



North- western Geelong REFCL

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1 Overview

Business	Powercor
Title	North-western Geelong REFCL
Project ID	PAL SUPP BUS 6.11
Category	Augmentation
Identified need	The identified need addressed by this investment is, within the mandated timeframes, to meet the required capacity performance standard for particular areas served by the Geelong and Corio zone substations contained in the Amended Bushfire Mitigation Regulations, as amended by the exemption order.
Recommended option	Option 3: construct a new zone in Gheringhap with two Ground Fault Neutralisers (GFNs), which will supply specified high-voltage feeders from Geelong (GL) and Corio (CRO) zone substations as well as undertaking other required works to meet the requirements of the Amended Bushfire Mitigation Regulations and the Victorian Government Order in Council.
Proposed start date	July 2021
Proposed commission date	February 2023
Supporting documents	<ol style="list-style-type: none"> 1. PAL SUPP ATT 249: North western Geelong REFCL: Gheringhap scope 2. PAL SUPP MOD 6.17: North western Geelong REFCL cost model 3. PAL SUPP ATT 250 - CSIRO, Assessment of bushfire risk neutrality – Bannockburn zone substation, December 2018.

Source: Powercor

The forecast capital and operating expenditure requirements for the 2021–2026 regulatory period, for the preferred option, are outlined in the table below.

Table 1 Expenditure requirement for preferred option (\$ million, 2021)

Expenditure forecast	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capital expenditure	2.1	50.7	0.0	0.0	0.0	52.8
Less augmentation already accounted for	2.0	1.0	0.3	0.5	0.2	4.1
Total expenditure requirement	0.1	49.7	-0.3	-0.5	-0.2	48.7

Source: Powercor

2 Summary and background

This chapter discusses:

- summary of the benefits of this amendment to our regulatory proposal
- the requirement for installing rapid earth fault current limiters (REFCLs) in specified zone substations in our network
- the Order in Council which provides a conditional variation to the location where the REFCLs must be installed
- the reasons leading to our decision to seek the variation to the locations where we must install REFCLs.

2.1 Summary

In January 2020, we lodged our regulatory proposal with the Australian Energy Regulator (AER) to install a REFCL at the Corio (CRO) zone substation. The purpose of the capital works was to comply with the requirements of the *Electricity Safety (Bushfire Mitigations) Regulations 2013*, as amended on 1 May 2016. These regulations require us to install REFCLs at Corio and Geelong zone substations, among others.

On 28 May 2020, an Order in Council was published in the Victorian Government's Gazette which provided an exemption from installing REFCLs at Corio and Geelong on condition that a new complying zone substation is established.

In this business case, we propose to install a REFCL in Gheringhap, which we consider to be in the long term interests of consumers. Our long term planning had identified future demand growth in the north western Geelong region, driven by new residential and commercial load. We had earmarked a zone substation in the vicinity of Bannockburn by 2030. The Gheringhap REFCL project therefore serves a dual purpose – it brings forward future planned work where the driver is demand, and meets our compliance obligations to reduce the risk of our assets contributing to a fire start in high bushfire risk areas.

Based on the analysis in this business case, we no longer propose to install REFCLs in the Corio and Geelong zone substations. The feeders from these zone substations that traverse high bushfire risk areas will be transferred to Gheringhap and REFCL protected. The remaining feeders are in urban areas, and we are no longer intending to undertake costly works for the purpose of reducing the risk of our assets starting a bushfire in these areas. Also, 10 high voltage (HV) customers will also no longer be required to harden their assets to withstand the operation of the REFCLs, or isolate themselves from the network. We consider that all electricity consumers, including our HV customers, are better off under this amended proposal.

2.2 Black Saturday bushfires

Following the Black Saturday bushfires in 2009, the Victorian Government established the Victorian Bushfire Royal Commission (VBRC) to consider how bushfires can be better prevented and managed in the future. In July 2010, the VBRC's final report was provided to the Victorian Government.

The VBRC's final report made a number of recommendations, including the following:¹

[t]he State amend the Regulations under Victoria's Electricity Safety Act 1998 and otherwise take such steps as may be required to give effect to the following:

¹ 2009 Victorian Bushfires Royal Commission, *Final Report, Summary*, July 2010, recommendation 27.

- *the progressive replacement of all SWER (single-wire earth return) power lines in Victoria with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk...*
- *the progressive replacement of all 22-kilovolt distribution feeders with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk as the feeders reach the end of their engineering lives.*

As part of the Victorian Government's consideration of the recommendations made by the VBRC in its final report, the Powerline Bushfire Safety Taskforce (**PBST**) was established. The PBST was required to investigate new cost efficient and effective technologies and operational practices to reduce catastrophic bushfire risk.

The PBST identified Rapid Earth Fault Current Limiters (**REFCLs**) installed in zone substations as an efficient and effective technology. A REFCL is a network protection device, normally installed in a zone substation that 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.

