HV air-break switches: CRO tagged interrupters

PAL BUS 4.04

Regulatory proposal 2021–2026

Powercor

January 2020

Contents

1 Overview

Business	Powercor
Title	HV air-break switches: CRO tagged interrupters
Project ID	PAL BUS 4.04 - HV ABS replacement program - Jan2020 - Public
Category	Replacement
Identified need	The identified need is to maintain a reliable supply of electricity to customers as selected types of air-break switches installed on our network are deemed obsolete for safety reasons.
Recommended option	Continue to replace all CRO-tagged air-break switches over a 12-year period
Proposed start date	2019
Proposed commission date	Ongoing
Supporting documents	PAL MOD 4.02 - HV ABS replacement program - Jan2020 - Public

Source: Powercor

In 2016, we experienced a number of safety incidents where expulsion interrupters fitted to high voltage (**HV**) switches failed when the switch was being opened. As a safety precaution, all air-break switches fitted with specific expulsion interrupters were tagged 'caution refer operations' (**CRO**), and deemed inoperable.

This business case considers the impact to our customers from the non-operation of these switches. This impact is primarily seen through increased planned outages.

As set out in our options analysis section, we commenced implementation of the preferred option in the second half of 2019.

The forecast capital expenditure requirements for the 2021–2026 regulatory period, for the preferred option, are outlined in table 1. These forecasts were modelled in calendar year terms, and converted to financial year estimates following changes to our reporting period (as required by the Victorian Government and the Australian Energy Regulator).

Table 1 Expenditure forecasts for preferred option ($ million, 2019)

Expenditure forecast	2021/22	2022/23	2023/24	202/254	2025/26	Total
Capital expenditure	1.32	1.32	1.32	1.32	1.32	6.61

Source: Powercor

2 Background

Outdoor HV distribution switchgear installed on our overhead distribution network allow us to isolate sections of the HV network for maintenance, augmentation and rectification of faults.

2.1 Existing population

The existing population of outdoor HV switches on our network is set out in table 2.

Table 2 Outdoor HV switch population (2019)

Type	Volume
Gas insulated switchgear	1,770
Gevea-branded air-break switches	2,031
Non-Gevea branded air-break switches	1,629

Source: Powercor

2.2 Existing asset management approach

The existing asset management approach for HV distribution switchgear differs depending on the switchgear type. An overview of the existing asset management approach for each of these types is provided below.

2.2.1 Gas insulated switchgear

Gas insulated switchgear are currently the preferred option for all new and replacement switches on our network. They are typically mounted on a buck-arm below the HV circuit.

These switches are cheaper to purchase than other switch types, and as they do not have an earth, no earth testing is required and there is minimal risk to the operator should the switch fail. There is no cyclic maintenance required and the switch can be automated for an incremental cost during installation if required.

2.2.2 Gevea branded air-break switches

Gevea branded air-break switches have been our preferred air-break switch since 2002. These switches are slightly more expensive to purchase and install than an equivalent gas insulated switch, and unlike gas insulated switchgear, they require a 20-year maintenance cycle.

Our asset age data indicates our population of Gevea branded air-break switches is predominately around 20-years old.

2.2.3 Non-Gevea branded air-break switches

Our non-Gevea branded air-break switches were installed on our network from the 1930–2000s. Only limited data exists regarding the make and/or model of these switches, and they are subject to a 20-year maintenance cycle.

These switches have a higher failure rate than gas insulated or Gevea branded air-break switches, and are generally unrepairable. There is a high likelihood that most of these switches are reaching the end of their useful lives.

These switches are also handle operated, and therefore pose a risk to the operator if failure occurs.

3 Identified need

The identified need is to maintain a reliable supply of electricity to customers as selected types of air-break switches installed on our network are deemed obsolete for safety reasons. These performance and safety factors are discussed in detail below.

3.1 Failure experience

In 2016, we experienced an increasing number of safety incidents where expulsion interrupters fitted to HV air-break switches failed when the switch was being opened (i.e. they did not perform the intended arc suppression function). This resulted in switch operators being showered with debris.

Expulsion interrupters are devices fitted to HV air-break switches that provide a second path for current to flow, with a spring-assisted extinguishing mechanism to break the arc once the main contacts are sufficiently far apart. These expulsion interrupters were introduced to our network in the early 1990s and became the preferred interrupter choice for new or retro-fitted switches.

