Revised Proposal

Attachment 5.13.M.7

Circuit Breakers (excludes switchboards) program CBA summary

January 2019

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Introduction

Ausgrid has reviewed the risks associated with circuit breakers by undertaking a quantitative risk assessment. This model covers the full range of circuit breaker voltages and insulation mediums as well as those integrated into switchboards (excluding switchboards already accounted for in Area Plans) and those that are standalone. 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:

- Switchgear - < = 11 KV ; Circuit Breaker
- Switchgear - > 22 KV & < = 33 KV ; Circuit Breaker
- Switchgear - > 33 KV & < = 66 KV ; Circuit Breaker
- Switchgear - > 66 KV & < = 132 KV ; Circuit Breaker

This excludes 11kV switchboards which were individually analysed as part of the Area Plan planning process (refer to separate document[2]). This model is used as an input to the distribution substation model[3], so that entire substations that are cost benefit positive under the distribution substation model, are excluded from this program (it is noted that there are no kiosk or outdoor enclosure substations containing circuit breakers that are cost benefit positive during FY20 to FY24).

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.

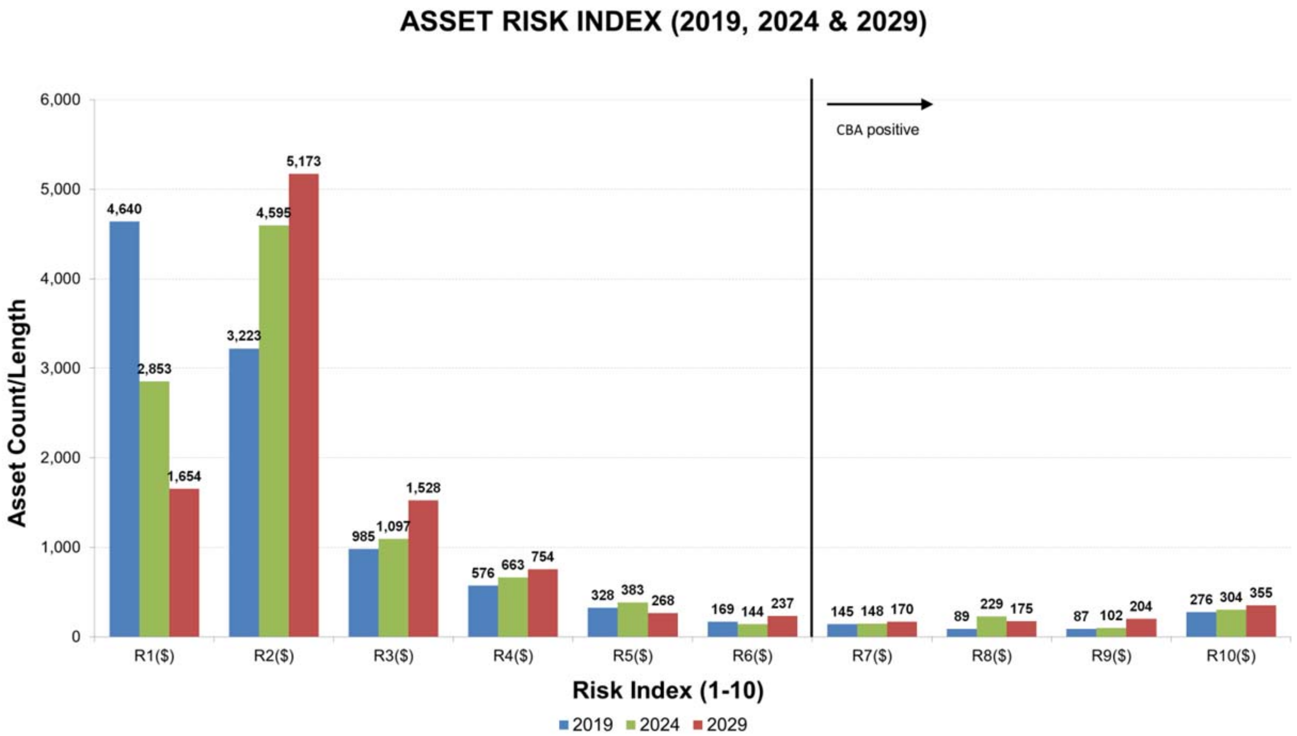
Based on the analysis completed, the model output is supporting the replacement of 783 circuit breakers by the end of FY24. This includes a total of 206 circuit breakers which have been committed in FY19 and a total of 577 circuit breakers which are cost benefit positive between FY20 to FY24.

