Revised Proposal

Attachment 5.13.M.8

High Voltage Fuse Switches program CBA summary

January 2019

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Introduction

Ausgrid has reviewed the risks associated with High Voltage Fuse Switches (fuse switches and RMUs) by undertaking a quantitative risk assessment. The population of fuse switches and RMUs has had a number of condition issues and the oil insulation medium is considered to have a higher risk to workers. 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 CBD Isolator and Earth Switches (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]).

This model is used as an input to the distribution substation model[4], so that substations that are also cost benefit positive for replacement have not been included in the forecast for this program.

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.

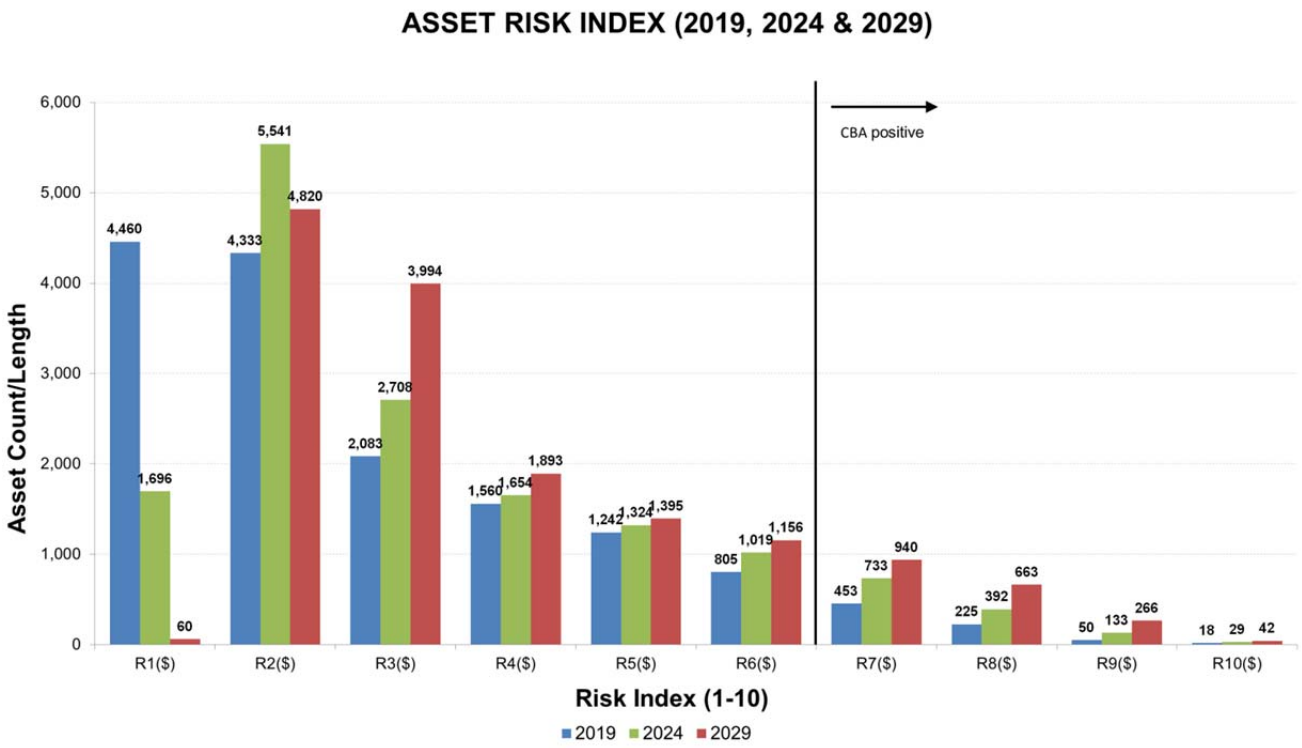
Based on the analysis completed, the model output is supporting the replacement of 1,287 fuse switches by the end of FY24. This includes a total of 191 fuse switches which have been committed in FY19 and 104 fuse switches where the entire substation replacement is cost benefit positive.

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.

