Revised Proposal

Attachment 5.13.M.18

CBD Distribution Transformers program CBA summary

January 2019

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Introduction

Ausgrid has reviewed the risks associated with CBD Transformers by undertaking a quantitative risk assessment. 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; >60kVA & <= 600kVA; Multiple Phase
- Transformers - Ground Outdoor / Indoor Chamber Mounted; < 22kV; > 600kVA; Multiple Phase

Ausgrid is not forecasting proactive replacement of any distribution transformers apart from:

- Those in the Sydney CBD (this document),
- Pole Top Substations where the pole is reaching end of life (refer to separate document[2]), and
- Distribution Substations where the whole substation is cost benefit positive (refer to separate document[3]).

Following failure of other distribution transformers, Ausgrid will undertake reactive replacement through reallocation of approved expenditure.

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.

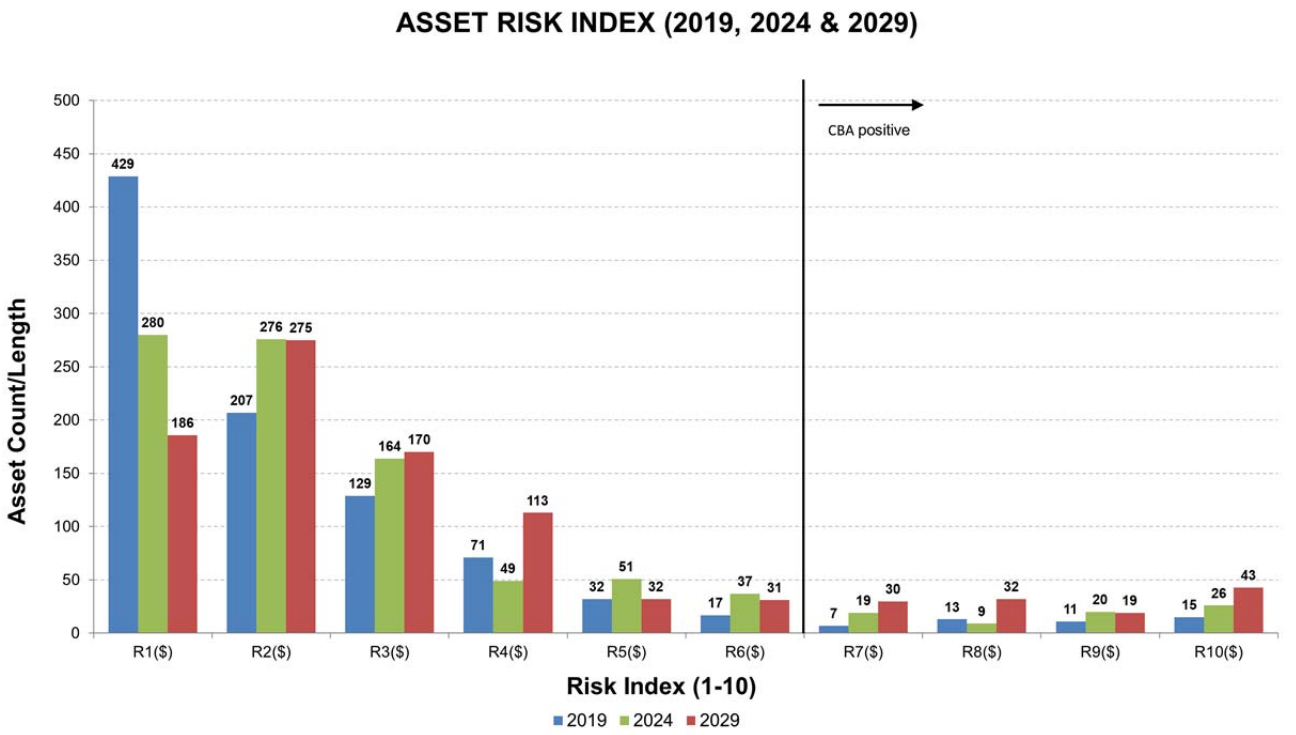
Based on the analysis completed, the model output is supporting the replacement of 74 CBD transformers by the end of FY24. This includes a total of 12 CBD transformers which have been committed in FY19 and a total of 62 CBD transformers which are cost benefit positive between FY20 to FY24.