Specifically, three models of expulsion interrupters are installed on our network:

- EziBreak (ABB Taplin)
- DuoGap (A.B. Chance)
- DoubleBreak (NGK Stanger)

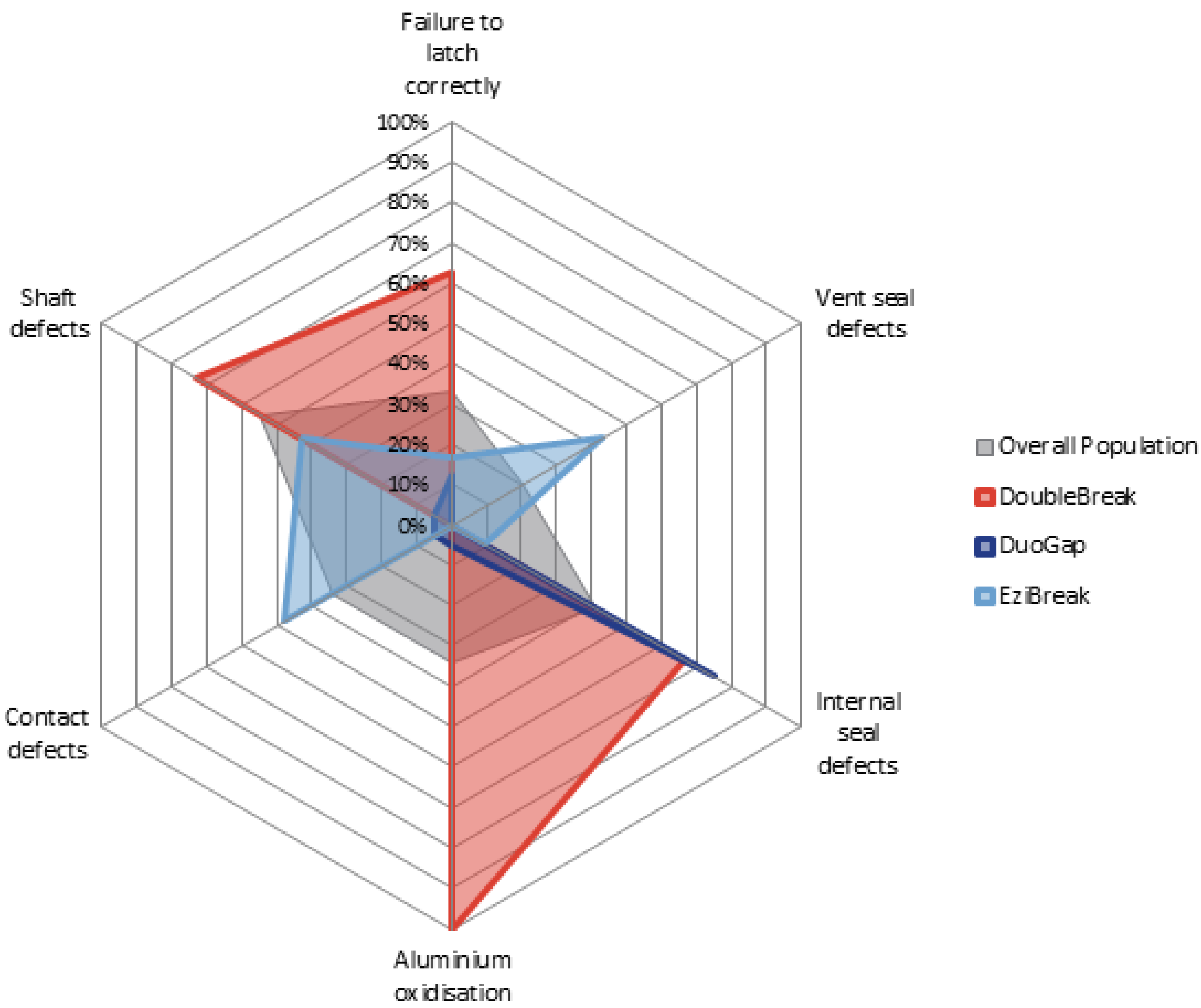
In total, approximately 25% of our HV air-break switchgear population are fitted with EziBreak, DuoGap or DoubleBreak expulsion interrupters.

3.2 Defect analysis

Following these safety incidents, 47 units were taken out of service for further examination. These units were used to better understand the observed defect types. These defect types are shown in appendix A.

The sample analysis found high defect rates with each type of expulsion interrupter, and that no single external factor was responsible for the high failure rates. A summary of this analysis is set out in figure 1.

Figure 1 Defect rate analysis: summary



Source: Powercor

It was also found that a condition inspection of in-service units would not provide a reliable assessment, and that after opening, the units cannot be economically repaired.