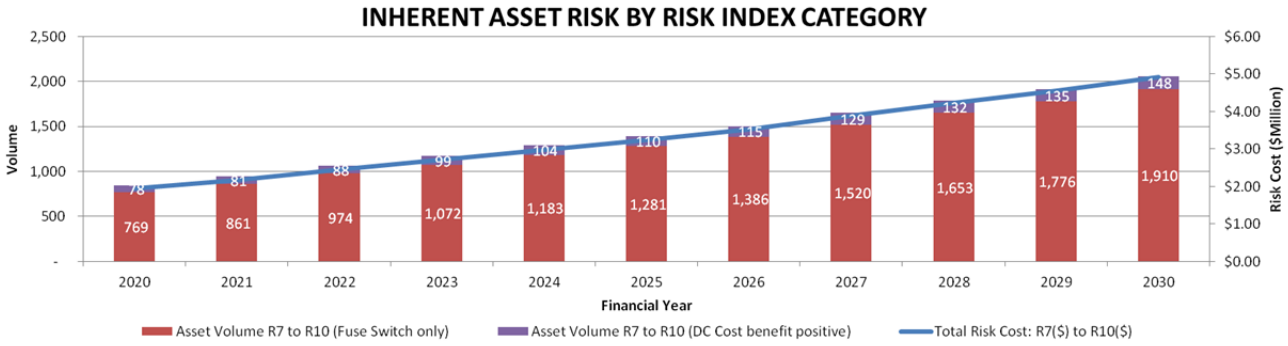
Risk Index

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.19 – High Voltage CBD Isolator and Earth 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 fuse switches and RMUs that are cost benefit positive is shown in the figure below. Those where the entire distribution substation is also cost benefit positive have been separated, as shown graphically below, and are not included in the quantities forecast within this program.

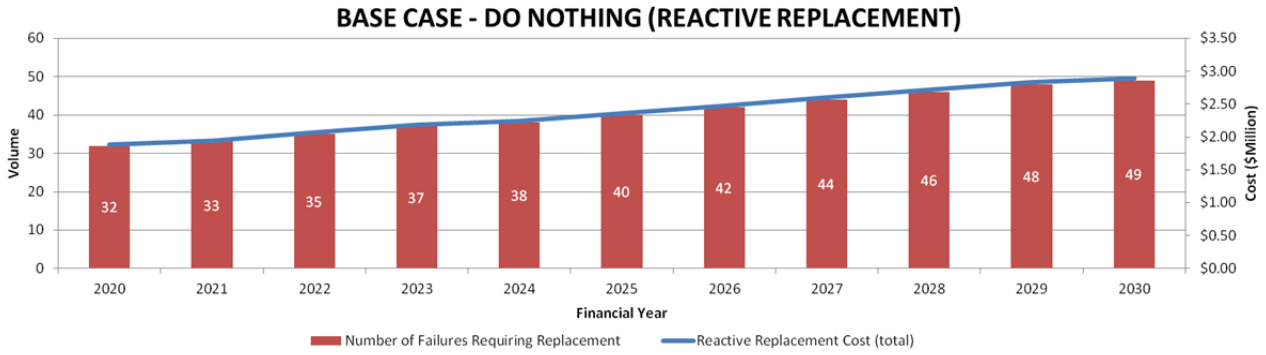


Option One – Base Case (Reactive Replacement)

Under a base case scenario, if Ausgrid were to adopt a reactively replace strategy, the minimum replacement quantities during FY20 to FY24 is 175 fuse switches and RMUs. 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	32	33	35	37	38