The PBST estimated the installation of REFCLs would reduce the likelihood of multi-phase powerlines starting bushfires by approximately 70 per cent.²

2.2.1 Mandating REFCLs

On 1 May 2016, the Victorian Government introduced regulations which amended the *Electricity Safety (Bushfire Mitigation) Regulations 2013 (Amended Bushfire Mitigation Regulations)*—to implement the PBST's findings. Powercor has 22 zone substations listed in the Amended Bushfire Mitigation Regulations, for which a mandated performance standard (the 'required capacity', as discussed in appendix A) has been established that requires the installation of REFCLs.

The Amended Bushfire Mitigation Regulations specifies the timeframes for achieving compliance at the 22 zone substations. That is, schedule two of the Amended Bushfire Mitigation Regulations assigns a number of 'points' to each of the selected zone substations. We are required to ensure the following:

- 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, were not less than 30 (this has been achieved)
- 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 address these requirements, the REFCL program was structured into three separate tranches, as shown in the figure below.

² Powerline Bushfire Safety Taskforce, *Final report*, 30 September 2011, p. 5.

Figure 1: REFCL tranches

Tranche one	Tranche two	Tranche three
<ul style="list-style-type: none"> • Gisborne (GSB) • Woodend (WND) • Camperdown (CDN) • Colac (CLC) • Castlemaine (CMN) • Maryborough (MRO) • Winchelsea (WIN) • Eaglehawk (EHK) 	<ul style="list-style-type: none"> • Bendigo TS (BETS) • Charlton (CTN) • Bendigo (BGO) • Ballarat South (BAS) • Ballarat North (BAN) • Geelong (GL) 	<ul style="list-style-type: none"> • Corio (CRO) • Koroit (KRT) • Stawell (STL) • Waurnd Ponds (WPD) • Hamilton (HTN) • Ararat (ART) • Merbein (MBN) • Terang (TRG)

Source: Powercor

These tranches broadly reflect our contingent project applications to the AER. It is noted, however, that Gisborne (GSB) and Woodend (WND) in tranche one were contained in our regulatory proposal for the 2016–2020 regulatory period as REFCL trial sites. Waurnd Ponds (WPD) was not included and Corio (CRO) was not funded in our third contingent project application.

The delivery program for the deployment of REFCLs has been amended during the 2016–2020 regulatory period. The planned installation of a REFCL at the Geelong (GL) zone substation was delayed and the timeframe for the Terang (TRG) and Ararat (ART) zone substations accelerated to ensure that we can achieve the relevant 'points' requirement by 1 May 2021.

2.2.2 Order in Council

On 28 May 2020 the Governor in Council, under section 120W of the Electricity Safety Act (1998), made an Order exempting us from the requirement to ensure that Geelong (GL) and Corio (CRO) are complying substations on the conditions that we:

- establish a new zone substation which is, and remains, a complying substation for purposes of section 120L and 120M(1)(c) of the Act
- transfer specified polyphase electric line segments from GL and CRO to that new zone substation
- for particular polyphase electric lines which continue to be served from GL and CRO that are located, or come to be located, in hazardous bushfire risk areas are covered or placed underground or supplied from a complying zone substation.

The Order in Council is provided in appendix B.

2.2.3 Bushfire Mitigation Civil Penalties Scheme

On 16 May 2017, the Victorian Government introduced the Bushfire Mitigation Civil Penalties Scheme via an amendment to the Electricity Safety Act 1998. The scheme includes financial penalties of up to \$2 million per point for any difference between the total number of required substation points prescribed in the Amended Bushfire Mitigation Regulations and that actually achieved. The scheme also includes a daily penalty up to \$5,500 per point for each day that a contravention with the Amended Bushfire Mitigation Regulations continues.

Evidently, the financial penalties for not achieving compliance by the due dates are significant. The imposition of the penalty regime reinforces the importance that the Victorian Government places on compliance with the Amended Bushfire Mitigation Regulations. Powercor supports the Victorian Government's objectives in relation to mitigating bushfire risk and significant progress has been made in relation to the REFCL installation program.

2.3 GL and CRO supply areas and alternative approaches

Both GL and CRO supply areas of Hazardous Bushfire Risk (**HBRA**) and Low Bushfire Risk (**LBRA**). However, of the:

- nine feeders emanating from GL, only two traverse significant areas of HBRA
- ten feeders emanating from CRO, only one traverses significant areas of HBRA.

This section discusses the investigation of alternative approaches to deliver the reduction in bushfire risk from the feeders currently served from GL and CRO.

2.3.1 Powerline Bushfire Safety Program analysis

In 2018 we approached the Powerline Bushfire Safety Program (**PBSP**) to better understand why the CRO and GL zone substations were included in the REFCL program.

Data provided by the PBSP included a presentation explaining the REFCL selection criteria and a feeder risk table showed that 99.94% of the bushfire risk that resulted in CRO and GL being legislated stations was on three (out of nineteen) feeders: CRO013, GL012 and GL015.

The PBSP information led us to consider an alternative approach, where the three feeders that traverse HBRA were supplied from a new zone substation, leaving CRO and GL to supply solely low bushfire risk areas. This concept had other benefits, notably:

- up to ten high voltage (HV) customers would not need to harden or isolate their networks
- a majority of distribution assets in an urban (LBRA) area would not require hardening
- additional network capacity would be established in an area planned for future growth, which is consistent with the long-term interests of customers.