In forming this decision Ausgrid considered three options and performed sensitivity analysis as described in this document. Ausgrid is recommending Option 3 – levelled replacement of all assets cost benefit positive by the end of FY24 for this asset category.

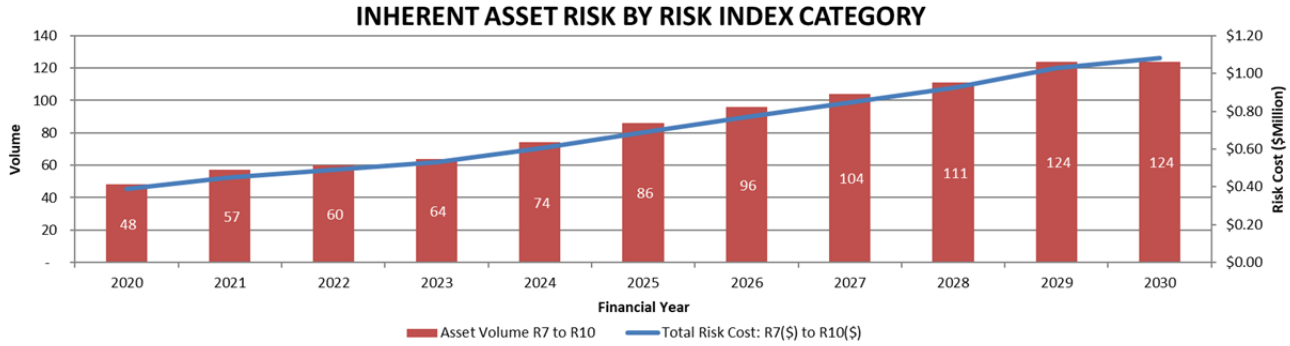
Risk Index

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
[2] Attachment 5.13.M.11 – Pole Top Substations program CBA summary
[3] Attachment 5.13.M.9 – Distribution Substations program CBA summary



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

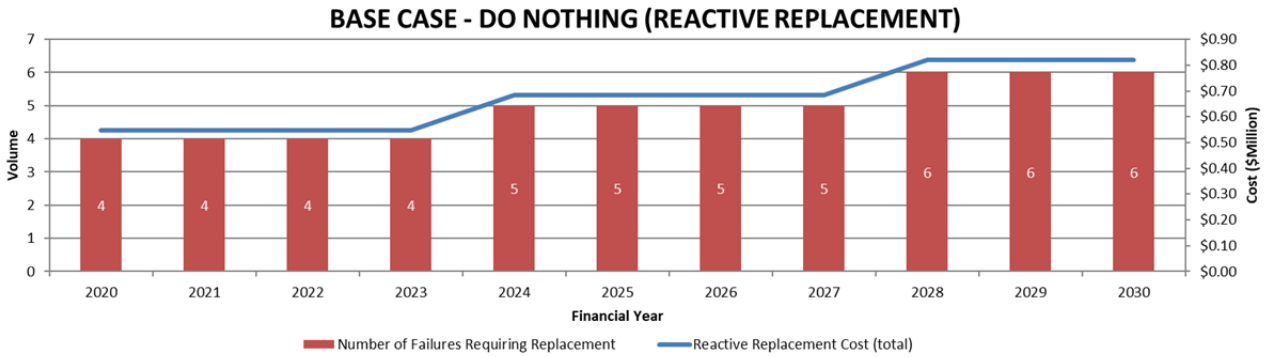


Option One – Base Case (Reactive Replacement)

Under a base case scenario, if Ausgrid were to adopt a reactive replacement strategy, the minimum replacement quantity during FY20 to FY24 is 21 CBD 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	4	4	4	4	5

