Revised Proposal

Attachment 5.13.M.19

High Voltage CBD Isolator and Earth Switches program CBA summary

January 2019

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Introduction

Ausgrid has reviewed the risks associated with CBD distribution substation high voltage isolator and earth (I&E) switches by undertaking a quantitative risk assessment. These assets were identified for individual analysis based on the unique design of the Sydney CBD underground substations in which they are installed. 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 - <= 11KV; Switch

Also included in this RIN category are:

- High voltage fuse switches and RMUs (refer to separate document[2]),
- Air Break Switches (refer to separate document[3]), and
- Distribution Substations where the whole substation is cost benefit positive (refer to separate document[4]).

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.

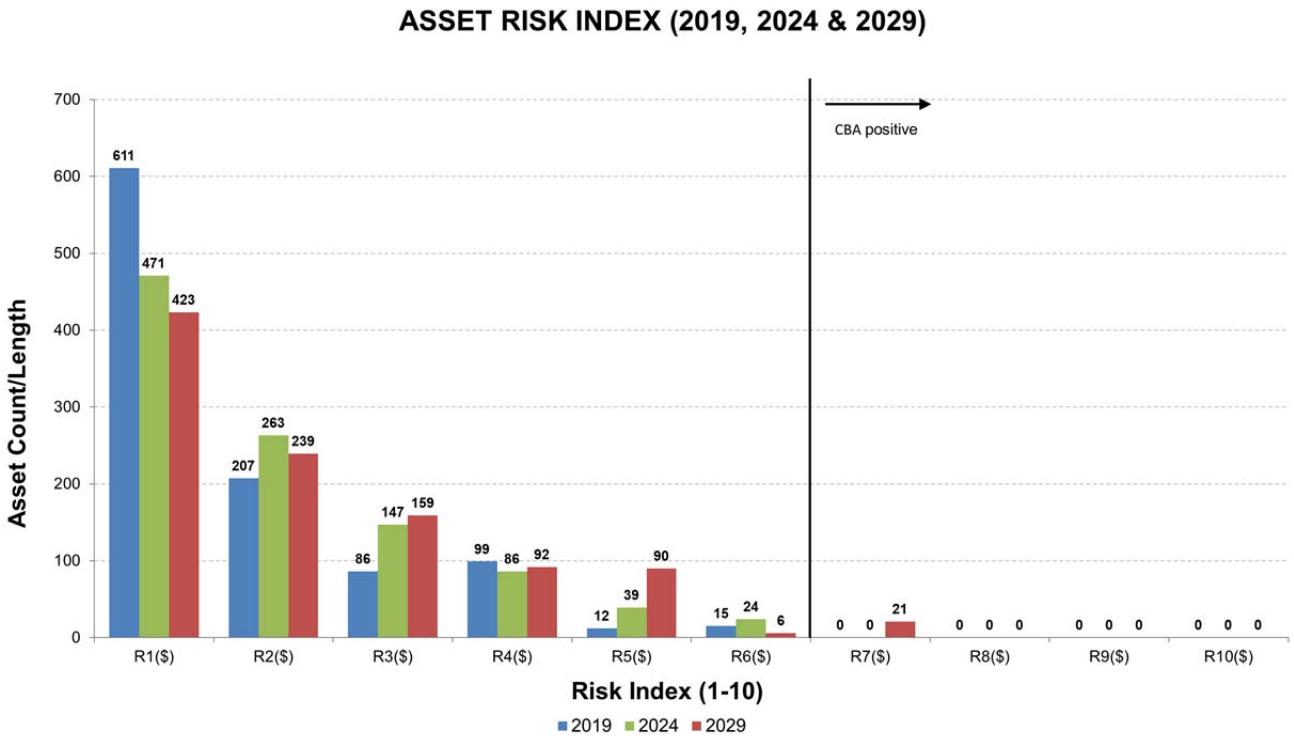
Ausgrid has committed to 21 CBD I&E switches being replaced in FY19. Based on the analysis completed, the model output is supporting the reactive replacement of a further 21 CBD I&E switches by the end of FY24.

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. Ausgrid notes that this is a key change from the previous strategy of planned replacement. This change is predominately driven by the network configuration of the CBD providing additional redundancy, reducing the unserved energy risk. However, the current version of the model does not account for the impact of multiple failures (second order events), which would lead to larger outage impacts. This will be considered in future versions of the model.

