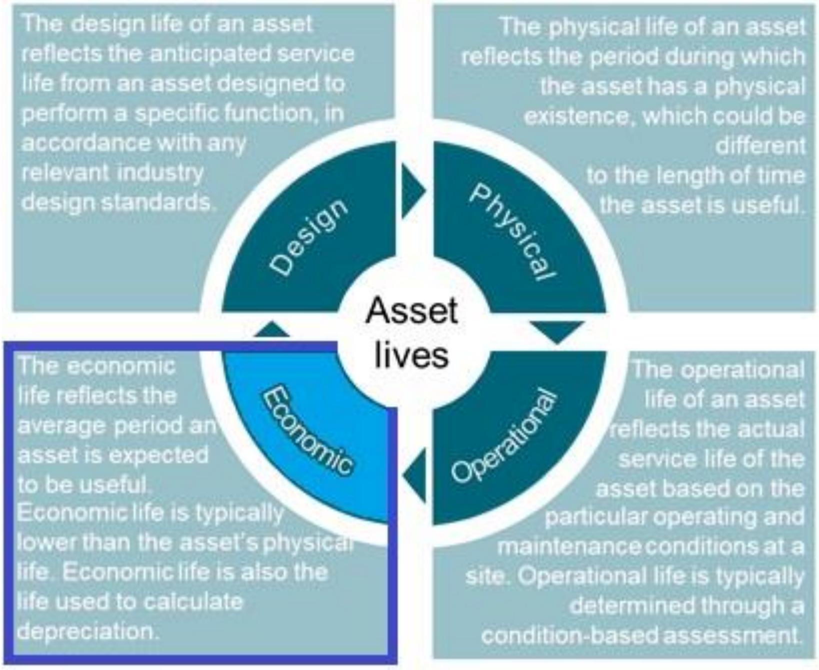
- the efficient, or least-cost, delivery of the service at a given service standard
- an incentive for efficient investment by the regulated business to incentivise the necessary investments to ensure long-run service delivery at a given service standard
- efficient, cost-reflective pricing to benefit customers

The adopted asset life can be determined by design, operational, economic or expected reliability methods.

The adopted asset life may also be developed having regard to statutory obligations, such as prescribed approaches under the National Electricity Rules or by reference to taxation requirements.

Figure 1 illustrates distinct different definitions for asset lives. They are often used interchangeably, but they are very different, and this can lead to misinterpretation and incorrect use of asset life data.

Figure 1 Asset lives[1]



The design life of an asset reflects the anticipated service life from an asset designed to perform a specific function, in accordance with any relevant industry design standards.

The physical life of an asset reflects the period during which the asset has a physical existence, which could be different to the length of time the asset is useful.

The economic life reflects the average period an asset is expected to be useful. Economic life is typically lower than the asset's physical life. Economic life is also the life used to calculate depreciation.

The operational life of an asset reflects the actual service life of the asset based on the particular operating and maintenance conditions at a site. Operational life is typically determined through a condition-based assessment.

3.2.1 Design life

The design life of an asset is the typical anticipated service life expected from an asset designed to meet a specific duty (example rated loading) under nominal operating conditions according to industry design standards, adopted ISO standards, Australian Standards or any other appropriate design code for the operation of the asset.

It is important to note that the design life represents an expected life of the asset without premature failure. Some individual assets will last much longer than the expected design life and others will fail prematurely. It is not uncommon therefore to have “over-age” assets included in any portfolio of assets. However, the relative quantity of “over-age” assets needs to be monitored and controlled to manage the risk that these assets pose. Design life does not contemplate any major capital refurbishment for life extension.

The engineering design will establish specifications that are designed to allow the asset to withstand, without failure, the most severe conditions likely to occur during the asset’s service. Factors which influence the design life include:

- ambient effects - moisture, pollution levels and other local contaminants
- operating pressures and temperatures
- dynamic effects
- cyclic loading
- number of operations
- thermal effects

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[1] Source: GHD Advisory

3.2.2 Physical life

An asset can be used while it continues to have a physical life, that is, until it is physically exhausted.

An effective life determination is an estimate of the period the asset can be used by any entity for a specified purpose. Often an asset is not used for a specified purpose for the whole of its physical life. For example, an asset may be retired from use for a specified purpose but be retained as a source of spare parts. In this instance, the effective life ends when the asset is retired.