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.

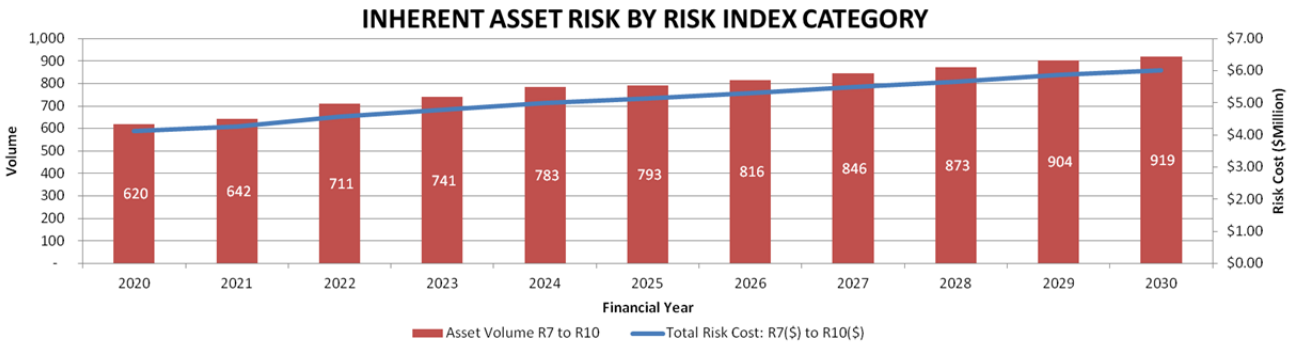
Risk Index

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 5.14.1 – Project justification for 11kV switchgear
[3] Attachment 5.13.M.9 – Distribution Substations program CBA summary



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

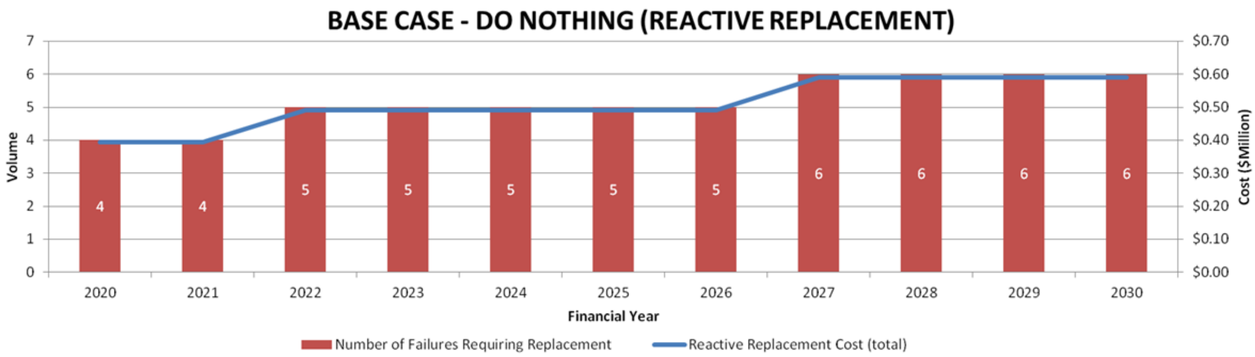


Option One – Base Case (Reactive Replacement)

Under a base case scenario, if Ausgrid were to adopt a reactive replacement strategy, the minimum replacement quantity during FY20 to FY24 is 23 circuit breakers. 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	5	5	5

