Ausgrid

Revised Proposal

Attachment 5.13.M.13

Major Transformers program CBA summary

January 2019

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Major Transformers program CBA summary

Introduction

Ausgrid has reviewed the risks associated with Major Transformers by undertaking a quantitative risk assessment. In analysing failures for Major Transformers, Ausgrid uses a Repair/Replace model to determine the most effective approach to be undertaken based on the cost of ongoing repair versus replacement. This model was considered when determining the Weibull parameters and the percentage replaced calculations. This document covers the outcomes of cost benefit analysis, and should be reviewed in conjunction with the cost benefit analysis (CBA) modelling methodology report[1].

Scope

This model covers a portion of the forecast mapped to the following RIN categories:

- Transformers - Ground Outdoor / Indoor Chamber Mounted; >= 22kV & <= 33kV; <= 15MVA
- Transformers - Ground Outdoor / Indoor Chamber Mounted; >= 22kV & <= 33kV; > 15MVA & <= 40MVA
- Transformers - Ground Outdoor / Indoor Chamber Mounted; > 33kV & <= 66kV; <= 15MVA
- Transformers - Ground Outdoor / Indoor Chamber Mounted; > 33kV & <= 66kV; > 15MVA & <= 40MVA
- Transformers - Ground Outdoor / Indoor Chamber Mounted; > 66kV & <= 132kV; <= 100MVA
- Transformers - Ground Outdoor / Indoor Chamber Mounted; > 66kV & <= 132kV; > 100MVA

Analysis Outcome

The analysis was completed using historical data up to and including FY18. The CBA models forecast risk from FY19 onwards. The quantities included in FY19 are reflective of Ausgrid's committed program in this year.

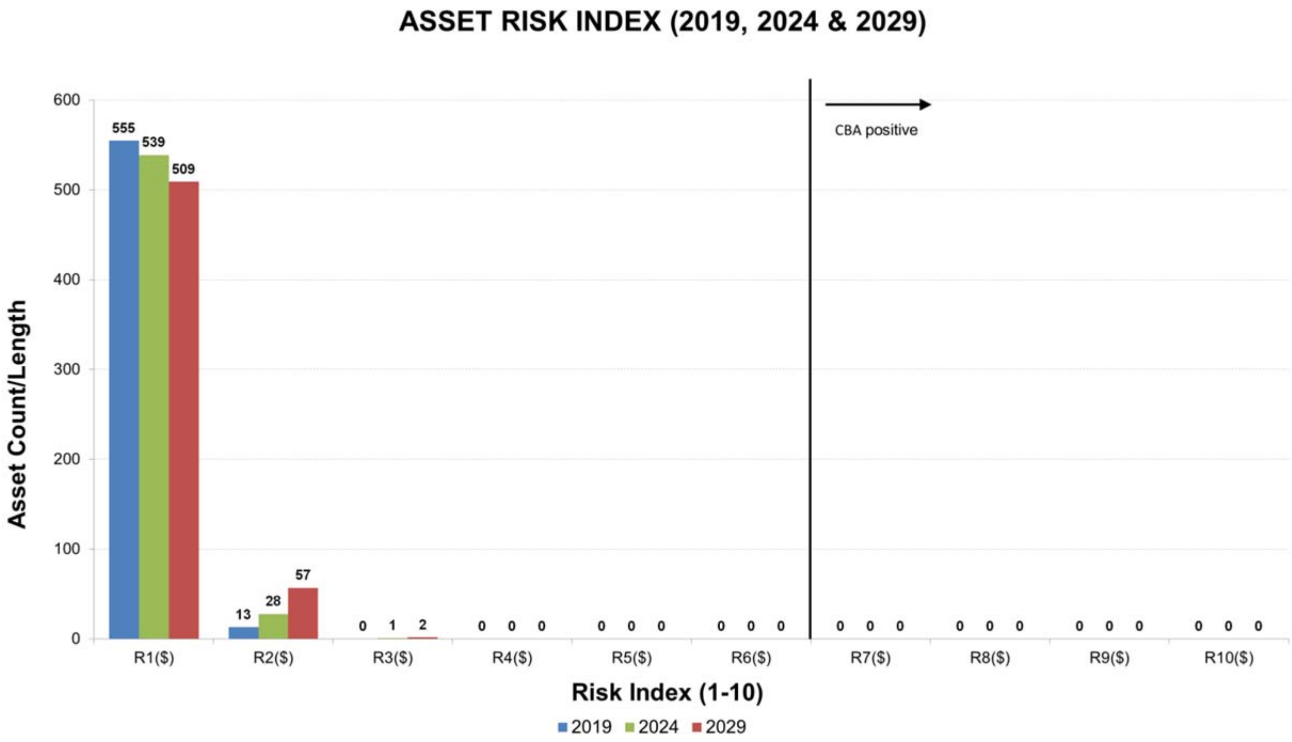
Ausgrid has committed to 6 Major Transformers being replaced in FY19. Based on the analysis completed, the model output is supporting the reactive replacement of a further 19 Major Transformers by the end of FY24.