An asset's physical life can be seen as the outer limit of its effective life. This is a useful starting point for analysing the factors to be considered in determining the effective life of the asset.

3.2.3 Operational life

The operating life (sometimes referred to as technical life) of an asset reflects the actual service life achieved by the asset which could vary depending on the period over which the asset is useful to its owner. It is typically determined through a condition-based approach. The operating life of an asset is sensitive to environmental factors, maintenance strategies and operating practices, and other factors such as shocks that may result in deterioration. Where the asset operates in an unfavourable environment, the rate of asset deterioration may increase, reducing its operating life. Maintenance and major refurbishment activities (both capex and opex) can be used to extend operating life. The actual operating life for particular assets in a population will vary from near zero (due to early life failures) to the maximum life (usually due to replacement).

3.2.4 Economic life

An asset's economic life reflects the period of usefulness of an asset to its owner. The economic life is used to calculate depreciation. In the electricity sector, the expected operating life of an asset prior to major refurbishment is the key consideration in determining the economic life of an asset that is appropriate for regulatory depreciation purposes. The economic life can therefore can be different to the actual physical, or the expected design or the operating life of an asset.

3.2.5 Statutory obligations and recent regulatory precedent

Clause 6A.6.3(b)(1) of the National Electricity Rules stipulates that asset depreciation schedules must "… *depreciate using a profile that reflects the nature of the assets, or category of assets, over the economic life of that asset, or category of assets*".[2] Hence, ElectraNet has a statutory obligation to depreciate all assets over the economic life of those assets.

The AER has indicated that it considers transmission network service providers should apply the same standard life across the same asset types, having regard to the environmental or operational factors that may affect the expected useful life of those assets.[3,4] Hence, it has indicated a preference to adjust the economic life of an asset by relevant technical considerations that may impact the expected economic life.

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[2] Clause 6A.6.3(b)(1) of the National Electricity Rules, available at: https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules/current

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

[4] Ibid., section 5.4.1, p. 12

3.2.6 Taxation rulings

The current Australian Taxation Office (ATO) ruling TR2018/4[5] (effective 1 July 2018) outlines the ATO's view regarding the appropriate life to adopt for asset depreciation purposes. The ruling sets out the methodology to calculate depreciation in accordance with the *Income Tax Assessment Act 1997*.

Clause 21 of the taxation ruling states that the ATO Commissioner "*… makes a determination of the effective life of a depreciating asset by estimating the period (in years, including fractions of years) the asset can be used by an entity for a specified purpose. If relevant for the asset, the Commissioner:*

(a) assumes it will be subject to wear and tear at a rate that is reasonable for the Commissioner to assume

(b) assumes it will be maintained in reasonably good order and condition; and

(c) *has regard to the period within which it is likely to be scrapped, sold for no more than scrap value or abandoned.*"[6]

The ATO considers a range of factors necessary to consider when determining the effective life of an asset. These factors include:

- the physical life of the asset and engineering information
- manufacturer's specifications and engineering information
- use of the asset by the relevant industry and related industries
- maintenance and repairs schedule
- obsolescence
- scrapping practices

Clause 27 of the taxation ruling notes that with regards to the manufacturing specifications and engineering information relevant to the consideration for an asset's effective life "*… the effective life of a new asset cannot be based solely on evidence of past use of the asset. The current design may differ for various reasons including advances in technology and different construction materials. Analysing manufacturing specifications and engineering information for the new asset is important when estimating its effective life.*"[7]

We have included consideration of the ATO taxation ruling as a supporting document, rather than a directive, and the proposed asset lives as indicative. However, we note that the definitions included in clauses 21 and 27 and we consider these suggest:

- Clause 21 relates the "effective life of a depreciating asset" with the period that an entity may make use of the asset for a specified purpose. We believe this suggests a link between the ATO's interpretation of effective life with the concept of economic life (as defined in section 3.2.4).
- Clause 27 highlights that consideration of any particular asset specification should be given to determining an effective life, rather than relying on broader and historic asset lives for assets in the same asset category.

