



Humpty Doo Zone Substation Condition Assessment Report

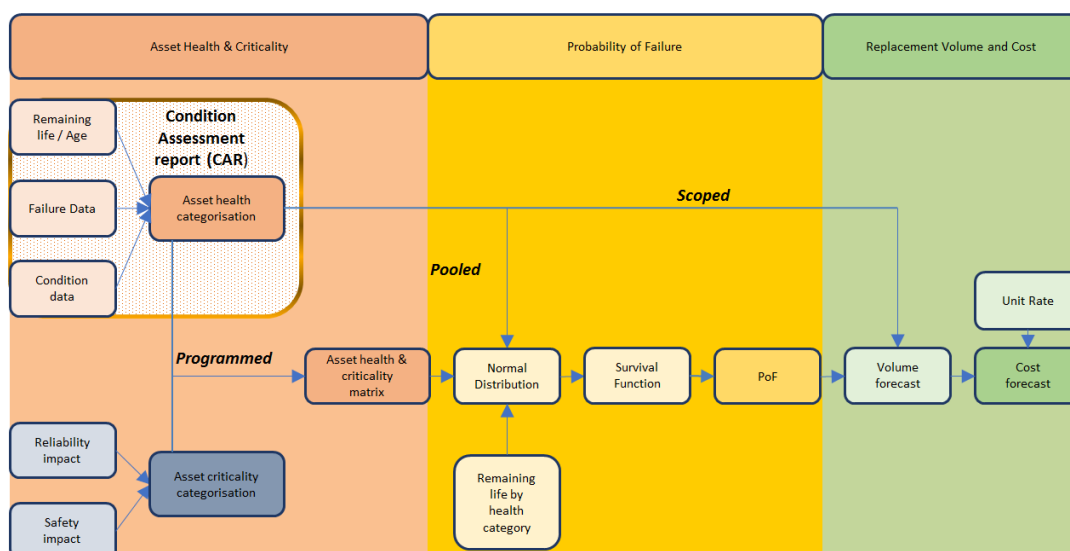
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1 Introduction

This condition assessment report (CAR) provides a structured condition assessment of all the assets in a format aligned to the PWC asset hierarchy¹ and applying the condition assessment criteria² for each asset class within the Humpty Doo 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.

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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 Humpty Doo 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
	<i>Loss of required function within 5 years</i>	<i>2.34 - 3</i>
	<i>Loss of required function within 5-15 years</i>	<i>1.68 – 2.33</i>
	<i>New asset / minor degradation (remaining life beyond 15 years)</i>	<i>1 – 1.67</i>

³ Consistent with Assets Health and Criticality Method D2018/72550

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Table 2 - Summary of asset health

Asset Class	Sub Asset	Asset Health Rating
Building structures	Overall	1.3
Civils / earthgrid	Overall	1.5
Protection	Overall	2.46
HV cable	Overall	N/A
ZSS TF's	Overall	N/A
	TF1	2.9
	TF2	2.9
22kV outdoor CB's	Overall	N/A
	CBH-22HD402	1.95
	CBH-22HD403	1.50
66kV CB's	Overall	N/A
	CB 66HD203	2.55
SCADA	Overall	3
Comms	Overall	1
Capacitor banks	Overall	N/A
Airconditioning	Overall	3
	Airconditioning	3
	Dehumidifier	N/A
66kV Isolators	Overall	2
66kV inst TF's	Overall	1.6
Fire systems	Overall	N/A
Aux TF	Overall	1
LV board	Overall	3
DC supplies	Overall	2
66kV busbar	Overall	2

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

Protection

The majority of the protection relays are over 15 years old with a significant number over 25 years old and are no longer supported. At the last routine maintenance in 2016, 2 out of the 12 relays were found to be out of setting tolerance during routine maintenance.

ZSS Transformers

Both transformers at Humpty Doo Zone Substation are 54 years old and have exceeded their design life of 50 years. Transformers 1 & 2 have current estimated DP values via Furan analysis of approx. 270 & 280 respectively. These values indicate the tensile strength of the paper insulation is severely reduced compromising their ability to withstand system transients. These values are expected to fall below 200 by 2023. A transformer is considered to be 'end of life' when the DP approaches 200. Estimated DP using furan analysis for both transformers may be over-estimated due to historical oil filtering and oil changes.

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Tests on both transformers have confirmed excessive moisture in the paper insulation and poor insulation resistance outside acceptable limits.

66kV Circuit Breaker

The CB at Humpty Doo is an ASEA HLC model which is 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.