In forming this decision Ausgrid considered three options and performed sensitivity analysis as described in this document. Ausgrid is recommending Option 1 – reactive replacement of failures until the end of FY24 for this asset category.

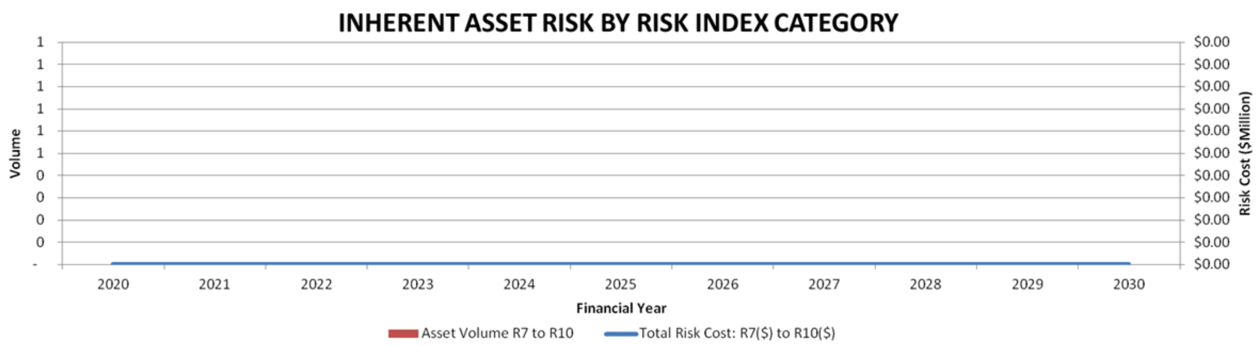
Risk Index

The normalised risk index below considers the probability of failure, consequence of failure and the annualised replacement cost.

[1] Attachment 5.13.M.0 – Repex program CBA modelling methodology



The inherent risk of Subtransmission Transformers that are cost benefit positive is shown in the figure below.



While it is inherently understood that Major Transformers can lead to significant outages, fires and worker safety consequences, the low risk shown in the Risk Index is reflective of Ausgrid's strong history in managing this asset class. The low Incident Conversion Rates (ICR) capture Ausgrid's strong recent history in managing this asset class utilising condition based replacement.