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



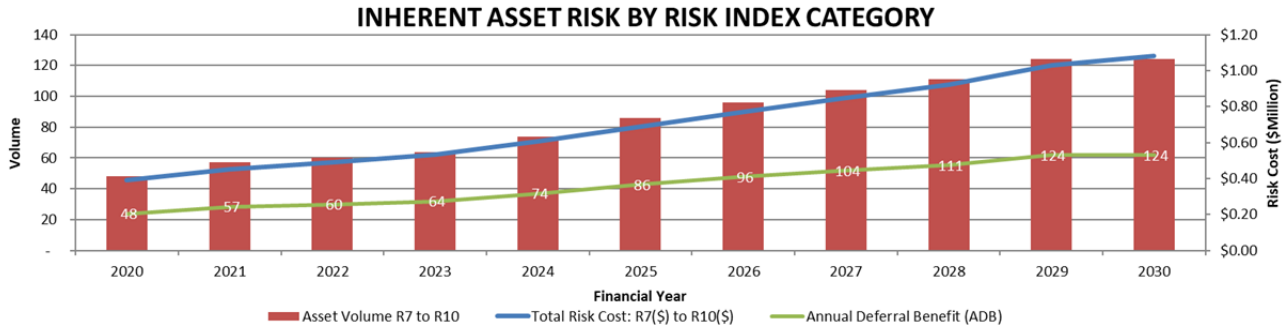
Option Two – Replace where cost benefit positive

Given Ausgrid plans to replace 12 CBD transformers in FY19, the recommended replacement quantity from the model is 62 CBD transformers. The table below shows the year in which these assets should be replaced based on when the benefit to customers exceeds the annualised deferral benefit:

Financial Year	FY20	FY21	FY22	FY23	FY24
Quantity for replacement	36	9	3	4	10

The large quantity in FY20 is due to a backlog of CBD transformers which are cost benefit positive.

Based on this replacement quantity, the annual deferral benefit against the inherent risk for all assets included in and above Risk Index 7 is shown in the figure below. The annual deferral benefit remains lower than the total risk as Ausgrid is not targeting any assets that are not cost benefit positive.



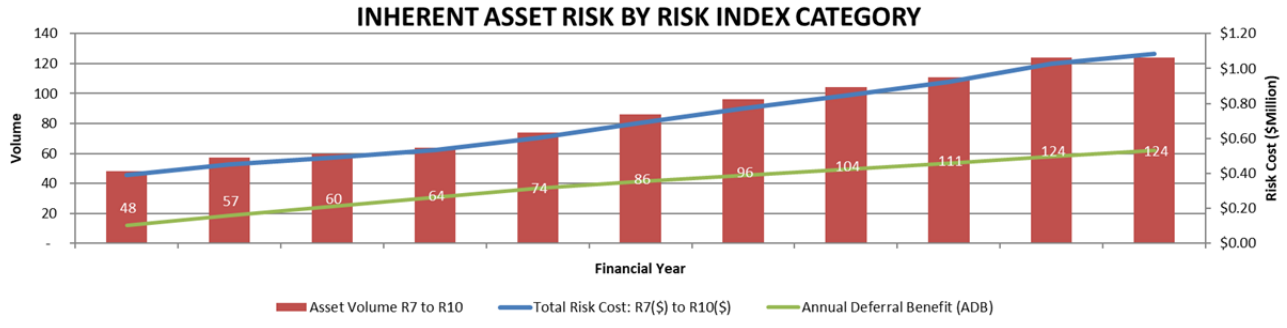
This option provides the maximum benefit to customers as it leads to the avoidance of risk at the point at which the benefits exceed the costs. However, the large delivery requirement in FY20 will not be reasonably achievable due to the constraints on network access, physical access and staff resourcing.

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

Given the delivery constraints, under this option Ausgrid have considered the levelled replacement of all CBD transformers that are cost benefit positive by the end of FY24. This results in approximately 12 transformers being replaced in the first three years and 13 transformers replaced in the last two years.

Financial Year	FY20	FY21	FY22	FY23	FY24
Quantity for replacement	12	12	12	13	13

Based on this replacement quantity, the annual deferral benefit against the inherent risk for all assets above Risk Index 7 is shown in the figure below.



This option balances achieving value for customers with consideration of the constraints associated with efficient delivery.

Data input

		Data Source
Population	931	SAP – Asset Register
Object Types	TX_DIST – Distribution transformer	SAP – Asset Register
Conditional & Functional Failures / Time Period	571 failures 6 years	SAP – Defect Records
Asset standard life	45.89 years	RAB life
WACC	3.90%	Regulated Rate

Planned Cost

Given the variation in annual cost, a weighted average for the period per asset was used in this model.

Cost	Data Source
$114,021	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.

