Cox Peninsula Centre Yard Substation Condition Assessment Report

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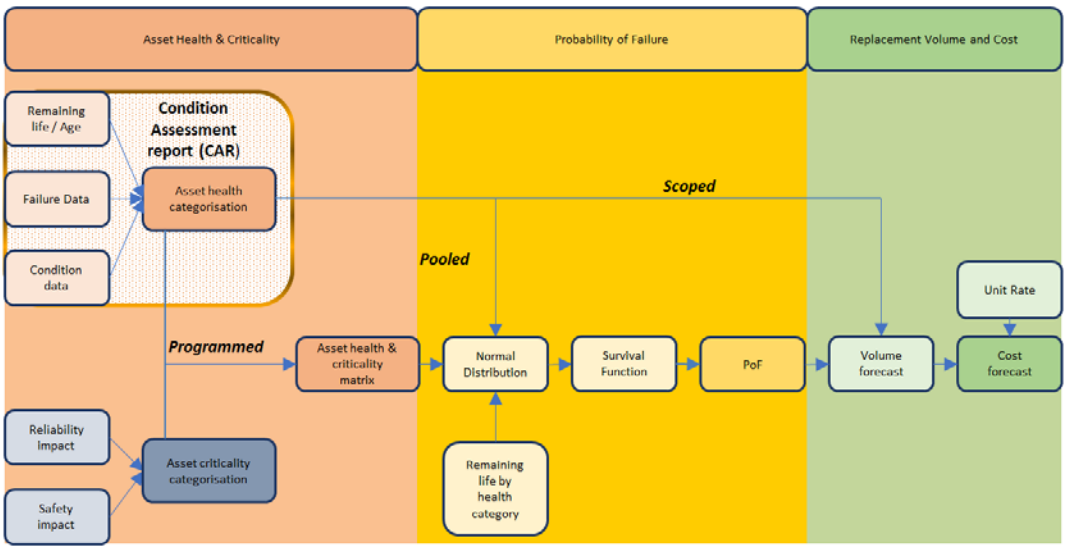
1 Introduction

This condition assessment report (CAR) provides a structured condition assessment of all the assets in a format aligned to the PWC asset hierarchy[1] and applying the condition assessment criteria[2] for each asset class within the Cox Peninsular ZSS. The CAR collates and summarises information from various PWC data sources that are either in raw data format or conditioned data and is traceable to the source. The following diagram illustrates where the CAR sits within the asset management process within PWC.

Figure 1 - Role of CAR in the PWC asset management process



1 Refer to PWC D2015/354287 Asset Data Template

2 Refer to PWC document D2018/65161 for a complete description of the PWC condition assessment methodology.

The output of the CAR is an assessment of remaining serviceable life before some form of intervention is required for the asset to continue to provide the service it was designed for. The information within the CAR is used as an input to determine the most effective asset class management plan and by definition the CAR **does not include a criticality assessment**.

2 Summary

The following table and commentary provides a summary of the asset health at Cox Peninsular ZSS. Table 1 describes the asset health definitions used in this CAR. A more detailed breakdown of the asset health components and scores can be found in section 5.

Table 1 - Asset health definitions

Code	Definition[3]	Asset Health Rating range
	Loss of required function within 5 years	*2.34 - 3*
	Loss of required function within 5-15 years	*1.68 – 2.33*
	New asset / minor degradation (remaining life beyond 15 years)	*1 – 1.67*

[3] Consistent with Assets Health and Criticality Method D2018/72550

Table 2 - Summary of asset health

Asset Class	Sub Asset	Asset Health Rating
Building structures	*Overall*	*2.2*
Civils / earthgrid	*Overall*	*1.5*
Protection	*Overall*	*2*
HV cable	*Overall*	*N/A*
ZSS TF's	*Overall*	*N/A*
	TF1	*2.8*
	TF2	*2.8*
11/22kV indoor switchboard	*Overall*	*N/A*
66kV CB's	*Overall*	*2.8*
	CB 66PC12	*2.8*
SCADA	*Overall*	*2*
Comms	*Overall*	*N/A*
Capacitor banks	*Overall*	*N/A*
Airconditioning	*Overall*	*1*
	Airconditioning	*1*
	Dehumidifier	*N/A*
66kV Isolators	*Overall*	*3*
66kV inst TF's	*Overall*	*3*
Fire systems	*Overall*	*3*
Aux TF	*Overall*	*3*
LV board	*Overall*	*3*
DC supplies	*Overall*	*2*
66kV busbar	*Overall*	*3*

The following additional commentary is provided to complement the above summary in relation to significant asset classes by exception.