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[5] ATO, *TR2018/4 Taxation Ruling Income tax: effective life of depreciating assets*, 27 June 2018

[6] ATO, *TR2018/4 Taxation Ruling Income tax: effective life of depreciating assets*, 27 June 2018, clause 21, p. 6

[7] Ibid., clause 27, p. 7

3.3 Factors relevant to determining synchronous condenser asset lives

We understand from manufacturers that synchronous condensers are designed in a similar way to synchronous generators, and as such the factors that will impact the asset life for a synchronous condenser will be similar to those for generators.

As the reliability of large generators is very high, many users expect at least 30 years of service from most major generator components, and life extensions can often be achieved below the equipment replacement costs.

The following are key parameters[8] to be considered in the management of synchronous condensers, so as to balance the cost of managing the assets against the risk of service level reduction such as reducing costs through avoidance or deferral of essential maintenance. These cover technical, operational, economic, and environmental factors and include:

- Risk management and financial models
- Operational impacts
- Major component risk areas

3.3.1 Risk management

This parameter requires an assessment of the risk associated with delaying investment. This typically takes one of two forms:

- Adjusting the nominal technical life for assets where the associated average anticipated risk is acceptable
- Identifying the components that need increased condition monitoring or other actions to be within an acceptable level of risk. This approach requires an assessment of the criticality of the asset based on a number of key inputs such as safety of people and the electrical system, potential environmental impacts in the event of failure, condition of the asset, any risks associated with the asset technology, and operating conditions (no. of start/stop operations, electrical environment, load factor)

3.3.2 Operational impacts

The life expectancy of a given machine will be normally greater when the machine is operated at constant load conditions rather than when the machine is subject to frequent load cycles or start/stop cycles. The change in centrifugal force-induced stresses from standstill to rated speed (or potentially over-speed) occurring over many cycles may cause fatigue and cracking in some metallic and insulating components depending upon the specific design.

Load cycling represents a long-term onerous mode of operation. When load is increased suddenly, the conductors will rise in temperature faster than core and other components and this will induce thermo-mechanical stresses within the stator winding which can affect the reliability of the machine.

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[8] CIGRE, *Guide on Economic Evaluation of Refurbishment/Replacement Decisions on Generators*, Working Group A1.05, December 2015

In addition, abnormal operating conditions can impact on the asset life including:

- loss of synchronism
- abnormal frequencies
- unbalanced currents due to unbalanced loads or unbalanced system faults or harmonics
- extreme emergency conditions with large disturbances in voltage, current, power flow and frequency

3.3.3 Major component risk areas

Most failures result from the gradual deterioration of components, until they no longer have the electrical and/or mechanical strength to withstand normal operating stresses or the transients occurring during abnormal regimes. However, some generator failures occur regardless of the original condition, monitoring activities or maintenance standards.

The major components are:

- stator winding - thermal deterioration caused by operation incidents or cooling issues, poor electrical connections, vibration
- stator core - shorting in insulation
- bushings - particularly due to continuous mechanical forces due to vibration and thermal expansion/contraction of leads
- casings
- rotor winding - thermal deterioration through mechanical forces during operation, thermal (load) cycling
- cooling systems

4. Analysis

4.1 Overview of approach

Our analysis considers the appropriate life to apply to synchronous condensers, having regard to the asset strategies and risk assessments undertaken by ElectraNet. In performing this analysis, we have undertaken an independent assessment from an asset management and engineering perspective considering the evaluation of an appropriate economic life for regulatory depreciation purposes for capital expenditure of ElectraNet's synchronous condensers.

In assessing depreciation life, GHD considers what would be the expected average survival of a fleet of similar synchronous condenser assets (combined with flywheels) and with a similar operating environment. We have used information provided to us by ElectraNet and other industry data available to GHD and publicly available information.

4.2 AER industry practice note for asset replacement

The AER has published an industry application note[9] following an Australian Energy Market Commission (AEMC) rule determination on 18 July 2017 regarding replacement expenditure planning arrangements.[10] This application note was developed "*… in response to NSP requests for clarity on how they might apply the NER*[11] *requirements to their replacement expenditure planning of network assets.*"[12]

To support the application note, the AER specified definitions for specific terms as these relate to asset replacement. Table 1 shows a selection of these definitions for terms that we consider are directly related to our assessment of economic life for the ElectraNet synchronous condensers.

