Mitigating REFCL reliability impacts

PAL BUS 4.05 - Mitigating REFCL reliability impacts - Jan2020 - Public

Regulatory proposal 2021–2026

Powercor

January 2020

Contents

1 Overview

Business	Powercor Australia
Title	Mitigating reliability impacts of Rapid Earth Fault Current Limiters (**REFCLs**)
Project ID	PAL BUS 4.05 - Mitigating REFCL reliability impacts - Jan2020 - Public
Category	Replacement capital expenditure
Identified need	Our existing network protection devices, automatic circuit reclosers (**ACRs**) and fuses, are not compatible with REFCLs. As a result, customers serviced by zone substations with REFCLs will experience a material deterioration in reliability. The identified need is to mitigate the reliability deterioration and reduce the value of unserved energy resulting from the incompatibility of REFCLs and traditional protection devices.
Recommended option	Option 1 – mitigate reliability impacts by replacing our existing traditional ACRs with smart ACRs on feeders supplied by zone substations where REFCLs are installed.
Proposed start date	2021/22
Proposed commission date	2023/24
Supporting documents	1. PAL MOD 4.03 - Smart ACR cost - Jan2020 - Public 2. PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public 3. PAL ATT094 - Bushfire mitigation plan - Dec2019 - Public 4. PAL ATT205 - ESV - acceptance of BMP - Dec2019 - Public 5. PAL ATT221 - REFCL T1 - Mar2017 - Public 6. PAL ATT222 - REFCL T2 - Apr2018 – Public 7. PAL ATT223 - REFCL T3 - Aug2019 – Public

We are required to progressively install Rapid Earth Fault Current Limiters (**REFCLs**) at 22 zone substations during 2018–2023 to comply with the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016 (**Amended Bushfire Mitigation Regulations**) which were implemented in Victoria on 1 May 2016. We currently have REFCLs installed at eight zone substations.

A REFCL is a network protection device, normally installed in a zone substation, which can reduce the risk of a fallen powerline causing a fire-start. It is capable of detecting when a powerline has fallen to the ground and (almost instantaneously) reduces the voltage on the fallen line.

Upon detecting a phase to ground fault, REFCLs operate almost instantaneously to isolate supply at the circuit breaker. REFCLs detect and isolate faults more quickly than our traditional network protection devices, automatic circuit reclosers (**ACR**) and fuses, which are located along the feeder downstream of the circuit breaker. Consequently, phase to ground faults occurring downstream of our ACRs and fuses are isolated by the REFCL at the circuit breaker rather than being isolated along the feeder by the ACR or fuse. This means that more customers are being taken off supply, for faults occurring downstream of ACRs and fuses.

In effect our existing traditional ACRs and fuses are not compatible with the REFCL technology because they cannot respond as quickly to detect and isolate supply.

Experience with REFCLs on our network to date demonstrates that significantly more customers are being taken off supply, for phase to ground faults occurring downstream of ACRs and fuses. This is resulting in a detrimental impact for customers supplied by zone substations with REFCLs installed. The impact to customers will worsen over time as more REFCLs are installed on our network. The table below demonstrates the value of unserved energy experience to date and the modelled annual impact once we have REFCLs operating at 22 zone substations.

Table 1 Value of unserved energy due to incompatibility of REFCLs and traditional protection devices, $m 2021

	July 2018 to October 2019 8 REFCL ZSs	Modelled annual impact 22 REFCL ZS
Value of unserved energy	3.1	20.7

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public

We are working closely with specialist vendors to develop more modern 'smart' ACRs, which are compatible with REFCLs. These smart ACRs will operate to detect and isolate supply on the feeder, downstream of the circuit breaker, before the REFCL isolates supply at the circuit breaker. Replacing our existing traditional ACRs with smart ACRs would mitigate some of the reliability impact of REFCLs on our network.

We have considered two options for addressing this issue, as shown in the table below.