2.3.2 CSIRO analysis

In December 2018, the Commonwealth Scientific and Industrial Research Organisation (**CSIRO**) prepared a bushfire risk analysis of the CRO and GL zone substation areas. The report found that a bushfire risk-neutral position could be achieved if a new REFCL-protected zone substation was constructed in the vicinity of Bannockburn with necessary distribution works, instead of installing REFCLs at CRO and GL zone substations.

The CSIRO analysis utilised datasets and mathematical modelling relating to the risk of powerline-initiated bushfires that had previously been undertaken by CSIRO for the PBSP between 2012 and 2017. The PBSP data and models were combined with our data to produce qualitative and quantitative insights in support of decisions on cost and risk optimal infrastructure change in areas primarily to the north and west of Geelong CBD.³

The analysis concluded there would be some residual risk associated with 43 overhead spans⁴, and that up to 10 HV customer installations would not need modifications to be compatible with REFCL operation. Therefore, it noted that risk neutrality may involve a minor amount of additional risk reduction activity (such as placing conductors underground or utilising covered conductors) on HV powerlines in the Geelong region.⁵

³ CSIRO, Assessment of bushfire risk neutrality – Bannockburn zone substation, December 2018, p. v.

⁴ CSIRO, Assessment of bushfire risk neutrality – Bannockburn zone substation, December 2018, p. vi.

⁵ CSIRO, Assessment of bushfire risk neutrality – Bannockburn zone substation, December 2018, p. vi.

2.3.3 Energy Safe Victoria technical report

Following discussions with Energy Safe Victoria (ESV), we formally-applied to ESV for an exemption from installing REFCLs at CRO and GL zone substations. In our application, we proposed to:

- establish a new REFCL-protected zone substation near Bannockburn
- REFCL-protect the three feeders from CRO and GL that traverse significant HBRA areas
- treat a few residual areas with remaining risk⁶ on CRO and GL networks through a combination of:
 - transferring to an adjacent REFCL-protected network
 - replacing existing bare overhead conductor with covered conductor
 - re-assessing the original risk classification to accept that there is no (bushfire) risk

In responding to our application, ESV undertook its own analysis on the residual risk and prepared a technical assessment report. The report highlighted further areas within the Geelong urban area that required bushfire risk mitigation works, including areas that were not considered in the original PBSP dataset as having bushfire risk. The technical report recommended that our exemption application be granted on the condition that the risk in these additional areas was addressed by either:

- providing REFCL protection
- replacing bare overhead with covered conductor or aerial bundled conductor or
- replacing bare overhead with underground cables.

2.3.4 Final proposal

In December 2019, we re-submitted our application to the ESV which included extending REFCL coverage further into the Geelong urban area as recommended in the ESV technical report. The application transfers additional parts of the CRO and GL networks onto the new REFCL-protected zone substation by making the following changes:

- CRO022: a new normally-open point between CRO022 and a new Bannockburn feeder to ensure all areas requiring bushfire mitigation are on a REFCL-protected network
- GL014: a new distribution tie to transfer a section of GL014 in HBRA to a REFCL protected network
- GL021: a new normally-open point between GL021 and a new Bannockburn feeder to ensure all areas requiring bushfire mitigation are on a REFCL-protected network.

Due to the layout of our distribution network, these changes have resulted in a more extensive distribution scope, meaning that five feeders will be required from the new zone substation in the vicinity of Bannockburn, and a new distribution tie (REFCL-protected) will be established from the north side of Queens Park to the south side.

In February 2020, ESV wrote to the Minister advising of their assessment of our application to exempt CRO and GL from the 'required capacity' obligations. ESV also recommended the Minister to afford favourable consideration to accepting our proposed exemption.

⁶ Our analysis found 107 overhead spans, rather than the 43 identified during the original PBSP dataset.

When taken together with the Department of Environment, Land, Water and Planning's (DELWP) advice, the Minister agreed with ESV's assessment and with recommendation. The Minister prepared a proposed Order in Council to grant the requested exemptions, for consideration by the Governor in Council. This final Order in Council was published on 28 May 2020, as discussed in section 2.1.2.

2.3.5 Impact on HV customers

There are 11 HV customer connection points for 10 HV customers impacted by the installation of REFCLs at the CRO and GL zone substations. This includes HV customers connected to feeders that are transferred to CRO and GL in the event of a network outage or other contingency event.

None of these HV customers are on the feeders that will be transferred from CRO and GL to the new zone substation. As a result, these HV customers will no longer need to ensure their assets can either withstand the higher voltages occurring during REFCL operation, or be isolated from the network, which is their responsibility following changes to the Victorian Electricity Distribution Code in August 2018.

2.3.6 Location of new zone substation

Bannockburn has long been intended as the site for a future Powercor zone substation. Given future demand growth in the north western Geelong region, driven by new residential and commercial load, the new zone substation had been intended to be constructed by 2030.