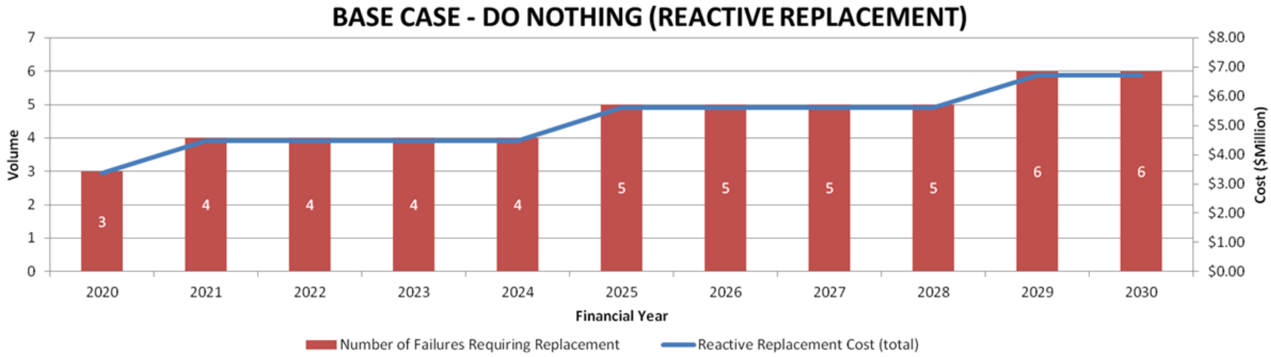
The historical failures included in the probability of failure modelling include both condition based failures (where the failure led to the replacement of the asset) and functional failures. An effective condition based replacement approach is captured within the failure forecast and therefore within the base case (reactive replacement) option.

Option One – Base Case (Reactive Replacement)

Under a base case scenario, if Ausgrid were to adopt a reactive replacement strategy, the minimum replacement quantity during FY20 to FY24 is 19 major transformers. The table below shows the quantity of assets which will require reactive replacement in the year that they are forecast to fail.

Financial Year	FY20	FY21	FY22	FY23	FY24
Quantity for replacement	3	4	4	4	4

This quantity represents the minimum required replacement volume with no proactive strategy is adopted.



Option Two – Replace where cost benefit positive

Given the model shows no Major Transformers as cost benefit positive before the end of FY24, this option is not considered as supported.

Option Three – Replace all cost benefit positive by the end of the period

Given the model shows no Major Transformers as cost benefit positive before the end of FY24, this option is not considered as supported.

Data input

		Data Source
Population	568	SAP – Asset Register
Object Types	TX_SUBTRAN – Subtransmission Power Tx TX_ZONE – Zone Power Tx	SAP – Asset Register
Conditional & Functional Failures / Time Period	38 failures 18 years This model is used in conjunction with a repair/replace model for all failures.	SAP – Defect Records
Asset standard life	45.89 years	RAB life
WACC	3.90%	Regulated Rate

Planned Replacement Cost

A weighted average for the period per asset was used in this model.

Cost	Data Source
$1,120,000	2020-24 Revised Regulatory Proposal (FY19 real direct costs +25% of indirect costs)

Weibull parameters

Developed by applying asset age to failure correlation using Ausgrid historical failure and asset data.

β_{good}	3.5648	$\beta_{average}$	3.7754	β_{poor}	3.9860
η_{good}	111.5424	$\eta_{average}$	85.7497	η_{poor}	67.7787

b (intercept)	-16.8060

Adjustments factors

Probability of Failure (PoF)	• Actual Failure Data • Age • Insulation type • Oil test results • Leakages
Probability of Consequence (PoC)	• Insulation type

Model calculated failures

	2020	2021	2022	2023	2024
Failures	3.5	3.7	3.9	4.1	4.4

Sensitivity

Ausgrid tested the sensitivity of the applied grossly disproportionate factor by applying a range of 3, based on worker safety. As this model is purely reactive this has no effect on the recommended replacement quantities or strategy.

Modelled inherent incident consequences

In determining the probability of severity, Ausgrid has utilised available information to determine the rate of occurrence of an event by each severity. These values were then tested for sensitivity.

Safety (specifically worker safety for this asset type)
Worker Safety ICR – 12.12 % (Ausgrid's recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 4,469,292	0.00182	10	0.015	167
Major	$ 446,929	0.00364	8	0.030	83
Moderate	$ 44,693	0.01818	6	0.150	17
Minor	$ 4,469	0.03636	4	0.300	8.3
Insignificant	$ 447	0.06121	2	0.505	4.9

Average **safety** consequence per asset: $99,832 per event.