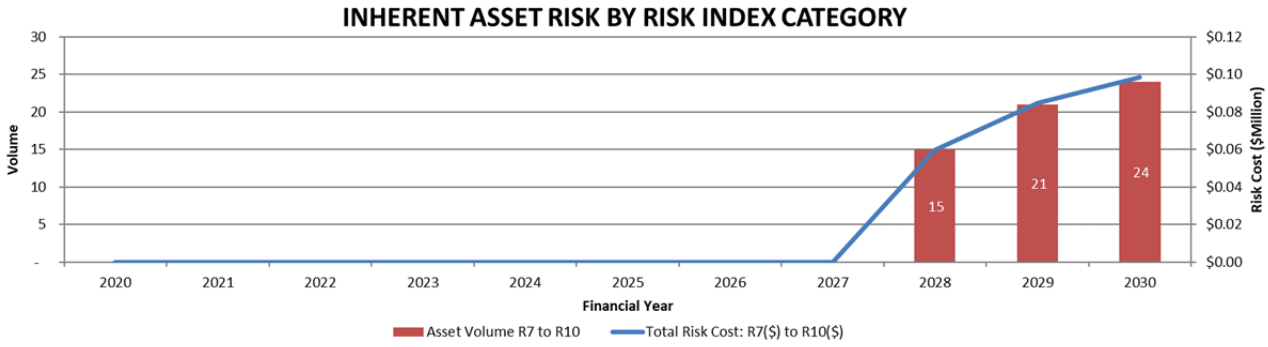
Risk Index

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.8 - High Voltage Fuse Switches program CBA summary
[3] Attachment 5.13.M.12 - High Voltage Air Break Switches program CBA summary
[4] Attachment 5.13.M.9 - Distribution Substations program CBA summary



The inherent risk of CBD I&E switches that are cost benefit positive is shown in the figure below, this shows that in the future the strategy for these assets may change between options.



Option One – Base Case (Reactive Replacement)

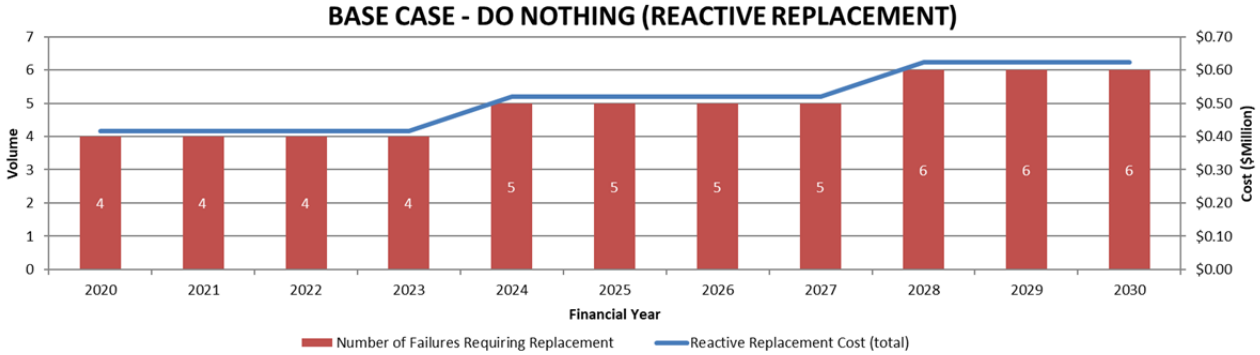
Under a base case scenario, if Ausgrid were to adopt a reactive replacement strategy, the minimum replacement quantity during FY20 to FY24 is 21 CBD I&E Switches. The table below shows the quantity of assets which will require reactive replacement in the year that they are forecast to fail.

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.

Due to the need for switches within an individual substation to be the same construction due to the linkage of protection and safety systems, it is anticipated that each failure will result in a substation of 3 worth of replacements.

Attachment 5.13.M.19 – High Voltage CBD Isolator and Earth Switches program CBA summary



Option Two – Replace where cost benefit positive

Given the model shows no CBD I&E switches 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 CBD I&E switches as cost benefit positive before the end of FY24, this option is not considered as supported.