SCADA

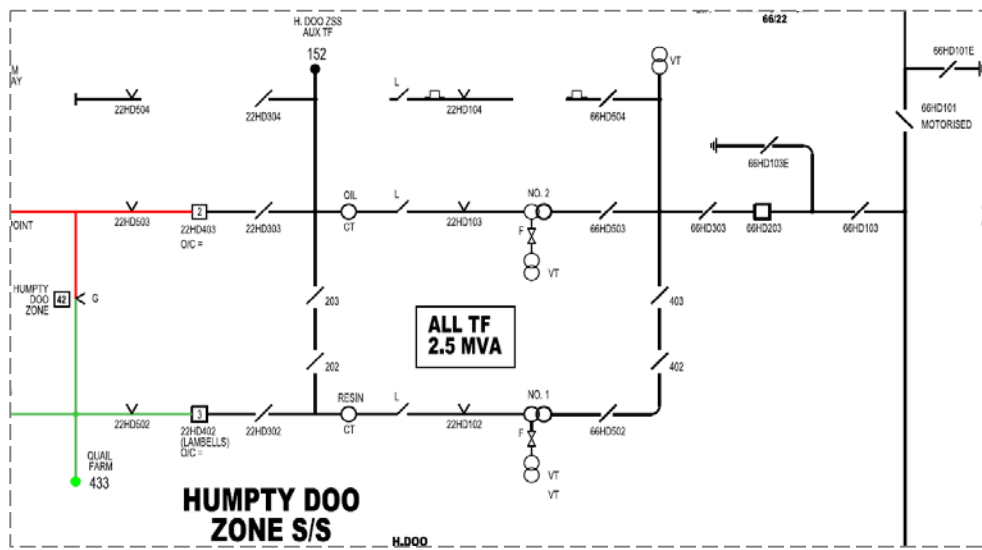
The Remote Terminal Unit (RTU) is over 30 years old and is no longer supported. Spare parts holdings for this RTU type are very limited and additional spares are only obtainable when retiring other units from service.

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3 Site Overview

Humpty Doo is a 66/22kV rural substation located approximately 50km south east of Darwin. The substation is teed off the Strangways-Mary River 66kV feeder and it supplies local and rural area and the nearby naval transmitter. Humpty Doo Zone Substation was established in 1980. The 66/22kV yard is an outdoor yard with two 66/22kV 2.5MVA Transformers, and outdoor 66kV & 22kV CBs and instrument transformers.

4 Single Line Diagram



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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
	<i>Loss of required function within 5 years</i>	2.34 - 3
	<i>Loss of required function within 5-15 years</i>	1.68 – 2.33
	<i>New asset / minor degradation (remaining life beyond 15 years)</i>	1 – 1.67

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Building structures		Overall	1.3	
		Independent structural report / site inspection report	2	
		Asbestos rating	2	
		Age	1	Building is 37 years old
Civils / earthgrid		Overall	1.5	
		Earthgrid test results	1	D2012/601211 2006 earthing report
		Assessment of switchyard	2	
Protection		Overall	2.46	
		Technology type	2.33	4 electromechanical 8 static
		Relay calibration	3	D2018/60081 Relay Defect Report
		Failure rate		Future measure

⁴ Consistent with PWC Assets Health and Criticality Methodology document D2018/72550

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Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
HV cable		Overall	N/A	No HV cable
		Construction technology / design / installation	N/A	
ZSS TF's		Overall	N/A	
	TF1	Overall	2.9	
		Degree of polymerisation	3	Currently DP = 270 but PWC DP model places DP below 200 by 2022. Ref: D2017/166034 Humpty Doo Transformer CAR
		Oil Analysis	2	Output from 'TxAnalyser' platform
		Age	3	
	TF2	Overall	2.9	
		Degree of polymerisation	3	Currently DP = 280 but PWC DP model places DP below 200 by 2023. Ref: D2017/166034 Humpty Doo Transformer CAR
		Oil Analysis	2	Output from 'TxAnalyser' platform
		Age	3	
22kV outdoor CB's		Overall	N/A	
	CBH-22HD402	Overall	1.95	
		Age	2	
		Condition Assessment	2	
		Defect count	2	
		Defect cost	3	
		Insulation technology	1	
		Mechanism technology	1	
	CBH-22HD403	Overall	1.50	
		Age	2	

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Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Condition Assessment	1	
		Defect count	3	
		Defect cost	3	
		Insulation technology	1	
		Mechanism technology	1	
66kV CB's		Overall	N/A	For all the following asset health parameters and calculation - parameters D2018/13333 HV Circuit Breakers Test Results Health and Criticality – all breakers
	CB 66HD203	Overall	2.55	
		Age	3	
		Condition Assessment	3	
		Defect count	2	
		Defect cost	1	
		Insulation technology	2	
		Mechanism technology	1	
SCADA		Overall	3	
		Age	3	D2017/319807
		Failure rate		Future measure
Comms		Overall	1	
		Age	1	D2017/319807
		Failure rate		Future measure
Capacitor banks		Overall	N/A	No capacitor bank
		Age	N/A	
Airconditioning		Overall	3	
	Airconditioning	Age	3	D2018/74141
	Dehumidifier	Age	N/A	No humidifier
66kV Isolators		Overall	2	

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Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Age	2	D2017/230246 Age profile data
66kV inst TF's		Overall	1.6	
		Age	1.6	D2017/230246 Age profile data. Note there are 6 assets that are 38 years old. From 2020 these would change AHR to 2.06
		Condition Assessment	N/A	Output from TxAnalyser
Fire systems		Overall	N/A	No fire system
		Defect cost		Future measure
		Age/Functionality/obsolescence	N/A	
Aux TF		Overall	1	
		Age	1	1999 - Maximo
LV board		Overall	3	
		Age	3	Original unit. Ongoing issues with CFS breakers & faulty change-over - Email D2018/76070
DC supplies		Overall	2	
		Age	2	D2017/230246 Age profile data
66kV busbar		Overall	2	
		Age	2	Original units. D2017/230246