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

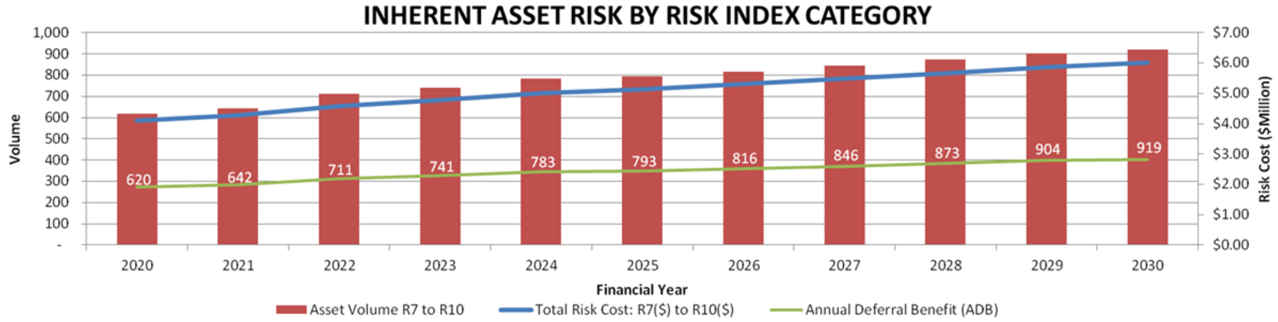


Option Two – Replace where cost benefit positive

Given Ausgrid plans to replace 206 circuit breakers in FY19, the recommended replacement quantity from the model is 577 circuit breakers. 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	414	22	69	30	42

The large quantity in FY20 is due to a backlog of circuit breakers which are cost benefit positive. 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. The annual deferral benefit remains lower than the total risk as Ausgrid is not targeting any assets that are not cost benefit positive.



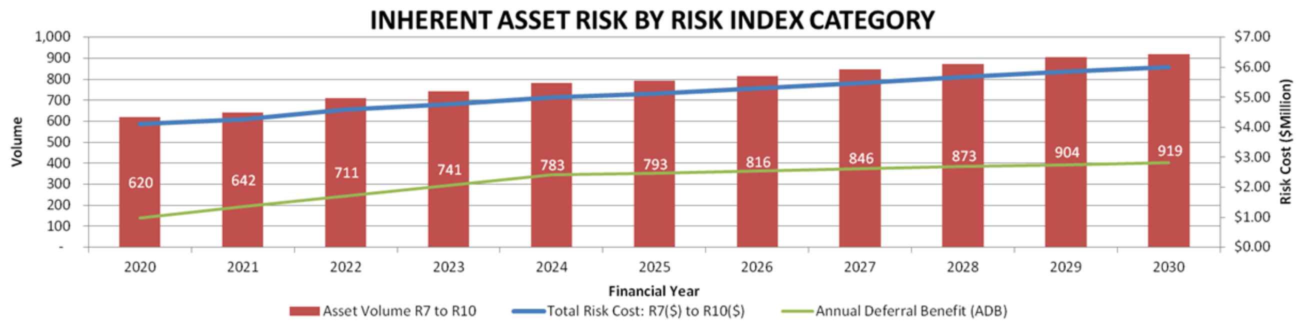
This option provides the maximum benefit to customers as it leads to the avoidance of risk at the point at which the benefits exceed the costs. However, the large delivery requirement in FY20 will not be reasonably achievable due to the constraints on network access, physical access and staff resourcing.

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

Given the delivery constraints, under this option Ausgrid have considered the replacement of all circuit breakers that are cost benefit positive by the end of FY24. This results in approximately 115 circuit breakers being replaced for the first three years and 116 circuit breakers in the last two years.

Financial Year	FY20	FY21	FY22	FY23	FY24
Quantity for replacement	115	115	115	116	116

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 by the end of FY24 with consideration of the delivery constraints.

Data input

		Data Source
Population	10,518	SAP – Asset Register
Object Types	SW_HV_CB – HV Circuit Breaker SW_HV_RMCB – Ring Main Circuit Breaker SW_HV_FLTT – Fault Thrower SW_LV_CB – LV Circuit Breaker SW_LV_NP – LV Network Protector	SAP – Asset Register
Conditional & Functional Failures / Time Period	2464 failures 6 years	SAP – Defect Records
Asset standard life	46.84 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
$81,969	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.