Ausgrid have proposed that inherently a fatality would occur due to a major transformer every 167 years (~150 years) based on the potential for an event to occur in industry. Changing the probability of severity to 0.030 (or a fatality every 83 years) and changing the probability of severity to 0.0075 (or a fatality every 333 years) indicates that the model overall is insensitive to changes in the probability of severity for safety risk.

Fire
ICR – 0%

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 66,000,000	n/a	10	n/a	n/a
Major	$ 6,600,000	n/a	8	n/a	n/a
Moderate	$ 660,000	n/a	6	n/a	n/a
Minor	$ 66,000	n/a	4	n/a	n/a
Insignificant	$ 6,600	n/a	2	n/a	n/a

Average **fire** consequence per asset: $n/a.

Ausgrid have not experienced any fires due to major transformers within the observation period, however, these have occurred outside of this period and in industry. Sensitivity analysis was completed to determine the effect of including fire consequence due to previously recorded transformer fires outside the observation period and known issues within industry. The effect of including fire risk resulted in negligible change to the model outcome overall.

Environment
ICR – 36.36% (Ausgrid's recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 10,193,119	0	1	n/a	n/a
Major	$ 4,558,501	0.00364	1	0.010	83
Moderate	$ 1,019,312	0.01818	1	0.050	17
Minor	$ 101,931	0.10908	1	0.300	2.8
Insignificant	$ 10,193	0.23270	1	0.640	1.3

Average **environment** consequence per asset: $ 48,596 per event.

Ausgrid's major transformers are generally installed in conjunction with an oil containment system, whilst these systems vary due to installation date, the risk of a severe environmental incident is low enough that the probability of consequence was considered negligible and set to zero. The risk of oil is still present for example when oil escapes the oil containment system, as well as Ausgrid having recorded noise complaints from some transformers allowing a probability of severity for major events to be set at 0.010 (or 83 years until event). Adjusting this to 0.020 (or an event every 42 years) or adjusting it to 0.005 (or an event every 167 years) does not change the model outcome. The model overall is insensitive to changes in the probability of severity for environment risk.

Loss of supply

Ausgrid's failure data has been reviewed to determine the proportion of failures resulting in unserved energy, with consideration of the number of outages recorded using data from Ausgrid's outage management system (OMS).

Outage Type	HV	Data Source
Proportion of failures resulting in unserved energy	0%	Weibull parameters include end of life failures only
VCR	$40.73/kWh	AEMO / AER
Average interruption duration	0 hrs	OMS - 3 year average
Time without supply	0 hrs	Calculated

Average **loss of supply** consequence per asset: $0 per event.

The proportion of failures resulting in unserved energy was set to zero as no outages were experienced within the observation period. However due to the network configuration and industry experience it is understood that a transformer failure can lead to unserved energy and therefore a value of zero does not accurately reflect the reliability risk. Sensitivity analysis was completed to determine the effect of what was deemed a typical outage time, shown below, this did not influence the outcome of the model as a reactive approach for replacement was determined.

Outage Type	HV
Proportion of failures resulting in unserved energy	100%
VCR	$40.73/kWh
Switching Time	2 hrs
Restoration/Repair Time	8 hrs
Switching Load % Lost Prior to	40%
Restoration/Repair Load % Lost Prior to	10%
Time without supply	1.60 hrs

Finance

		Data Source
Annual deferral benefit of reactive	$42,040	20% increase on planned replacement cost applied at the WACC
Repair cost	$6,528	FY13-FY18 actuals (Direct '19)
Proportion replaced	100%	Weibull values for end of life failures only
Weighted replacement/repair cost	**$46,195**	Calculated
Maintenance original asset per annum	$2,928	Based on historical maintenance
Maintenance replacement asset per annum	$1,983	Based on historical maintenance
Maintenance benefit per asset per annum	**$945**	Calculated

Average **financial** consequence/benefit per asset: $47,140 per event.

AVERAGE TOTAL CONSEQUENCE per asset: $195,568 (including POC x C($))