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



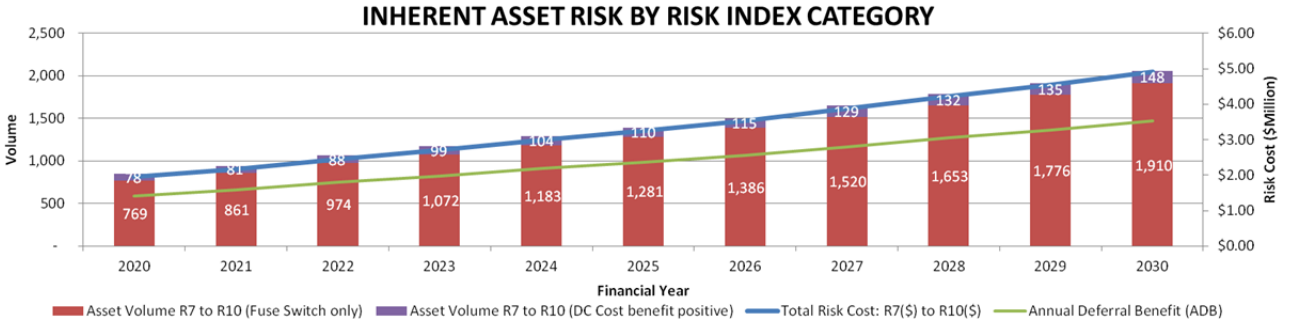
Option Two – Replace where cost benefit positive

Given Ausgrid plans to replace 191 fuse switches and RMUs in FY19 as well as 104 being cost benefit positive for the entire distribution substation replacement, the recommended replacement quantity for the FY20 to FY24 period is 992 switches. 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	578	92	113	98	111

The large quantity in FY20 is due to a backlog of switches which are cost benefit positive and using this option would all be replaced in the first year.

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.



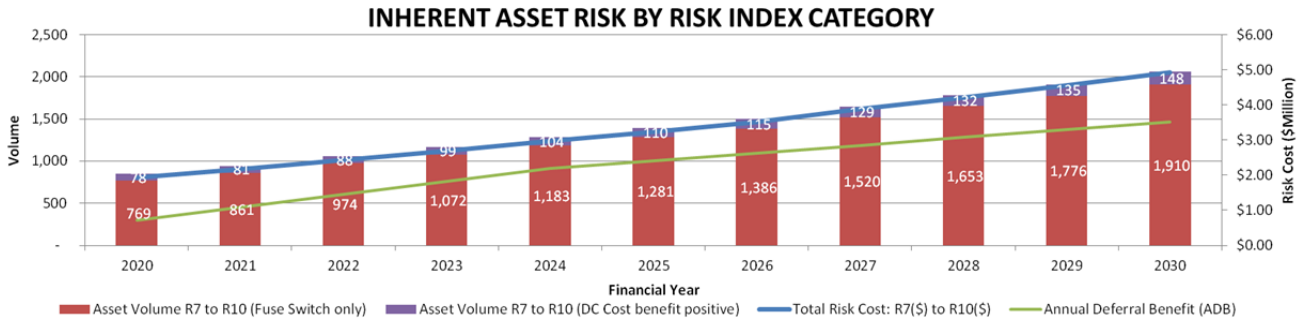
This option provides the maximum benefit to customers as it leads to the avoidance of risk at the point at which the benefits exceed the costs. However, the large delivery requirement in FY20 will not be reasonably achievable due to the constraints on network access, physical access and staff resourcing.

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 switches that are cost benefit positive by the end of FY24. This results in 198 switches being replaced in the first three years and 199 switches being replaced in the last 2 years.

Financial Year	FY20	FY21	FY22	FY23	FY24
Quantity for replacement	198	198	198	199	199

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 between FY20 and FY24 with consideration of the delivery constraints.

Data input

		Data Source
Population	15,229	SAP – Asset Register
Object Types	SW_HV_FS – HV Fuse Switch SW_HV_RMU – Ring Main Isolator Unit	SAP – Asset Register
Conditional & Functional Failures / Time Period	754 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
$49,176	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}	2.3439	$\beta_{average}$	2.3762	β_{poor}	2.4084
η_{good}	71.6242	$\eta_{average}$	67.5860	η_{poor}	63.8747

b (intercept)	-10.0117

Adjustments factors

Probability of Failure (PoF)	• Age • Years since last intrusive maintenance – Oil equip. only • Distance from coast (km) – SF6/Cast Resin equip. only
Probability of Consequence (PoC)	• Substation Configuration Type • Equipment Insulation Type

Model calculated failures

	2020	2021	2022	2023	2024
Failures	132	139	146	153	160

Sensitivity

Ausgrid tested the sensitivity of the applied grossly disproportionate factor by applying a factor of 3 to safety and fire consequences, based on worker safety. The impact of these changes is a 33% reduction to the overall recommended replacement quantities. The model is therefore highly sensitive to the grossly disproportionate factor applied.