	Chamber Tx	Underground Tx
β_{good}	3.0092	4.4677
η_{good}	60.2921	67.0844
$\beta_{average}$	3.0576	4.7033
$\eta_{average}$	56.5020	54.3423
β_{poor}	3.1060	4.9388
η_{poor}	53.0574	44.9140
b (intercept)	-12.3352	-18.7910

Adjustments factors

Probability of Failure (PoF)	• Actual Failure Data • Age • Equipment construction type (conservator style)
Probability of Consequence (PoC)	• Substation configuration (e.g. basement)

Model calculated failures

	2020	2021	2022	2023	2024
Failures	37	39	41	43	46

Sensitivity

Ausgrid tested the sensitivity of the applied grossly disproportionate factor by applying a factor of 3 for all safety and fire severities. The impact of these changes is a 50% reduction to the overall recommended replacement quantities within the FY20 to FY24 period. The model is therefore highly sensitive to the grossly disproportionate factor.

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 – 0.10% (Ausgrid's recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 4,469,292	0.00011	10	0.110	260
Major	$ 446,929	0.00015	8	0.150	191
Moderate	$ 44,693	0.00020	6	0.200	143
Minor	$ 4,469	0.00025	4	0.250	115
Insignificant	$ 447	0.00029	2	0.290	99

Average **safety** consequence per asset: $5,511 per event.

As there have been no known events of distribution transformers resulting in fatalities, Ausgrid have proposed a lower probability of severities for CBD transformers due to the reduced exposure risk with a fatality occurring event 260 years (~250 years). Changing the probability of severity to 0.220 (or 1 fatality every 130 years), increases the average safety consequence by 89% and increases the recommended replacements by 32 planned over the FY20 to FY24 period. Changing this to 0.055 (or 1 fatality every 521 years), reduces the average safety consequence by 45% and reduces the recommended replacements by 10 planned over the FY20 to FY24 period.

Fire
ICR – 0.67% (Industry recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 66,000,000	0	10	n/a	n/a
Major	$ 6,600,000	0.000067	8	0.010	427
Moderate	$ 660,000	0.001005	6	0.150	29
Minor	$ 66,000	0.002010	4	0.300	14
Insignificant	$ 6,600	0.003618	2	0.540	7.9

Average **fire** consequence per asset: $8,096 per event.

Due to the location of these assets being within a substation, the risk of a severe fire incident was low enough that the probability of consequence for severe events was set to zero. Changing the probability of severity for major fire events to 0.020 (or 1 major fire every 214 years), increases the average fire consequence by 44% and increases the recommended replacements by 21 planned over the FY20 to FY24 period. Changing this to 0.05 (or 1 major fire every 855 years), reduces the average fire consequence by 22% and reduces the recommended replacements by 9 planned over the FY20 to FY24 period.

Environment
ICR – 1.47% (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	0.000059	1	0.004	487
Moderate	$ 1,019,312	0.000118	1	0.008	244
Minor	$ 101,931	0.001470	1	0.100	20
Insignificant	$ 10,193	0.013054	1	0.888	2.2

Average **environment** consequence per asset: $ 671 per event.

Due to the location of these assets being within a substation, the risk of a severe environmental incident was low enough that the probability of consequence was set to zero. Changing the probability of severity for major environmental events to 0.008 (or 1 major environmental incident every 244 years), increases the average environmental consequence by 40% and does not change the recommended replacements over the FY20 to FY24 period. Changing this to 0.002 (or 1 major environmental incident every 974 years), reduces the average

environmental consequence by 20% and reduces the recommended replacements by 3 planned over the FY20 to FY24 period. 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	CBD	Data Source
Proportion of failures resulting in unserved energy	21%	OMS - 3 year average
VCR	$47.49/kWh	AEMO / AER
Average interruption duration	5.03 hrs	OMS - 3 year average
Time without supply	1.03 hrs	Calculated

Average **loss of supply** consequence per asset: $23,761 per event.

Finance

		Data Source
Annual deferral benefit of reactive	$5,136	20% increase on planned replacement cost applied at the WACC
Repair cost	$3,627	FY13-FY18 actuals (Direct '19)
Proportion replaced	10%	SAP – Asset Register
Weighted replacement/repair cost	**$3,778**	Calculated
Maintenance original asset per annum	$0	Based on historical maintenance
Maintenance replacement asset per annum	$0	Based on historical maintenance
Maintenance benefit per asset per annum	**$0**	Calculated

Average **financial** consequence/benefit per asset: $3,778 per event.

AVERAGE TOTAL CONSEQUENCE per asset: $41,817 (including POC x C($))