Table 2 Options for addressing reliability impacts of REFCLs during 2021–2026 regulatory period, $m June 2021

Option	Description	Capex	Value of unserved energy due to REFCL incompatibility
0	Do nothing - do not replace traditional ACRs with smart ACRs	0.0	94.7
1	Mitigate reliability impacts - replace traditional ACRs with smart ACRs on REFCL network	13.0	50.4

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public and PAL MOD 4.03 - Smart ACR cost - Jan2020 - Public

We recommend option 1 to mitigate the reliability impacts of REFCLs by replacing our traditional ACRs with smart ACRs which are compatible with REFCL technology. This option will prevent customers located upstream of the ACR from experiencing poorer reliability than before REFCLs were installed.

2 Background

2.1 Requirement to install REFCLs

On 1 May 2016, the Amended Bushfire Mitigation Regulations were implemented in Victoria. The Amended Bushfire Mitigation Regulations require our bushfire mitigation plan (**BMP**) to include details of the preventative strategies and programs by which we will ensure each polyphase electric line originating from selected zone substations in our network meet specified capacity requirements. The Amended Bushfire Mitigation Regulations specify the timeframes by which the selected zone substations must meet these capacity requirements. That is, schedule two of the Amended Bushfire Mitigation Regulations assigns a number of 'points' to each of the selected zone substations. We are then required to ensure the following:[1]

- at 1 May 2019, the points set out in schedule two [of the Amended Bushfire Mitigation Regulations] in relation to each zone substation upgraded, when totalled, are not less than 30
- at 1 May 2021, the points set out in schedule two in relation to each zone substation upgraded, when totalled, are not less than 55
- on and from 1 May 2023, in our supply network, each polyphase electric line originating from every zone substation specified in schedule two has the required capacity.

To achieve this regulatory obligation we are installing REFCLs at 22 zone substations in three tranches as shown in the table below.

Figure 1 REFCL installation program

	Tranche 1				Tranche 2				Tranche 3			
Count	*Station*	*Actual Install*	*Required Capacity*	*Points*	*Station*	*Planned Install [1]*	*Required Capacity*	*Points*	*Station*	*Planned Install [1]*	*Required Capacity*	*Points*
1	Gisborne	Apr-17	Aug-18	3	Ararat	Nov-19	Dec-20	1	Corio	Nov-22	Dec-22	1
2	Camperdown	Apr-18	Oct-18	4	Ballarat North	Jun-20	Dec-20	4	Geelong	Nov-22	Dec-22	4
3	Castlemaine	May-18	Feb-19	4	Ballarat South	Oct-20	Dec-20	5	Hamilton	Oct-21	Dec-22	2
4	Eaglehawk	Nov-18	Mar-19	5	Bendigo	Aug-20	Dec-20	1	Koroit	Aug-21	Dec-22	2
5	Maryborough	Jun-18	Feb-19	5	Bendigo TS	Nov-20	Dec-20	5	Merbein	Nov-21	Dec-22	1
6	Winchelsea	Nov-18	Mar-19	5	Charlton	Sep-19	Dec-20	2	Stawell	Mar-22	Dec-22	1
7	Woodend	May-17	Feb-19	4	Colac	Jun-19	Dec-20	5	Waurn Ponds	Jun-22	Dec-22	4
8					Terang	Sep-20	Dec-20	2				
Subtotal				30				25				15
Total				30				55				70
Target				**30**				**55**				**70**

Source: PAL ATT094: Powercor, Bushfire Mitigation Plan, Revision 6, 9 December 2019, p. 22.

2.2 Incompatibility of REFCLs and traditional protection devices

Our traditional network protection devices include ACRs and fuses. Upon detecting a fault, ACRs and fuses operate to isolate supply. This limits the number of customers impacted by the fault to those downstream of the device.

REFCLs are a new form of protection device, which rapidly detect phase to ground faults and operate almost instantaneously to isolate supply at the circuit breaker.