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

Worker Safety ICR – 0.48% (Industry recorded ICR)
Physical Impact ICR – 0.25% (Industry recorded ICR)
Shock ICR – 0.25% (Industry recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 4,469,292	0.00008	10	0.008	102
Major	$ 446,929	0.00049	8	0.050	16
Moderate	$ 44,693	0.00147	6	0.150	5.4
Minor	$ 4,469	0.00294	4	0.300	2.7
Insignificant	$ 447	0.00482	2	0.492	1.7

Average **safety** consequence per asset: $5,707 per event.

Ausgrid have proposed that inherently a fatality would occur due to a failure of a fuse switch or RMU every 100 years based on experiences within industry where fatalities have occurred recently. Changing the probability of severity to 0.016 (or 1 fatality every 51 years), increases the average safety consequence by 61% and increases the recommended replacements by 227 planned over the period. Changing this to 0.005 (or 1 fatality every 203 years), reduces the average safety consequence by 31% and reduces the recommended replacements by 122 planned over the period.

Fire

ICR – 0.79% (Ausgrid's recorded ICR)

Severity	Cost of Consequence	Probability of Consequence	Grossly DF	Probability of Severity	Years until event
Severe	$ 66,000,000	0.00000079	10	0.0001	10,073
Major	$ 6,600,000	0.00000790	8	0.004	252
Moderate	$ 660,000	0.00079000	6	0.100	10
Minor	$ 66,000	0.00158000	4	0.200	5.0
Insignificant	$ 6,600	0.00552131	2	0.696	1.4

Average **fire** consequence per asset: $5,808 per event.

Due to the construction type and location of these assets being within a substation, the risk of severe or major fires was insignificant so that the probability of severity was set to a low value of a major consequence every 252 years and severe every 10,073 years. However substation fires are experienced due to switches so an appropriate probability of severity for the remaining consequences was calibrated. Changing the probability of severity to 0.0002 for a severe fire (or 1 every 5,037 years), increases the average fire consequence by 9% and increases the recommended replacements by 31 planned over the period. Changing this to 0.00005 (or 1 every 20,146 years), reduces the average fire consequence by 4% and reduces the recommended replacements by 18 planned over the period.

Environment

ICR – 0.95% (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	0.000095	1	0.010	84
Minor	$ 101,931	0.002850	1	0.300	2.8
Insignificant	$ 10,193	0.006555	1	0.690	1.2

Average **environment** consequence per asset: $454 per event.

Due to the location of these assets being within a substation, the risk of severe and major environmental damage was considered negligible so that the probability of consequence was set to zero. Varying the

probability of severity for moderate environmental events results in a change of less than 0.5%. 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).

Outage Type	HV	Data Source
Proportion of failures resulting in unserved energy	32%	OMS - 3 year average
VCR	$40.73/kWh	AEMO / AER
Average interruption duration	2.70 hrs	OMS - 3 year average
Time without supply	0.86 hrs	Calculated

Average **loss of supply** consequence per asset: $44,550 per event.

Finance

		Data Source
Annual deferral benefit of reactive	$2,215	20% increase on planned replacement cost applied at the WACC
Repair cost	$5,170	FY13-FY18 actuals (Direct '19)
Proportion replaced	24%	SAP – Asset Register
Weighted replacement/repair cost	**$4,461**	Calculated
Maintenance original asset per annum	$250	Based on historical maintenance
Maintenance replacement asset per annum	$23	Based on historical maintenance
Maintenance benefit per asset per annum	**$227**	Calculated

Average **financial** consequence/benefit per asset: $4,688 per event.

AVERAGE TOTAL CONSEQUENCE per asset: $61,207 (including POC x C($))