Table 1 AER definitions[13]

Term	Definition
Asset refurbishment	Expenditure to extend the engineering life expectancy of an asset (but not increase its functionality) by replacing or repairing parts of an asset rather than the whole. These activities are generally capex as they extend the productive life of an asset, but could also be opex depending on the work performed and relevant accounting practices.
Asset retirement	Removing an asset or part of a fleet of assets from service
Economic life	When the total cost of providing the required service from the asset no longer represents the lowest long run cost to consumers of providing that service (i.e. after considering alternatives)
Technical life	Typical expected life of an asset before it fails in service under normal operating conditions. The technical life may differ between businesses (due to different operation environment factors) and between asset classes.

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[9] AER, *Industry practice application note - Asset replacement planning*, reference 63054 - D19/2978, January 2019

[10] AEMC, Rule determination: *National Electricity Amendment (Replacement expenditure planning arrangements) Rule 2017,* July 2017

[11] National Electricity Rules

[12] AER, *Industry practice application note - Asset replacement planning*, reference 63054 - D19/2978, January 2019, section 1.1, p. 1

[13] Ibid., section 1.5, Table 1, pp. 5-8

As such, we consider the AER definition of economic life in Table 1, which focuses on service to the customer, does not differentiate between initial capital expenditure for the acquisition and construction of the asset, and any subsequent major refurbishment capex that may extend the operational life of the asset. Consequently, we consider this definition is more appropriate to determining a suitable life for replacement or retirement of the asset, as opposed to nominating a regulatory economic life for the initial capital expenditure (refer section 3.2.4).

4.3 ATO effective lives for power generation assets

As an extract from our previous advice (refer Appendix A), Table 2 summarises a selection of the published effective lives for power generation assets that are similar to equipment associated with synchronous condensers. It is recognised that this ATO schedule is applicable to taxation depreciation, and we have included this information in our assessment as an indicative guide only.

Table 2 ATO power generation asset depreciation schedule[14]

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
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

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[14] ATO, *TR2018/4 Taxation Ruling Income tax: effective life of depreciating assets*, 27 June 2018, asset categories 26110 to 26400, pp. 176-180

Fundamentally, a synchronous condenser is a synchronous generator operating without the shaft being connected to any other plant, but spinning freely. It supports network by providing system strength (fault contribution), inertia, voltage support and reactive power compensation.

Whilst the ATO does not specifically include synchronous condensers as an asset type, it does assign effective 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, particularly with the additional complexity of a flywheel attached to the condenser rotor shaft. These assets have a nominated ATO depreciation life of 30 years, and therefore we consider that this taxation ruling implies that the effective life for rotating plant similar to synchronous condensers has a 30-year effective life.

It is important to note that operational environments in which most synchronous generators operate are less onerous than stream turbine generators, and the criticality to system security are less than those that will be applicable to the synchronous condensers to be deployed by ElectraNet. Furthermore, the plant will include flywheels which will increase the mechanical and electrical stresses on the machines during their operating life. Hence the operational demand of these particular units will be more like those of power station generators.

4.4 Electricity industry examples

Common asset categories do not exist across electricity transmission utilities for reactive plant. In some cases synchronous condensers are grouped with other types of reactive plant into one asset class for depreciation purposes. As mentioned above, the plant capacity and operating duty will differ and this is very relevant in the case for the proposed ElectraNet plant. The industry examples for discussion below are examples that either GHD has provided in the past or that the AER has referenced, and these may not as indicated, reflect the operating duty for the ElectraNet plant.

4.4.1 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. These synchronous condensers were considered to have an operating (technical) life[15] of between 40 and 50 years, with major refurbishments required after the initial 20-25 years of operation.

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.[16]

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

[16] Ibid.

Given the lack of need for these units to provide network strength and a relatively much lower consequence of failure, we do not consider that these three synchronous condensers should be viewed as good examples of in-service life for assets that need to reliably provide support to the transmission network.

4.4.2 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.[17] 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 have had further major refurbishment as recently as 2011/12.

This included the replacement of:

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

The indication is that these synchronous generators have had major refurbishments on average every 27 years.

4.4.3 SP Energy Networks - Project Phoenix

In December 2016, Ofgem approved a Network Innovation Project for SP Transmission to demonstrate a sustainable design, deployment and operational control of a synchronous condenser with a hybrid co-ordinated control system combined with a static condenser (STATCOM) device, which is referred to as a Hybrid Synchronous Condenser (H-SC).