ZSS Transformers

Overall electrical tests indicate elevated moisture within the insulation system; this is supported by electrical tests indicating 3.5% & 3.9% water in the paper insulation system respectively and elevated water saturation levels in the oil. Elevated moisture significantly reduces the ability of the transformer to withstand system events due to 'bubbling'.

Oxidation levels are advancing with elevated acidity, lower interfacial tension and increasing losses within the oil.

Elevated bushing losses have been identified and the OLTC is no longer functional. The OLTC is now being operated as an off-load-tap-changer.

Transformers 1 & 2 have estimated DP values of approx. 176 & 220 respectively using furan analysis. These values indicate the tensile strength of the paper insulation is severely reduced compromising their ability to withstand system transients.

66kV Circuit Breaker

The CB at Cox Peninsula is an ASEA HLC model. These are installed widely across the PWC network. Several of this type of CB have experienced failures with one catastrophic failure in 2011. They are becoming increasingly unreliable as the fleet ages. One of the primary causes of failure is contamination of the oil interrupting medium with water. The HLC circuit breaker is a "free-breathing" design. In the humid and wet environment of the Darwin region, significant amounts of moisture can enter the breaker and build up over time. This is exacerbated by oil leaks, which are becoming more frequent as a result of ageing seals and sealing surfaces perishing or being damaged over time. As a result significant volumes of "free" water (i.e. water below the oil) must be drained from the circuit breaker stacks at each maintenance outage. The presence of free water considerably increases the risk of the circuit breaker failing to break fault currents when required, since it lowers the dielectric. Insulation resistance testing is performed during routine maintenance to ensure the integrity of the circuit breaker insulation, and is a useful indicator for the presence of moisture and degraded oil. The failure rate for "as-found" insulation resistance is approximately 30% since testing began in 2008. By comparison, the failure rate for non-HLC circuit breakers is approximately 7%.strength of the oil.

There also have been multiple instances of mechanisms seizing, operating slowly, or tripping through (tripping immediately after closing). The failure rate for "as-found" opening time during routine maintenance is approximately 15%. Mechanism failures can usually be restored by maintenance crews, however there have been instances where restored mechanisms have failed again shortly afterwards, requiring multiple outages and visits to correct. The mechanism failures are thought to be caused by the build-up of dirt and corrosion, failed dampers and inadequate lubrication over long periods. To resolve these issues a complete refurbishment of the mechanisms is required.

PWC experience indicates that end of life for these CBs in the PWC network is around 40 years. Routine maintenance activities over the life of these circuit breakers have not been effective at maintaining their condition. Contemporary asset management practices have been applied to these assets since the 2008 Davies Review into a major substation failure within PWC. However the failure modes targeted through maintenance are consistently recurring indicating major refurbishment or replacement is necessary.

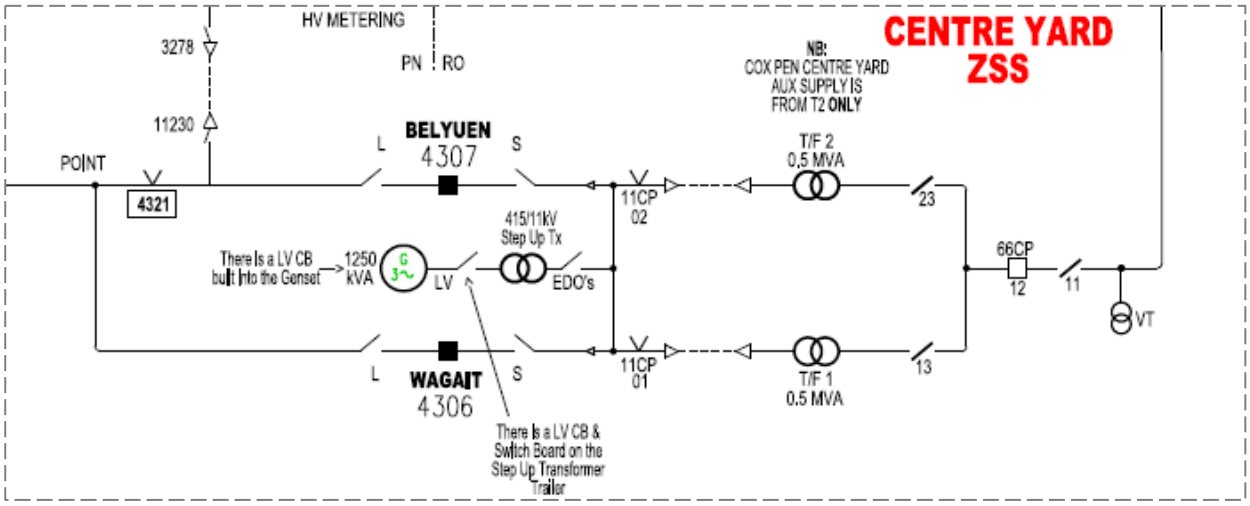
Building Structures

A structural report has not been completed, however the floor of the control building has recently had significant reinforcement work completed on the flooring due to termite damage. This is a temporary measure only and the building (demountable type) may have additional structural damage and is planned for further assessment.