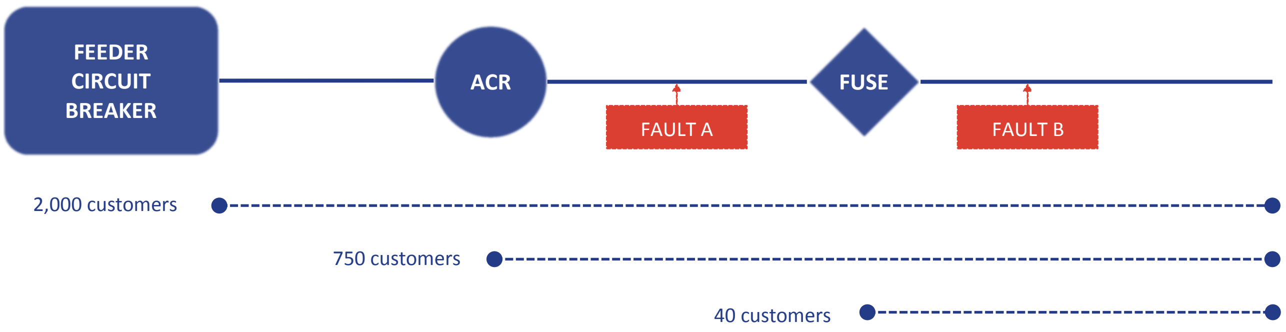
Our experience with REFCLs on our network has demonstrated that, irrespective of the operating mode, REFCLs react more quickly than our traditional protection devices to detect faults and isolate supply. Consequently, if there is a REFCL operating, phase to ground faults which would have been isolated along the feeder by our

1 Electricity Safety (Bushfire Mitigation) Regulations 2013, Authorised version no. 004, cl. 7(3)(a).

traditional protection devices are instead isolated by the REFCL at the circuit breaker. This means that more customers are taken off supply, for phase to ground faults occurring along the feeder downstream of ACRs and fuses.

The figure and table below provides two simplified examples of the impact on the number of customers impacted by a phase to ground fault with and without REFCLs.

Figure 2 Simplified example of protection devices on feeder



Source: Powercor

Table 3 Simplified example of reliability impacts from REFCLs

Example	No REFCL	REFCL	Impact of REFCL
Fault A. Fault occurs downstream of ACR	ACR operates 750 customers off supply	Circuit breaker trips 2,000 customers off supply	Additional 1,250 customers off supply
Fault B. Fault occurs downstream of fuse	Fuse operates 40 customers off supply	Circuit breaker trips 2,000 customers off supply	Additional 1,960 customers off supply

Source: Powercor

The almost instantaneous speed at which REFCLs operate is not compatible with our existing traditional protection devices because they cannot respond as quickly to detect faults and isolate supply along the feeder. The traditional protection devices have therefore become redundant on our REFCL network for phase to ground faults.

2.3 Reliability impacts on our network

We currently have eight REFCLs in operation and our customers are already experiencing significant deteriorations in network reliability. We are able to directly measure the incremental reliability impact on our customers from the incompatibility of REFCLs and traditional protection devices. This is because we know the fault location and how many customers are located between each protection device and the circuit breaker.

The table below demonstrates the deterioration in reliability already experienced by our customers as a result of the REFCLs isolating supply at the circuit breaker before our traditional protection devices could operate.

Table 4 Actual reliability impact on our customers between July 2018 and October 2019

Zone substation	Date operational	No. of events	Unserved energy, MWh	Value of unserved energy, $m
GSB	December 2016	7	14.9	0.7
WND	June 2017	8	4.2	0.2
CDN	April 2018	4	3.0	0.1
MRO	September 2018	3	5.4	0.2
CMN	September 2018	2	8.4	0.4
WIN	December 2018	2	2.5	0.1
EHK	December 2018	4	16.2	0.7
CLC	June 2019	8	15.4	0.7
Total		**38**	**70.0**	**3.1**

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public. The model also provides the full list of faults where additional customers have been impacted due to REFCLs operating before traditional protection devices.

The impact on our customers resulting from the incompatibility of REFCLs and our traditional protection devices is characterised by recent experience in Apollo Bay.

Our customers in Apollo Bay are protected by a REFCL installed at our Colac (**CLC**) zone substation. This REFCL was commissioned in 2018.