The project is known as Project Phoenix, and is intended to address significant system issues on the Great Britain transmission network due to the progressive retirement of synchronous generation plants. It represents the global first use of this type of device in a transmission network, and is intended to improve

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

power quality and grid stability. The budget for the work is approximately £18 million, and is planned to be completed by March 2021.

The project is a partnership of SP Energy Networks, National Grid, the University of Strathclyde, the Technical University of Denmark and ABB. Whilst synchronous condensers are not new technology, this project is the first implementation of two technologies combined and controlled by a hybrid co-ordinated control system. The trial hybrid solution is based on a 70 MVar synchronous condenser and a 70 MVar STATCOM.[18]

In the project business case, SP Energy Networks noted that the asset life for the new H-SC devices is 40 years.[19] The installation of the H-SCs in Project Phoenix will increase the transfer capacity of the network across nominated boundaries, as well as increase the fault level allowing interconnectors to transfer power at their maximum capacity. SP Energy Networks consider that a new stand-alone H-SC is a "*… more desirable option in terms of capacity released as its benefits are realised for 40 years after initial installation.*"[20]

We note that the business case has identified a 40-year period over which the H-SC has a market benefit in comparison with other options, but it is not clear from the business case, that is publicly available, if there were major refurbishment costs considered in order to achieve an operating life of 40 years for the H-SCs. We also note the unique nature of this experimental installation makes any meaningful comparison with stand-alone synchronous condensers difficult.

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[18] Ofgem, *SP TRANSMISSION, Phoenix, System security & Synchronous compensators*, RIIO NIC 2016, section B.5, p. 63; https://www.ofgem.gov.uk/publications-and-updates/electricity-nic-submission-scottish-power-transmission-phoenix

[19] Ibid., section B.2, p. 55

[20] Ibid., section B.6, p. 63

5. Responding to AER Draft Decision

In the Draft Decision, the AER disagreed with the 30-year life proposed by ElectraNet for synchronous condensers, citing the AusNet Services industry example and observing "*… These assets are reliant on the contingent project being triggered … We consider that there is significant uncertainty as to the final form of ElectraNet's contingent project. For example, what will be the final design, and how often will the assets be used—that is, only during summer peak demand. We will determine an asset life for this asset class once the contingent project trigger for this project is met. At that stage, the final design and operation of the synchronous condensers will be better known. As such, at the time of this draft decision, we consider that ElectraNet's proposed standard asset life of 30 years for the 'Synchronous condensers' asset class would not lead to a depreciation profile that reflects the nature of the assets over the economic life of the assets within this asset class.*"[21]

On 5 June 2019, the AER raised three key issues regarding the proposed economic life for synchronous condensers, and requested further information:

1. **Design life of synchronous condensers -** the AER stated that "*… ElectraNet noted that the design life of the asset listed by the manufacturer (ABB) is stated as 30 years. GHD … advised that ABB provided anecdotal evidence that the asset life of the synchronous condensers is 25-30 years. Could you please provide additional information to support the manufacturer's design life of 30 years for this asset?*"
2. **Impact of asset utilisation on asset life -** the AER queried the relationship between the high utilisation of synchronous condenser assets and a shortened economic life "*... ElectraNet stated that there is a high forecast utilisation of the condensers and that this supports the use of a shorter asset life. Could you please provide additional information to clarify how this high utilisation has been forecast, and what assumptions have been made?*"
3. **Maintenance program including major refurbishments -** AER noted ElectraNet proposed that a requirement of a major replacement of the condenser's components after 30 years could support a shorter asset life "*... Could you please provide additional information on the component parts which will be required to be replaced to maintain the operation of the condensers after 30 years? Why these replacement or refurbishment works would not enable the asset to operate to the end of its technical life such that a replacement of the whole asset is required? We note that some of AusNet's condensers have had their initial technical life extended*[22] *by a further 10 years due to refurbishments.*"

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[21] AER, *Draft Decision ElectraNet transmission determination 2018 to 2023: Attachment 5 - Regulatory depreciation*, October 2017, p. 5-18

[22] AusNet Services, *Appendix 4A: Victorian Electricity transmission network capital expenditure overview – 2014/15 to 2016/17*, p. 66; https://www.aer.gov.au/system/files/SP%20AusNet%20-%20Appendix%204A%20-%20Capital%20expenditure%20overview%20-%2028%20February%202013.pdf

5.1 Our findings

We provide the following information in response to the issues raised by the AER:

1. **Design life** - During the tendering process, ElectraNet requested information from each supplier regarding the expected life for their plant and equipment according the requirements of the specification. Manufacturers have responded to ElectraNet's tenders typically indicating a life of 25 to 30 years before major plant related refurbishment work may be expected.