During preliminary analysis into the preferred site for a new complying zone substation, we met with Golden Plains Shire to discuss future land use. This discussion identified a proposal for an employment hub in the vicinity of Gheringhap, as opposed to the vicinity of Bannockburn which is earmarked for residential development.

Due to the nature of the future land use, we considered that Gheringhap would also be a credible option for installing a new complying zone substation.

3 Identified need

The identified need addressed by this investment is, within the mandated timeframes, to meet the required capacity performance standard for particular areas served by the Geelong and Corio zone substations contained in the Amended Bushfire Mitigation Regulations, or the conditional exemption contained in the Order in Council.

The identified need requires that we achieve 'required capacity' by 1 May 2023, and maintain compliance over the remainder of the 2021–2026 regulatory period.

Network capacitance forecasts are a key driver of meeting the identified need.

3.1 Network capacitance forecasts

We are required to meet and maintain 'required capacity' at a complying zone substation, in accordance with the Amended Bushfire Mitigation Regulations. Ground Fault Neutralisers (**GFNs**) manufactured by Swedish Neutral are currently the only available REFCLs that are capable of complying with the performance requirements.

In order for the GFN to be capable of detecting an earth fault of impedance up to 25,400 ohms, the network size must be limited. Calculations indicate that a limit of 108 amps of capacitive charging current is a suitable sized distribution network for GFN operation at our new zone substation, based on results from similar zone substations.

The total network capacitance is a function of the overhead line length and underground cable length. The figure of 0.068 A/km is used for overhead line, after tests at the Gisborne and Woodend zone substations where GFNs have been installed. The figure for underground cable being used is between 2.0-6.1 A/km, depending on the size and type of underground cable, after tests at Colac zone substation showed the previous figure of 2.73 A/km for all cables to be too low and not representative of the type of underground cables in our distribution network. The updated underground cable figures are based on the cable manufacturer's datasheet.

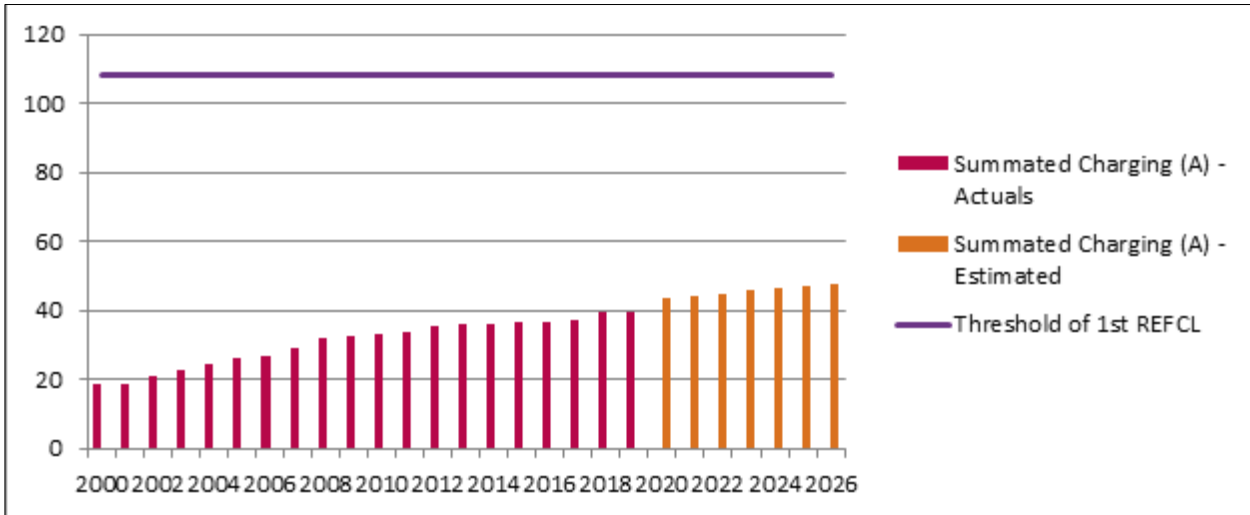
Network capacitance forecasts have been developed to 2026 by applying a growth rate based on the previous five year's average annual growth in network capacitance. One off programs of work, such as the undergrounding of overhead networks as part of the VBRC Powerline Replacement Program, are removed from the growth rate calculations. Any forecast works for these one-off programs are factored into the network capacitance forecasts to reflect the forecast year of completion. The 2019 network capacitance forecast was developed by using the available actual data for 2019, including all proposed works that have not been completed and adding half of the annual forecast growth rate since the actual data only included just under the first half of the 2019 year's actuals.

This approach to the forecasting of capacitive charging current was presented to the Victorian REFCL Technical Working Group on 9 September 2019. Membership of the REFCL Technical Working Group includes ESV. The Technical Working Group did not recommend any changes to the methodology, which we regard as a reasonable approach for estimating network capacitance.

3.1.1 Corio capacitance forecast

For CRO, there is presently 217km of overhead line and 8.3km of underground cable for an estimated network capacitance of 36 amps requiring one GFN. The network area includes transfer feeders. However, we also need to take account of forecast increases in network capacitance over the period to 2026, as shown in the figure below.