	Sub transmission CB	HV CB	LV CB
β_{good}	1.4498	1.8998	2.2171
η_{good}	21.9087	33.2254	48.8767
$\beta_{average}$	1.4999	1.9240	2.2636
$\eta_{average}$	19.7620	31.7912	45.1250
β_{poor}	1.5500	1.9482	2.3101
η_{poor}	17.9449	30.4523	41.7953
b (intercept)	-4.4754	-6.6555	-8.6231

Adjustments factors

Probability of Failure (PoF)	• Actual Failure Data • Age • Insulation resistance
Probability of Consequence (PoC)	• Insulation type • Voltage level

Model calculated failures

	2020	2021	2022	2023	2024
Failures	430	448	467	485	503

Sensitivity

Ausgrid tested the sensitivity of the applied grossly disproportionate factor by applying a factor of 3 to safety and fire consequences, based on the worker safety risk. The impact of these changes is a 3% reduction to the overall recommended replacement quantities. Therefore the model is not overly 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 – 0.12% (Ausgrid recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 4,469,292	0.000024	10	0.020	101
Major	$ 446,929	0.000048	8	0.040	51
Moderate	$ 44,693	0.000096	6	0.080	25
Minor	$ 4,469	0.000240	4	0.200	10
Insignificant	$ 447	0.000792	2	0.660	3.1

Average **safety** consequence per asset: $1,275 per event.

Ausgrid have proposed that inherently a fatality would occur due to a failure of a circuit breaker every 101 years based on a recent fatality experienced within the industry. Changing the probability of severity to 0.040 (or 1 fatality every 51 years), increases the average safety consequence by 84% and increases the recommended replacements by 19 planned over the period. Changing this to 0.010 (or 1 fatality every 203 years), reduces the average safety consequence by 42% and reduces the recommended replacements by 14 planned over the period.

Fire

ICR – 0.15% (Ausgrid's 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	0.0000015	8	0.001	1,623
Moderate	$ 660,000	0.0000240	6	0.016	101
Minor	$ 66,000	0.0001500	4	0.100	16
Insignificant	$ 6,600	0.0013245	2	0.883	1.8

Average **fire** consequence per asset: $231 per event.

Due to the location of these assets being within a substation, the risk of a severe fire incident was considered implausible such that the probability of consequence was set to zero. Changing the probability of severity for a major fire to 0.002 (or 1 major fire every 812 years), increases the average fire consequence by 35% and increases the recommended replacements by 8 planned over the period. Changing this to 0.0005 (or 1 major fire every 3,247 years), reduces the average fire consequence by 17% and does not change the recommended replacements.

Environment

ICR – 0.12% (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	0.0000012	1	0.001	2,029
Moderate	$ 1,019,312	0.0000120	1	0.010	203
Minor	$ 101,931	0.0003000	1	0.250	8.1
Insignificant	$ 10,193	0.0008868	1	0.739	2.7

Average **environment** consequence per asset: $57 per event.

Due to the location of these assets being within a substation, the risk of a severe environmental incident was considered negligible, such that the probability of consequence was set to zero. Changing the probability of severity for a major environmental incident to 0.002 (or 1 major environmental incident every 1,015 years), increases the average fire consequence by 11% and does not change the recommended replacements. Changing this to 0.0005 (or 1 major environmental incident every 4,058 years), reduces the average environmental consequence by 4% and does not change the recommended replacements. 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	LV	HV	Sub-transmission	Data Source
Proportion of failures resulting in unserved energy	10%	12%	2%	OMS - 3 year average
VCR	$40.73/kWh	$40.73/kWh	$40.73/kWh	AEMO / AER
Average interruption duration	3.9 hrs	2.3 hrs	1.7 hrs	OMS - 3 year average
Time without supply	0.39 hrs	0.28 hrs	0.03 hrs	Calculated

Average **loss of supply** consequence per asset: $14,130 per event.

Finance

		Data Source
Annual deferral benefit of reactive	$3,692	20% increase on planned replacement cost applied at the WACC
Repair cost	$2,765	FY13-FY18 actuals (Direct '19)
Proportion replaced	1%	SAP – Asset Register
Weighted replacement/repair cost	**$2,774**	Calculated
Maintenance original asset per annum	$478	Based on historical maintenance
Maintenance replacement asset per annum	$236	Based on historical maintenance
Maintenance benefit per asset per annum	**$242**	Calculated

Average **financial** consequence/benefit per asset: $3,016 per event.

AVERAGE TOTAL CONSEQUENCE per asset: $18,709 (including POC x C($))