Since commissioning of this REFCL, our Apollo Bay auto-loop scheme has not been operable. Auto-loop schemes rely on ACRs to automatically switch supply after a fault. As a result, the community in Apollo Bay have experienced an increase in the number of outages.

The feedback from our customers has been widely publicised, particularly the impact on our business customers:

> *"We're trying to run businesses, we've got people's livelihoods that are going to be impacted significantly if something's not done."*
>
> *"Obviously we're gearing up for a busy season and it's not just Apollo Bay. I imagine it's a lot of country towns where this system has been implemented, they're going to be in the same situation. We're going into our busiest time of the year, we're not going to be able to function, we're not going to be able to open the door."*
>
> *“We can’t get a generator because it’s not worth it to outlay $10,000 to $15,000.”*
>
> *“In winter the food can keep. But in summertime we have to throw everything out if it lasts too long."*
>
> *“We’ve got 23 apartments here, [we’ve] got international guests that we’re charging reasonable money – it’s not a budget place – and they expect the air conditioners to work and the lights to work.”*

We listened to our customers, and in September 2019 we chose to temporarily disable the CLC REFCL.

3 Identified need

3.1 Reliability impacts in future

The reliability impact on our customers from the incompatibility of REFCLs and traditional protection devices will worsen over time as more REFCLs are installed on our network. In accordance with the Amended Bushfire Mitigation Regulations and our BMP, we are required to have REFCLs operating at 22 of our zone substations by 2023.

The reliability impact of REFCLs will differ by zone substation depending on the configuration of the network. There will be greater impacts on customers on zone substations with longer feeders for example Camperdown, Castlemaine and Maryborough. This is because there are more customers located along the feeder between the traditional protection devices and the circuit breaker. As discussed above, there is also significant impact on customers in Apollo Bay, served by the Colac zone substation, which rely on an autoloop scheme.

We have modelled the impact on reliability which will occur once we have REFCLs installed at the 22 Zone substations. Our modelling is based on five years of recent historical fault data at each zone substation prior to the installation of REFCLs:

- tranche 1 (excl. Colac zone substation) - 2011/12 to 2015/16
- tranches 2 (incl. Colac zone substation) and 3 - 2014/15 to 2018/19. [2]

The historical fault data captures the percentage of faults which are phase to ground, the fault location relative to fuses, ACRs and the circuit breaker, and the number of customers located between fuses, ACRs and the circuit breaker.

Using this data we calculate the additional customer minutes off supply (**CMOS**) resulting from the incompatibility of REFCLs with our traditional protection devices. We convert this to the quantum of unserved energy and then apply the value of customer reliability[3] to calculate the lost value to customers of unserved energy.

The table below provides the increase in unserved energy per annum that would occur as a result of incompatibility of REFCLs and traditional protection devices, presented by tranche of REFCLs installed.

Table 5 Annual reliability impact of incompatibility of REFCLs and traditional protection devices

Tranche	Additional CMOS minutes p.a.	Unserved energy MWh p.a.	Value of unserved energy $m p.a.
Tranche 1 ZSS (excl. CLC)	6,931,889	153.0	6.8
Tranche 2 ZSS (incl. CLC)	9,663,185	213.3	9.5
Tranche 3 ZSS	4,359,624	96.2	4.3
Total	**20,954,698**	**462.4**	**20.7**

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public

2 Note we have modelled the reliability impacts at Colac zone substation as part of tranche 2 given it was only commissioned late in the 2018/2019 fire season and was placed into full operation in June 2019.

3 PAL ATT043: AEMO, Value of Customer Reliability Review, September 2014, p. 40, aggregate Victorian (excluding direct connects) escalated by CPI to $2021.

3.2 Smart ACRs

To address the reliability impacts resulting from the incompatibility of traditional network protection devices with REFCLs, we are working closely with specialist vendors to develop smart ACRs.

Smart ACRs will operate in the same way as existing ACRS but at a much faster speed, compatible with the speed of the REFCL technology. Installing smart ACRs would allow us to detect and isolate faults at the ACR, preventing customers located between the ACR and circuit breaker from experiencing a fault. The smart ACRs would therefore assist to restore our reliability performance to pre-REFCL levels for faults occurring between ACRs and fuses.