Figure 2: CRO network charging current forecast per year



Source: Powercor

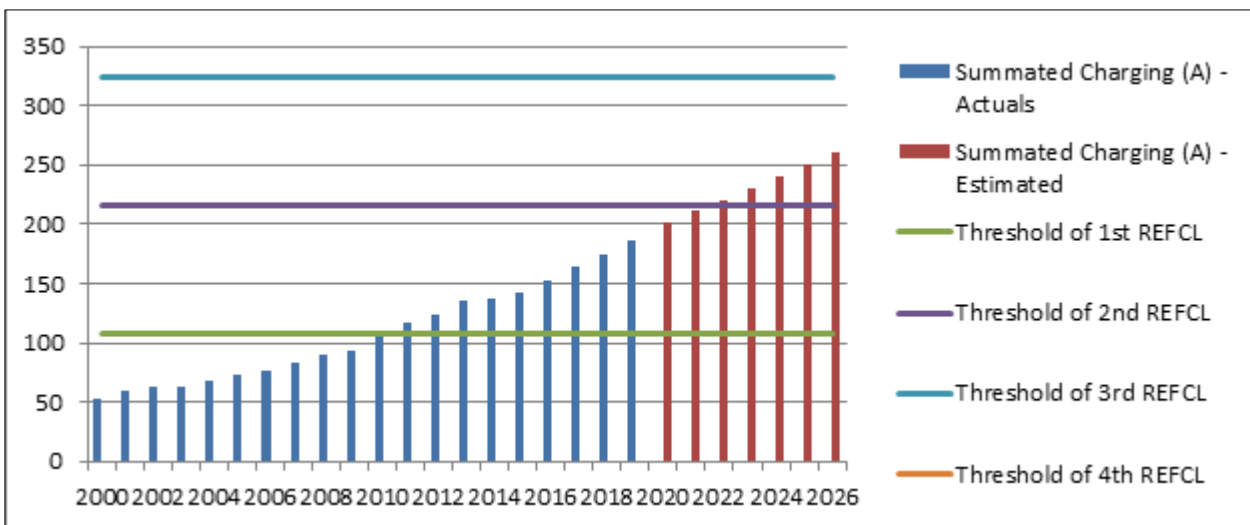
The CRO zone substation requires one GFN unit, and associated equipment, as outlined in the business case PAL BUS 6.10 Corio Supply Area.

3.1.2 Geelong capacitance forecast

For GL, there is presently 41km of underground cable and 561km of overhead line for an estimated network capacitance of 200 amps requiring two GFNs. However, we also need to take account of forecast increases in network capacitance over the period to 2026.

We estimate the network capacitance at GL will be 216 amps in 2022, increasing to more than 250 amps by the end of the regulatory period in 2026. This is shown in the figure below.

Figure 3 GL network charging current forecast per year



Source: Powercor

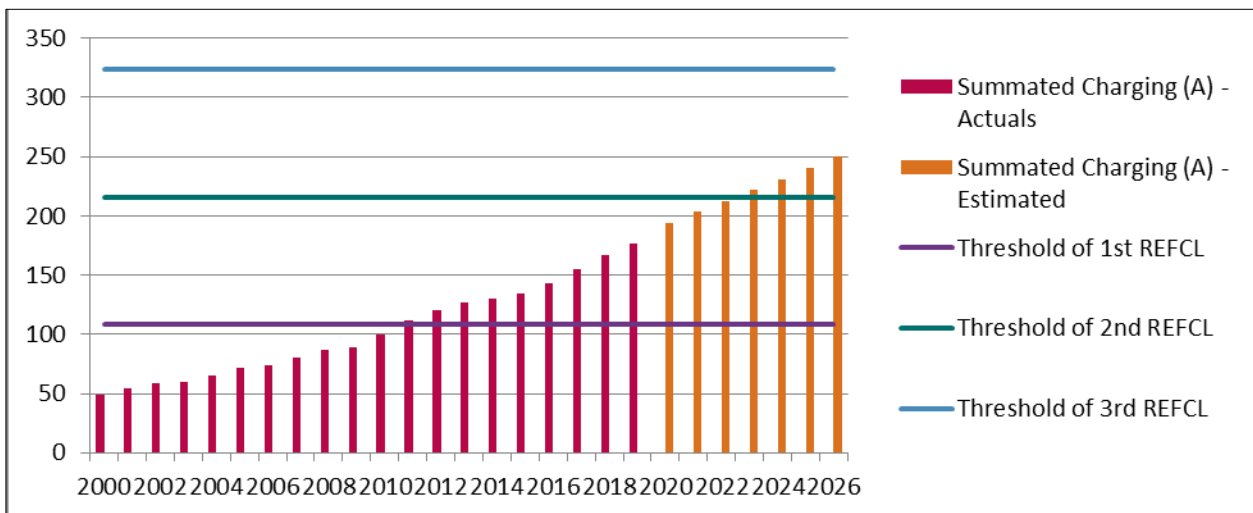
As this forecast indicates, the capacitance by 2026 will exceed the capacity of two GFNs. The GL zone substation has only two 22kV busses, and so to install a third GFN will require an additional 66/22kV transformer and 22kV bus unless capacitance mitigation action is taken.