3 Site Overview

Cox Peninsular Centre Yard Zone Substation was established in 1972. The substation is supplied by a single overhead 66kV line which is fed via a subsea cable from Darwin. The 66kV yard is an outdoor type and the 66kV CB is an ASEA HLC minimum oil type. There are two 66/11 kV 0.5MVA transformers supplying two overhead feeders which supply the township of Wagait and local communities.

4 Single Line Diagram



5 Asset Condition Assessment

The following asset condition assessment is based on the current PWC condition assessment criteria for its various asset classes. The supporting test results and values where applicable have been extracted from relevant PWC asset databases and reports.

The three levels of asset health are characterised as follows.

Code	Definition[4]	Asset Health Rating range
	Loss of required function within 5 years	*2.34 - 3*
	Loss of required function within 5-15 years	*1.68 – 2.33*
	New asset / minor degradation (remaining life beyond 15 years)	*1 – 1.67*

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Building structures		***Overall***	***2.2***	
		Independent structural report / site inspection report	**3**	Building is falling apart, requires major repairs
		Asbestos rating	**2**	The building contains asbestos but is managed.
		Age	**2**	This is the original building established in 1972 will be 52 years old in the RY2020-24 regulatory period.
Civils / earthgrid		***Overall***	***1.5***	46 years old
		Earthgrid test results	**1**	Minor remedial work D2012 601211
		Assessment of switchyard	**2**	
Protection		***Overall***	***2***	
		Technology type	**2**	1 digital. D2018/77513
		Relay calibration	**N/A**	D2018/60081 Relay Defect Report
		Failure rate		Future measure

[4] Consistent with Assets Health and Criticality Method D2018/72550

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
HV cable		***Overall***	***N/A***	
		Construction technology / design / installation	***N/A***	
ZSS TF's		***Overall***	***N/A***	
	TF1	Overall	**2.8**	
		Degree of polymerisation	**3**	Ref: D2017/325447 Transformer CAR
		Oil Analysis	**1**	Output from 'TxAnalyser' platform
		Age	**3**	
	TF2	Overall	**2.8**	
		Degree of polymerisation	**3**	DP is 220, will be below 200 in the RY2020-24 regulatory period.
		Oil Analysis	**1**	Output from 'TxAnalyser' platform
		Age	**3**	
11/22kV indoor switchboard		***Overall***	***N/A***	
66kV CB's		***Overall***	***2.8***	For all the following asset health parameters and calculation - parameters D2018/13333 HV Circuit Breakers Test Results Health and Criticality – all breakers
	CB 66CP12	Overall	**2.8**	ASEA HLC – D2017/364601 HLC replacement program
		Age	**3**	
		Condition Assessment	**3**	
		Defect count	**3**	
		Defect cost	**3**	
		Insulation technology	**2**	
		Mechanism technology	**1**	
SCADA		***Overall***	***2***	
		Age	**2**	D2017/319807 S&C NPD Submission
		Failure rate		Future measure
Comms		***Overall***	***N/A***	

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Age		
		Failure rate		Future measure
Capacitor banks		***Overall***	***N/A***	
		Age		
Airconditioning		***Overall***	***1***	D2018/74141
	Airconditioning	Age	1	
	Dehumidifier	Age	***N/A***	
66kV Isolators		***Overall***	***3***	D2017/230246 Age Profile Data
		Age	**3**	
66kV inst TF's		***Overall***	***3***	D2017/230246 Age Profile Data
		Age	**3**	
		Condition Assessment	**N/A**	
Fire systems		***Overall***	***3***	
		Defect cost		Future measure
		Age/Functionality/obsolescence	**3**	Email – D2018/76875
Aux TF		***Overall***	***3***	D2017/230246 Age Profile Data
		Age	**3**	
LV board		***Overall***	***3***	Original board >40yrs old
		Age	***3***	
DC supplies		***Overall***	***2***	D2017/230246 Age Profile Data
		Age	**2**	
66kV busbar		***Overall***	***3***	Original busbars
		Age	**3**	