4 Options analysis

Several options were considered to address the identified need of maintaining a reliable supply of electricity to customers as selected types of air-break switches installed on our network are deemed obsolete for safety reasons. These options address the identified need to varying extents, and as such, our analysis considers which option maximises the net economic benefits. This assessment of net economic benefits is presented relative to a 'do-nothing' scenario.

As shown in table 3, option two—accelerate the replacement of CRO-tagged switches over a 7-year period—maximises the net economic benefits to customers. Our preferred option, however, is to continue to replace all CRO-tagged air-break switches over a 12-year period (which has a similar benefits case, but lower immediate costs to customers).

Table 3 Summary of net economic benefits relative to the do-nothing option ($ million, 2019)

	Option	Net economic benefits
Do-nothing	Retain defective switches in a permanently inoperable state	-
1	Continue to replace all CRO-tagged air-break switches over a 12-year period	56.7
2	Accelerate replacement of CRO-tagged air-break switches over a shorter (7-year) period	58.7
3	Extend replacement of CRO-tagged air-break switches over a longer (17-year) period	46.0

Source: Powercor

The options considered are discussed in further detail below. The analysis supporting our assessment of alternative options, including relevant assumptions, is included in the attached model.[1]

4.1 Assessment of credible options

4.1.1 Do nothing: retain defective switches in a permanently inoperable state

The 'do-nothing' option does not involve any capital expenditure. Under this option, we would retain the defective switches in our network in a permanently inoperable state. There are currently 920 CRO-tagged air-break switches on our network.

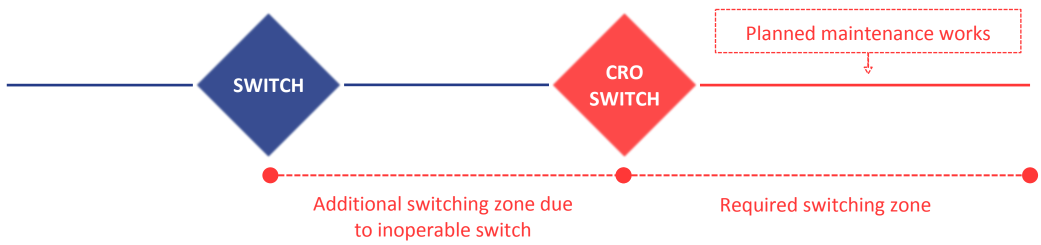
As these switches are inoperable there are no on-going maintenance costs. There is also no safety risk associated with this option.

This option, however, will increase planned outages faced by our customers. For example, where the switch immediately upstream of the planned works is deemed inoperable, a switch further upstream will need to be operated.[2] As shown in figure 2, this results in an additional switching zone of customers without supply.

1 PAL MOD 4.02 - HV ABS replacement program - Jan2020 - Public

2 Upstream means closer to the source of electrical current.

Figure 2 Additional switching zone due to CRO-tagged switch



Source: Powercor

Our modelling for this option recognises that some CRO-tagged switches can be opened when they are de-energised. This reduces the time customers in the additional switching zone are off supply. As there are many different possible network configurations, we have estimated the average planned outage impact due to CRO-tagged switches using the following assumptions:

- the value of customer reliability (**VCR**) for a planned outage is equal to 25% of the VCR for unplanned outages, which is consistent with previous regulatory decisions (where a value for planned outages has been assigned)[3]
- the proportion of CRO-tagged switches that can be opened when they are de-energised is equal to 24% (reflecting the proportion of DoubleBreak and EziBreak switches in the CRO-tagged population; these types cannot be operated)
- each switching zone has the same demand for the purposes of determining the unserved energy, based on a network average value, as it is impracticable to model the demand associated with each defective switch
- the average time of a planned outage is equal to 6 hours, whereas the operation of a de-energised switch typically takes 45 minutes
- the reliability impact on unplanned outages of this option is expected to be small, as fault current is interrupted by circuit breakers rather than switches; hence, the impact of defective switches on unplanned outages is excluded from the assessment.

A summary of the market benefits and costs of this option is shown in table 4. The impact of other options are compared to this value to derive the benefits of those options (and hence, the net economic benefits are 'base-lined' to zero in table 3).

Table 4 Do-nothing: benefits assessment ($ million, 2019)

Option	NPV costs	NPV benefits	Net economic benefits
Retain defective switches in a permanently inoperable state	-	-130.9	-130.9

Source: Powercor

[3] The Essential Services Commission of Victoria previously applied a value of 25% of the VCR for unplanned outages.

4.1.2 Option one: continue to replace all CRO-tagged air-break switches over a 12-year period

This option involves continuing our existing program to replace all CRO-tagged air-break switches over a 12-year period. This program commenced in the second half of 2019, and is scheduled to be completed by 2030.