3.1.3 Alternative complying zone substation capacitance forecast

For the proposed option of a new complying zone substation at Bannockburn (BBN) or Gheringhap (GHP) in lieu of REFCL protecting both CRO and GL zone substations, the capacitance forecasts are based on the feeder sections being transferred from CRO and GL.

The new complying zone substation will have sections of CRO13, CRO022, GL012, GL014, GL015 and GL021 transferred to it. This is expected to add an estimated 37.4MVA of load and approximately 177A of charging current. Given that the new zone substation will supply the Highton and Bannockburn growth areas, the charging current growth rate is around 9A per annum.

Figure 4 Alternative complying zone substation network charging current forecast per year



Source: Powercor

As shown in the figure above, by the end of the regulatory period, it is estimated there will be 250A of charging current at the new complying zone substation. Three GFNs will be required, assuming no other capacitance mitigation works are undertaken.

4 Options analysis

This section undertakes an analysis to assess three options to meet the identified need, as well as a sensitivity analysis of those options and costs.

4.1 Cost assessment

As explained in section 3, the identified need in relation to the north and west Geelong area is driven by our compliance obligations.

The installation of GFNs is the only technically feasible solution currently available to meet the performance requirements specified in the Amended Bushfire Mitigation Regulations. The deployment of a REFCL and associated equipment in the zone substation also requires works to be undertaken on the feeder network to enable the REFCL to perform. These works relates to network hardening, capacitive balancing, harmonics and damping. These costs are reflected in the overall option cost.

The table below shows the three options that we have examined in response to the identified need for the north-west Geelong supply area. A 'do nothing' option was not considered because it would fail to address our compliance obligations. Benefits have not been calculated for the options on the basis of the works constituting reliability-corrective action, consistent with the Regulatory Investment Test for Distribution guidelines.

Table 2 Summary of comparative costs (\$ million, 2021)

Option	Costs
1 Install 1 REFCL at CRO, and install 2 REFCLs at GL, and transfer of some load and capacitive charging current from GL to CRO	53.38
2 Construct new Bannockburn (BBN) substation with 2 x 25/33MVA transformers, 2 REFCLs and 1 isolating substation	57.39
3 Construct new Gheringhap (GHP) substation with 2 x 25/33MVA transformers, 2 REFCLs and 1 isolating substation	52.80

Source: Powercor

The costs of each option have been prepared on the same basis as our recent contingent project application provided to the AER.⁷ The analysis supporting our assessment of alternative options, including relevant assumptions, is included in the attached model.

The table above therefore identifies Option 3 as having lowest cost to address the identified need.

It is noted that in order to meet the Amended Bushfire Mitigation Regulations, the timing of the works including commissioning and testing by 1 May 2023.

Each option considered is discussed in further detail below.

⁷ AER, *Final decision, Powercor Australia Contingent Project, Installation of Rapid Earth Fault Current Limiters (REFCLs) – tranche three*, January 2020.

4.1.1 Option 1: Install REFCL at CRO, and install 2 off REFCLs to cover the GL area, with some feeder transfers to CRO

This option achieves compliance with the existing Amended Bushfire Mitigation Regulations by installing REFCLs at GL and CRO. Based on the characteristics of the GL supply area (particularly the extent of the underground network), the GL zone substation will require three GFNs to comply with the capacity requirements by 2026.

CRO (REFCL only works)

As discussed in section 3, the capacitance forecasts at CRO at the end of the regulatory period in 2026 would be 46 amps, which requires the installation on one GFN. This is associated with a load of 49.4 MVA.

In terms of CRO, the following works outlined below are required. These are also set out in the business case *PAL BUS 6.10 - Corio supply area - Jan2020 – Public.pdf*.

- install 1 GFN with neutral bus
- rebuild the control room to accommodate the secondary protection and control works
- ensure all 22kV distribution feeders are REFCL ready by installing appropriate surge arrestors, automatic circuit reclosers (ACRs) and balancing units.

GL (REFCL only works)

As discussed in section 3, the capacitance forecasts at GL at the end of the regulatory period in 2026 would be 260 amps, which requires the installation of three GFNs. This is associated with a load of 76.3 MVA.

The GL zone substation is currently physically constrained and significant works will be required for this project.⁸ The works needs to conform to the CitiPower/Powercor technical standards for zone substations. There is insufficient space to install 3 REFCLs, and associated equipment (Arc suppression coils, neutral bus modules, inverter equipment), an additional transformer and upgraded station service transformers within the GL zone substation. Bus extensions on the existing 22 kV bus are not viable as the site boundaries impede on the footprint required for the extensions. The purchase of further land on either side is not an option as all sides are bound by road reserves.

GL (REFCL and transfer of load works)

Rather than installing 3 REFCLs at GL, the only credible option is transfer some of the GL network to CRO to reduce the GL total capacitive charging current to below 216 amps, and install two GFNs at GL.

This would still require converting one outdoor 22kV bus into an indoor switchroom, and reconfigure the 22kV feeder network to transfer some GL feeder sections to CRO, to take advantage of the available charging current capacity at CRO.