Data input

		Data Source
Population	1,030	SAP – Asset Register
Object Types	SW_HV_ISOL – HV Isolator	SAP – Asset Register
Conditional & Functional Failures / Time Period	59 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
$104,020	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}	2.5802	$\beta_{average}$	2.7574	β_{poor}	2.9345
η_{good}	121.5250	$\eta_{average}$	89.2742	η_{poor}	68.0704

b (intercept)	-12.3853

Adjustments factors

Probability of Failure (PoF)	• Age • Insulation type
Probability of Consequence (PoC)	• Insulation type

Model calculated failures

	2020	2021	2022	2023	2024
Failures	9	10	10	11	11

Sensitivity

Ausgrid tested the sensitivity of the applied grossly disproportionate factor by applying a factor of 3, for all safety and fire severities. 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 – 4.00% (Ausgrid's recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 4,469,292	0.00110	10	0.0275	101
Major	$ 446,929	0.00200	8	0.050	56
Moderate	$ 44,693	0.00600	6	0.150	19
Minor	$ 4,469	0.01200	4	0.300	9.3
Insignificant	$ 447	0.01890	2	0.473	5.9

Average **safety** consequence per asset: $58,153 per event.

These switches are unique to Ausgrid's Sydney CBD network. Ausgrid have proposed that inherently a fatality would occur due to a failure of a CBD I&E switch every 101 years based on the unknown rating capacity of a number of legacy equipment construction types. Changing the probability of severity to 0.055 (or 1 fatality every 50 years), increases the average safety consequence by 85% and increases the recommended replacements by 126 planned at the end of FY24. Changing this to 0.014 (or 1 fatality every 199 years), reduces the average safety consequence by 41% and does not impact the recommended reactive replacement quantity at the end of FY24.

Fire

ICR – 0.62% (Minimum industry recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 66,000,000	0	10	0.000	n/a
Major	$ 6,600,000	0	8	0.000	n/a
Moderate	$ 660,000	0.0011036	6	0.178	101
Minor	$ 66,000	0.0018600	4	0.300	60
Insignificant	$ 6,600	0.0032364	2	0.522	34

Average **fire** consequence per asset: $4,904 per event.

Due to the construction type and location of these assets being within a substation, the risk of severe or major fires was low enough that the probability of consequence was set to zero. Changing the probability of severity for moderate fire events to 0.356 (or 1 moderate fire every 50 years), increases the average fire consequence by 89% and increases the recommended replacements by 15 planned until the end of FY24. Changing this to 0.089 (or 1 moderate fire every 202 years), reduces the average fire consequence by 44% and does not impact the recommended reactive replacement quantity until the end of FY24.

The model overall is insensitive to changes in the probability of severity for fire risk.

Environment

ICR – 0.26% (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	0.000	n/a
Major	$ 4,558,501	0	1	0.000	n/a
Moderate	$ 1,019,312	0	1	0.000	n/a
Minor	$ 101,931	0.00026	1	0.100	428
Insignificant	$ 10,193	0.00234	1	0.900	48

Average **environment** consequence per asset: $50 per event.

Due to the location of these assets being within a substation, the risk of severe, major or moderate environmental damage was low enough that the probability of consequence was set to zero. The model overall is insensitive to changes in the probability of severity for environmental 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). With the Sydney CBD, the network is configured in a triplex system and therefore the failure of a single unit would not typically result in unserved energy, however the model does not consider the percentage of time the CBD triplex network is switched abnormally or multiple events. In these instances significant unserved energy could be experienced within the Sydney CBD.

Outage Type	CBD	Data Source
Proportion of failures resulting in unserved energy	0%	OMS - 3 year average
VCR	$47.49/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.

Ausgrid has tested the sensitivity of applying outages for 5% and 10% of failures using a bottom up built restoration/repair time, this has negligible effect on the model and does not support replacements beyond the reactive quantities.

Finance

		Data Source
Annual deferral benefit of reactive	$3,905	20% increase on planned replacement cost applied at the WACC
Repair cost	$4,665	FY13-FY18 actuals (Direct '19)
Proportion replaced	43%	SAP – Asset Register
Weighted replacement/repair cost	**$4,338**	Calculated
Maintenance original asset per annum	$24	Based on historical maintenance
Maintenance replacement asset per annum	$24	Based on historical maintenance
Maintenance benefit per asset per annum	**$0**	Calculated

Average **financial** consequence/benefit per asset: $4,338 per event.

AVERAGE TOTAL CONSEQUENCE per asset: $67,445 (including POC x C($))