The costs of this option are based on recent observed material costs, and our average labour cost for installing gas insulated switches over the period 2016–2018. Gas insulated switches are the preferred option for all new and replacement switches on our network, and have lower life-cycle costs than other alternatives.

The benefits of this option are equal to the sum of the avoided planned outages from additional switching zones, minus the impact of the planned outage to replace the corresponding switch. In estimating the impact on customers when replacing the switch, we have assumed a level of job-bundling can be achieved with existing planned outages (i.e. as much as possible, CRO-tagged switch replacements will be aligned with existing planned outages to avoid the need for additional outages; capped at a maximum of 50% in any given year).

This option addresses the identified need, and has similar net economic benefits to option two (which maximises net economic benefits). A summary of the market benefits and costs of this option relative to the do-nothing option is shown in table 5.

Table 5 Option one: benefits assessment ($ million, 2019)

Option	NPV costs	NPV benefits	Net economic benefits
Continue to replace all CRO-tagged air-break switches over a 12-year period	-12.8	69.5	56.7

Source: Powercor

4.1.3 Option two: accelerate replacement of CRO-tagged air-break switches over a 7-year period

This option involves accelerating our existing CRO-tagged switch replacement program to be completed by 2025.

The costs and benefits of this option have been calculated consistently with the assumptions set out under option one. A summary of the market benefits and costs of this option relative to the do-nothing option is shown in table 6.

Table 6 Option two: benefits assessment ($ million, 2019)

Option	NPV costs	NPV benefits	Net economic benefits
Accelerate replacement of CRO-tagged air-break switches over a shorter (7-year) period	-13.6	72.3	58.7

Source: Powercor

4.1.4 Option three: extend replacement of CRO-tagged air-break switches over a 17-year period

This option involves extending our existing CRO-tagged switch replacement program to be completed over a longer timeframe, by 2035.

The costs and benefits of this option have been calculated consistently with the assumptions set out under option one. A summary of the market benefits and costs of this option relative to the do-nothing option is shown in table 7.

Table 7 Option three: benefits assessment ($ million, 2019)

Option	NPV costs	NPV benefits	Net economic benefits
Extend replacement of CRO-tagged air-break switches over a longer (17-year) period	-12.0	58.0	46.0

Source: Powercor

4.2 Sensitivity analysis

A sensitivity assessment was performed to review the impact on the ranking of the options from varying the rate of job-bundling possible under different timeframes. This assumption is subject to a level of engineering judgement, as actual data is not readily available. Specifically, we tested the impact of increasing and decreasing this assumption by 10%.

The preferred option provided net economic benefits above the do-nothing scenario for all scenarios. Similarly, the relative ranking of the options remained the same under each scenario.

5 Recommendation

The preferred option, as set out in section 4, is to continue to replace all CRO-tagged air-break switches over a 12-year period. The forecast capital expenditure requirements for the 2021–2026 regulatory period are outlined in table 8.

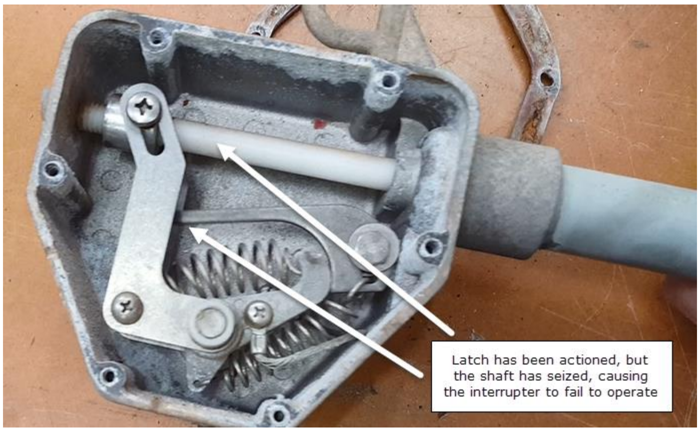
Table 8 Expenditure forecasts for preferred option ($ million, 2019)

Expenditure forecast	2021/22	2022/23	2023/24	202/254	2025/26	Total
Capital expenditure	1.32	1.32	1.32	1.32	1.32	6.61

Source: Powercor

A Defect types

Figure 3 Defect type: failure to latch correctly



Source: Powercor

Figure 4 Defect type: vent seal blockages

Source: Powercor

Figure 5 Defect type: internal seal defects

Source: Powercor

Figure 6 Defect type: aluminium oxidisation

Source: Powercor

Figure 7 Defect type: damage to contacts

Source: Powercor

Figure 8 Defect type: poor shaft condition

Source: Powercor