At GL this would involve:

- dismantling one existing outdoor 22 kV switchyard bus
- establishing a new 22 kV switch room for one 22 kV bus
- locating two REFCLs in the former outdoor switchyard bus area

⁸ This was discussed in our scope for GL included as part of our second contingent project application. Refer REFCL 2.06 GL functional design scope v1.0.pdf, submitted 20 April 2018.

- rearranging the GL015 22 kV feeder onto no. 1 22 kV bus with the GL024 22 kV feeder connecting to the no. 2 22 kV bus
- establishing seven new 22 kV indoor circuit breakers to replace the one outdoor bus 22 kV circuit breakers with an indoor switchboard. The indoor switchboard is to house the required transformer circuit breaker, bus tie circuit breaker, and five 22 kV feeder circuit breakers
- transferring a large section of GL015 feeder to CRO
- ensuring all 22kV distribution feeders are REFCL ready by installing appropriate surge arrestors, ACRs and balancing units.

As a result of these works, GL would have two GFNs, 206 amps of capacitive charging current and a forecast load of 66 MVA.

CRO (additional works for transfer of load from GL)

The transfer of 10.3 MVA of load (53.6 amps) together with the works to augment the network to allow the transfer, will result in additional 61.9 amps of charging current at CRO.

Together with the forecast increases in load growth at CRO, would mean that the total load at CRO would exceed the capacity of the two transformers. The load, after the transfers, would be 59.78 MVA. Therefore a third transformer would be required. It would have 107.9 amps of capacitive charging current, which is just below the limit of the single GFN.

At CRO this would involve the following works in addition to the REFCL works:

- installing a new third transformer and new 22kV 800A circuit breaker for the new CRO011 22kV HV feeder
- configuring the new CRO011 22kV feeder with 1.8km of subsidiary overhead conductor, and 2.2km of underground cable.

A summary of capital costs⁹ of this option are shown in table 3.

Table 3 Option 1: estimated cost (\$ million, 2021)

Option 1	Total
Install REFCL at CRO, and install 2 off REFCLs to cover the GL area, with some feeder transfers to CRO	53.38

Source: Powercor

4.1.2 Option 2: new Bannockburn zone substation with 2 x 25/33MVA transformers, 2 REFCLs and 1 isolating substation

This option achieves compliance with the Order by establishing a new complying substation at Bannockburn (BBN) and supplying specified polyphase electric lines from the new substation. Additionally, an isolating substation would be required to reduce the capacitance loading on the GFNs.

⁹ The costs in the tables in this section relate to the assessment period from 2021 to 2038, expressed in NPV terms.

As discussed in section 3, the capacitance forecast for the new complying zone substation is 177 amps, associated with 37.4 MVA of load in 2023. This will increase to 250 amps of capacitive charging current in 2026, associated with a load of 41 MVA.

This option would require the following works:

- purchase suitable land for the new zone substation
- install two new 25/33 MVA transformers along with two 22kV busses, and two GFNs, at the new BBN zone substation
- construct 39km of new 66kV sub-transmission lines to connect BBN into the existing 66kV loop between Geelong Terminal station (**GTS**) and CRO and Ford Norlane (**FDN**)
- construct 21km of new overhead 22kV feeders, 3km of new 22kV underground cable, and augment 7km of existing 22kV overhead feeders to connect the bushfire risk supply areas as specified in the Order in Council onto BBN from the current CRO and GL zone substations
- network hardening of the 22kV feeder sections transferred from CRO and GL to BBN.

This option also involves the construction of 1 new 6MVA isolation substation, which would need to be built on the feeder network to isolate a 34 amps section of underground cable GL021 in the Highton area. An ESV exemption would be required for this isolation substation.

A summary of capital costs of this option are shown in table 4.

Table 4 Option 2: estimated costs (\$ million, 2021)

Option	Total
New BBN substation with 2x 25/33MVA transformers, two off REFCLs and 1 isolating substations	57.39

Source: Powercor

4.1.3 Option 3: new Gheringhap zone substation with 2 x 25/33MVA transformers, 2 REFCLs and 1 isolating substation

This option modifies Option 2 by constructing a new zone substation at Gheringhap (**GHP**), closer to central Geelong than Bannockburn.

As discussed in section 3, the capacitance forecast for the new complying zone substation is 177 amps, associated with 37.4 MVA of load in 2023. This will increase to 250 amps of capacitive charging current in 2026, associated with a load of 41 MVA.

This option would require the following site works:

- purchase suitable land for the new zone substation (based on discussions with Golden Plains Shire, as discussed in section 2.2.6)
- install two new 25/33 MVA transformers along with two 22kV busses, and two GFNs, at the new GHP zone substation
- construct 29km of new 66kV sub-transmission lines to connect GHP into the existing 66kV loop between Geelong Terminal station (**GTS**) and CRO and Ford Norlane (**FDN**)
- construct 21km of new overhead 22kV feeders, 3km of new 22kV underground cable, and augment 7km of existing 22kV overhead feeders to connect the bushfire risk supply areas as specified in the Order in Council onto GHP from the current CRO and GL zone substations

- network hardening of the 22kV feeder sections transferred from CRO and GL to GHP.