We are confident smart ACR technology will be developed during 2020, enabling us to trial the technology on our network in 2021 and then commence a smart ACR roll out program from 2021/22.

Given the criticality of this technology for restoring network reliability for our customers, our BMP states we will roll out a smart ACR replacement program to mitigate the reliability impact of REFCLs.

Unfortunately there is no foreseeable new technology which could replace our traditional fuses. Consequently, we currently do not have a solution for mitigating the deterioration of reliability for customers located downstream of fuses.

The table below demonstrates the value of unserved energy which is saved by replacing our existing ACRs with smart ACRs.

Table 6 Annual value of unserved energy saved by installing smart ACRs, $m p.a.

	Value of unserved energy with REFCL and traditional protection	Value of unserved energy with REFCL and smart ACRs	Value of energy saved by installing smart ACRs
Tranche 1 ZSS (excl. CLC)	6.8	4.0	2.8
Tranche 2 ZSS (incl. CLC)	9.5	4.4	5.1
Tranche 3 ZSS	4.3	2.8	1.5
Total	**20.7**	**11.2**	**9.4**

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public and PAL MOD 4.03 - Smart ACR cost - Jan2020 - Public

4 Options analysis

4.1 Options summary

The table below provides a summary of the costs and value of unserved energy over the 2021–2026 regulatory period for each of the identified options.

Table 7 Options Summary, capital expenditure and value of additional unserved energy over 2021–2026, $m June 2021

Option	Description	Capex	Value of unserved energy due to REFCL incompatibility
0	Do nothing - do not replace traditional ACRs with smart ACRs	0.0	94.7
1	Mitigate reliability impacts - replace traditional ACRs with smart ACRs on REFCL network	13.0	50.4

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public and PAL MOD 4.03 - Smart ACR cost - Jan2020 - Public

4.2 Option 0 – Do nothing

Option 0 involves doing nothing to mitigate the reliability impacts on our customers resulting from the incompatibility of REFCLs and traditional protection devices.

Under this option our customers will experience significant deterioration in reliability, with more customers off supply for longer duration. The number of customers impacted will increase as we progressively install REFCLs in 22 zone substations in accordance with our BMP to meet the Amended Bushfire Mitigation Regulations.

The table below demonstrates the annual impact on customers from option 0 - do nothing.

Table 8 Modelled additional value of unserved energy, per annum

Tranche	Additional CMOS, minutes p.a.	Unserved energy, kwh p.a.	Value of unserved energy, $m p.a.
Tranche 1 ZSS (excl. CLC)	6,931,889	153.0	6.8
Tranche 2 ZSS (incl. CLC)	9,663,185	213.3	9.5
Tranche 3 ZSS	4,359,624	96.2	4.3
Total	**20,954,698**	**462.4**	**20.7**

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public

Option 0 would be inconsistent with the National Electricity Rules, specially clause 6.5.7 requires we forecast the capital expenditure required to meet the capital expenditure objectives, including to maintain reliability of supply (clause 6.5.7 (3)(iii)).

Option 0 would also be inconsistent with the National Electricity Objective which is (emphasise added):

> *to promote efficient investment in, and efficient operation and use of, energy services for the long term interests of consumers of energy with respect to price, quality, safety,* ***reliability*** *and security of supply of energy.*

Therefore, option 0 is not in the long term interests of customers and is not consistent with the regulatory framework.

4.3 Option 1 – Mitigate reliability impacts

This option involves mitigating the detrimental reliability impacts caused by the incompatibility of REFCLs and our traditional protection devices. Under this option we will replace our existing traditional ACRs located on feeders supplied by the 22 zone substations where REFCLs are, or will be, installed with smart ACRs.

Under option 1 we would undertake our smart ACR replacement program as shown in the table below.