   GHD expects there will be opportunities to refurbish the plant with further capital expenditure to extend the life of the assets beyond 30 years, and manufacturers will also typically indicate potential for extension in the operating life for synchronous generators. However, we consider there to be additional risks to the potential of extended life due to the expected higher mechanical, thermal and electrical stresses with the synchronous condenser and flywheel combined plant configuration. The flywheel plant has had little operating history and the thermal and mechanical stresses on the combined plant will be higher.

2. **Asset utilisation** - With regards to the forecast high utilisation, ElectraNet advised:

   - ElectraNet is required to maintain minimum fault levels at key locations of the SA power system as published by AEMO. These fault levels are required to be maintained at all times.

   - Recent operating experience demonstrates that synchronous generation dispatch has reduced such that generation directions are increasingly necessary to maintain the mandated minimum fault levels. Following the installation of the synchronous condensers the need to direct generation will be replaced by the synchronous condensers.

   - Based on the above requirements the synchronous condensers are intended to run continuously except for when scheduled maintenance outages are necessary.

   In responding to this question, we believe it is appropriate to consider the type of utilisation of synchronous condensers on electricity networks in the past. Reactive compensation and voltage support in the past usually followed known patterns and in many cases the synchronous condensers may only be required for voltage support in seasonal peak demand periods. Applications also tended to support localised weak grids or to support stability in case of the loss of HVDC links between two networks, such as the case in New Zealand.

   Support for synchronous system inertia or increasing system strength, requires units to be spinning in reserve in readiness for fault events when they occur. The proposed application by ElectraNet and the specification for the synchronous condensers has particular characteristics which differ from these past typical applications:

   - Each synchronous condenser will be combined with large scale flywheels to increase inertia provided by the synchronous condensers to 1100 MW. The size of these flywheels presents a degree of scale which has had limited operational experience internationally.

   - The synchronous condensers are to provide system strength (fault level) and inertia by operating continuously, in readiness to support the network voltages during and following system disturbances. Due to this reliance on the synchronous condensers to support the system in the absence of synchronous generation that has been displaced by non-synchronous generation, the response requirement places higher electrical and mechanical stresses on the combined synchronous condenser/flywheel system relative to the response previously required of multiple individual synchronous generators. ElectraNet has specified that the units shall be capable of unrestricted repetitive response throughout the entire dynamic operating range of the synchronous condenser.

  - The synchronous condensers will provide reactive compensation under an operational environment demanding rapid and continuous regulation of MVAr flows compared with systems installed on networks with lower levels of renewable energy generation.
  - The demands for system strength, inertia, reactive power and voltage regulation over the next 30 years and how dynamic that demand will be is uncertain.

3. **Component replacement -** The following components could require replacement within the 30-year period and around the nominal time periods indicated below:
   - Replacement of control/HMI systems including AVR with new technology ~ every 15 years
   - Stator/rotor rewinds ~ 25-30 years
   - Excitation system ~ 25-30 years
   - Other balance of plant: Replacement of electrical secondary systems (LV AC & DC, protection) ~ 25-30 years
   - Flywheel rotor/other major component replacement: Unquantifiable risk within the first 30 years.

The key parameters affecting the asset life are discussed in section 3.3.

Refurbishment versus replacement, and versus disposal decisions need to consider performance requirements and the value that can be provided by the assets at the time interventions are required for either refurbishment or replacement expenditure. Whether or not refurbishment is the optimum solution for life extension will depend on the future performance requirements and costs. Even though a 30-year economic life may be applied for the initial expenditure there may still be a requirement for additional capital expenditure during this initial life (rather than just at 30 years) and equally life extension expenditure may not be required until after 30 years (a probability function around the average expected life).