Table 9 Smart ACR roll out program

Zone substation	Year smart ACR installed	Volume of ACRs
Tranche 1 ZSS	2021/22	61
Tranche 2 ZSS	2021/22	93
Tranche 3 ZSS	2023/24	81
Total		**235**

Source: PAL MOD 4.03 - Smart ACR cost - Jan2020 - Public

For tranche 3, we expect smart ACRs to be available at the time REFCLs are installed. Therefore any ACRs being replaced as part of the hardening works to enable REFCL installation will be replaced with smart ACRs. The costs of installing these smart ACRs are therefore already captured in our tranche 3 contingent project application and our business case for the Surf Coast.[4] This business case therefore only includes the residual volume of ACRs on tranche 3 zone substations which are not planned to be replaced as part of the REFCL hardening works.

We have developed our forecast capital expenditure for installing smart ACRs based on the costing approach used in our REFCL contingent project applications,[5] as shown in the table below.

4 PAL BUS 6.01 - Surf coast supply area - Jan2020 - Public

5 Powercor cost models for REFCL contingent project applications - PAL ATT PAL ATT221 - REFCL T1 - Mar2017 - Public, PAL ATT222 - REFCL T2 - Apr2018 – Public, PAL ATT223 - REFCL T3 - Aug2019 – Public

Table 10 Expenditure forecasting approach for installing smart ACRs

Cost category	Source	Reason
Materials unit cost	ACR materials unit cost in tranche 3 contingent project application	Reflects the current material cost of traditional ACRs which we estimate to be the minimum material cost for smart ACRs
Labour unit cost	Labour unit costs for live line workers and sub-testers for the relevant geographic location based on unit rate in our tranche 1,2 and 3 applications	Reflects the current labour rates for installing traditional ACRs in the relevant geographic location
Labour installation time	Labour installation time for each ZSS based on the ACR installation time from the relevant tranche 1, 2 and 3 contingent project application	Reflects the labour time for ACR installation reflecting differences in travel times and network configuration for each ZSS

Source: Powercor

The table below provides the total forecast capital expenditure for the smart ACR roll out under option 1and the modelled value of energy saved in 2021-2026. Importantly, the benefits to customers will extend beyond the 2021-2026 period, at a value of $10m per annum.

Table 11 Smart ACR roll out, capital expenditure and value of energy saved, $m 2021

	Capital expenditure 2021-2026	Value of energy saved 2021-2026	Value of energy saved 2026-2031
Tranche 1	3.4	14.2	14.2
Tranche 2	5.3	25.7	25.7
Tranche 3	4.2	4.4	7.3
Total	**13.0**	**44.3**	**47.2**

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public and PAL MOD 4.03 - Smart ACR cost - Jan2020 - Public
Note The value of energy saved applies from 2021/22 for tranches 1 and 2 and 2023/24 for tranche 3 in accordance with the timing of the smart ACR roll out.

4.4 Recommendation

We recommend option 1 to mitigate the reliability impacts of REFCLs through a smart ACR replacement program. This option will offset the reliability impacts from the incompatibility of REFCLs with our traditional ACRs. However, reliability detriments will still occur as, at this point in time, there is no foreseeable equivalent 'smart fuse' technology to replace our traditional fuses.

The benefit to customers of installing smart ACRs at our 22 RECFL zone substations significantly outweighs the project costs, as shown in the table above.

We do not consider option 0 - do nothing - is a tenable solution. Doing nothing results in significant reliability impacts on customers which would be inconsistent with the National Electricity Rules and National Electricity Objective.

The annual costs and benefits to customers of our proposed smart ACR roll out during the 2021-2026 are provided in the table below.

Table 12 Smart ACR roll out, capital expenditure and value of saved energy over 2021-2026, $m 2021

	2021/22	2022/23	2023/24	2024/25	2025/26	Total 2021-2026
Capital expenditure	3.4	5.3	4.2	-	-	13.0
Value of saved energy	8.0	8.0	9.4	9.4	9.4	44.3

Source: PAL MOD 4.04 - Smart ACR benefits - Jan2020 - Public and PAL MOD 4.03 - Smart ACR cost - Jan2020 - Public