A business case would need to be presented to determine the optimum option as to whether to refurbish or replace the assets. Disposal would also be an option if the asset no longer provides a feasible benefit. This assessment would be subject to the Regulatory Investment Test for Transmission (assuming the capital cost of the most expensive credible option exceeded $6 million).

5.1.1 AEMO advice

To support their planning functions of the NEM electricity grid and Western Australia power system, AEMO maintains a dataset that includes estimates of current technology costs and generator performance characteristics for both existing generators and for new entrants to the market. This dataset also encompasses the technical operating parameters of these units.

In September 2018, AEMO engaged GHD to undertake a review and update of the existing dataset and to populate new entrant costs and technical parameters across a selection of generation and storage technologies. The primary purpose of this exercise was to update the generic dataset for use by AEMO in their planning functions.

In reviewing synchronous condensers, we suggested a nominal 40-year technical/operational life (refer section 3.2.2 for definition) assuming that these would be standard assets operating periodically or as required for addressing voltage control and/or system strength. Note that this does not represent the assessed economic life of these assets for regulatory purposes, as explained in section 3.2.4. In this context, we understand that provision of periodic voltage control is a less onerous duty than providing continuous system strength provision and, likely less critical service, as there are newer technologies (STATCOMs, inverters) that can also provide this service.

We consider our advice in this instance was specific to supporting the AEMO planning function, and of a necessarily generic nature for this purpose. It is not directly applicable to the type of synchronous condensers that ElectraNet are proposing to install (as these include a high-inertia flywheel), nor to a synchronous condenser that will provide a critical system strength service with high utilisation.

6. Recommendations

We do not agree with the AER’s conclusion of a 40-year life as the appropriate economic life for the synchronous condensers included in the project proposed by ElectraNet for the following reasons:

- The Regulator has relied upon the in-service life achieved for assets installed in the AusNet Services transmission network as an indicator for economic life. As noted in section 4.4.1, these units were in poor condition during their time when installed, and provided little support to the network. With reference to section 3.2.4, economic life is “*… the period of usefulness of an asset to its owner*”. As AEMO and AusNet Services agreed that these four synchronous condensers provided little benefit to the network, and there was no net market benefit in replacing them, we do not agree that there should be any inference made on the economic life of these synchronous condensers and the period they were installed, which we believe is more closely related to physical life for the AusNet Services assets (refer section 3.2.2).
- Project Phoenix is an innovation project, investigating the performance of a new Hybrid Synchronous Condenser as a device to assist with grid stability in the GB transmission network. We note that ABB has nominated an asset life of 40 years, although we believe this is likely related to separate design lives that have typically been applied to standard synchronous condensers and STATCOMs. As SP Energy Networks gains operational experience with the new innovative H-SCs, it will become clearer if this experimental composite solution provides the economic benefits and operational efficiencies that have been forecast.
- The specific plant specification requirements for the ElectraNet synchronous condensers, include large scale flywheels which will increase mechanical and electrical stresses during the operating life of the plant.
- All manufacturers indicate an expected life of 30 years for the specified plant, prior to any major refurbishment being required to extend the asset’s operational life.
- The ElectraNet synchronous condensers will have an operating regime more similar to power generation units and will also have a high demand to be provide dynamic reactive power response.

We consider that the consideration of the appropriate asset life for depreciation purposes should begin firstly with the specific requirements, both the operating environment and plant specification for the ElectraNet assets, and the guidance provided by the manufacturers of the equipment and then seeking comparable historical experience of other network provider applications for synchronous condensers. We believe Clause 27 of the ATO taxation ruling (refers section 3.2.6) supports our contention that consideration should be given to the different configuration of the ElectraNet synchronous condensers (which include a flywheel) in assessing an economic life.

In addition, we concur with the AER industry application note that typical expected life for an asset should consider any specific operation environment factors (refer section 4.2) as a particular use for an asset based on its specific configuration and operating requirements may result in an expected or forecast useful life different to the normal industry standard.

Our key conclusion is that 30 years is recommended as the appropriate economic asset life for regulatory purposes for the synchronous condensers (complete with flywheels) proposed by ElectraNet, based on all the information and considerations above.

Appendices

Appendix A - GHD advice of March 2017

The following is the advice originally provided to ElectraNet as part of their regulatory submission for 2018-23 to the AER.

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.

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[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]

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[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

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[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.

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[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.

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[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.

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[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

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