This option also involves the construction of 1 new 6MVA isolation substation, which would need to be built on the feeder network to isolate a 34 amps section of underground cable GL021 in the Highton area. An ESV exemption would be required for this isolation substation.

A summary of the capital costs of this option are shown in the table below.

Table 5 Option 3: estimated costs (\$ million, 2021)

Option	Total
New GHP substation with 2x 25/33MVA transformers, two off REFCLs and 1 isolating substation	52.80

Source: Powercor

4.1.4 Other options considered, but not costed

The following additional options were considered in preliminary planning investigations, but were rejected either because the costs were prohibitive, or the option was unable to meet our compliance obligations:

- **Demand management.** As already noted, demand management is unable to address our compliance obligations under the Amended Bushfire Mitigation Regulations. This option is therefore not feasible.

4.2 Comparative analysis

There are other costs, apart from Powercor capital costs, applicable to each option. These costs include the necessary hardening or isolation costs if any HV customer is connected to a REFCL protected network, and any associated AusNet Services Transmission costs at the Geelong Terminal Station.

In Option 1, the 10 HV customer connections across CRO and GL are within the REFCL protected area, and would require hardening or an isolation transformer. For the comparative analysis, it is estimated that for each customer connection there would be an assumed cost of 50% of a typical isolating substation cost. This assumption is on the basis that the cost of an isolating substation is the maximum cost per connection, but across all the HV customer connections a 50/50 mix of hardening works and isolating substation solutions would be adopted by these customers.

In options 2 and 3, none of the 10 HV customers noted above are within the REFCL protected area of BBN or GHP, and as such no customer hardening or isolation is required.

In options 2 and 3, AusNet Services Transmission has estimated the upgraded 66kV connection into Geelong Terminal Station would cost \$650k.

Considering all these costs, table 6 below highlights that option 3 has the lowest cost.

Table 6 Summary of costs (\$ million, 2021)

	Option	Costs
1	Install REFCL at CRO, and install 2 off REFCLs to cover the GL area, with some feeder transfers to CRO	59.98
2	Construct new Bannockburn (BBN) substation with 2 x 25/33MVA transformers, 2 REFCLs and 1 isolating substation	58.04
3	Construct new Gheringhap (GHP) substation with 2 x 25/33MVA transformers, 2 REFCLs and 1 isolating substation	53.45

The analysis shows that Option 3 provides a lower cost compared to the alternative options. As each of the options employ a similar mix of capital and operating expenditure, the ranking of the options will not change by varying these input assumptions. The ranking is also unaffected by changes in the cost of capital.

It should be noted that the timing of the option is driven by our bushfire obligations, and therefore is unaffected by any sensitivity analysis.

5 Recommendation

Option 3 is preferred because it addresses the identified need and provides the lowest cost by providing a feasible solution for achieving our compliance obligations in relation to the Amended Bushfire Mitigation Regulations at CRO and GL zone substations. The option assumes an exemption request is agreed by ESV for the isolating transformer.

The proposed design of the new GHP zone substation and distribution feeder network is provided in the attached scope. To meet the timeframes required under the Amended Bushfire Mitigation Regulations, the proposed works should be completed by 1 May 2023.

The forecast capital expenditure requirements for the 2021–2026 regulatory period are outlined in table 8. The operating expenditure forecasts for the ongoing costs of annual performance testing and maintaining compliance are covered through a separate operating expenditure step change submission.

Table 7 Expenditure forecasts for the preferred option (\$ million, 2021)

Expenditure forecast	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capital expenditure	2.09	50.71				52.80
TOTAL	2.09	50.71				52.80

Source: Powercor

5.1.1 Removal of costs already included in regulatory proposal

It is noted that the preferred option requires augmentation works in the Geelong area to meet the identified need. These works are already included in our regulatory proposal where the driver is augmentation to meet expected demand.¹⁰ As a result, the following costs are removed from this business case to ensure that there is no double-counting:

- GL013 new feeder to Batesford
- GL012 third phase (Barrabool Road stage 2 to pole 136)
- GL015 new regulator P124A Moorabool Valley
- GL 22kV transformers no. 1 and 2 circuit breaker augmentation.

The revised costs for the preferred solution for the purposes of the regulatory proposal are shown in the table below.

¹⁰ Refer PAL MOD 6.1. These works would be required in addition to the installation of REFCLs at CRO and GL, per option 1. However, they are required to meet the identified need of compliance with the Amended Bushfire Mitigation Regulations for options 2 and 3 and therefore are included in the total cost of these options.

Table 8 Expenditure forecasts for the preferred option for the purposes of the Regulatory Proposal (\$million, 2021)

Expenditure forecast	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capital expenditure	2.1	50.7	0.0	0.0	0.0	52.8
Less augmentation accounted for	2.0	1.0	0.3	0.5	0.2	4.1
Total	0.1	49.7	-0.3	-0.5	-0.2	48.7

Source: Powercor

A. REFCL requirements

These zone substation works include the installation of the REFCL itself, as well as corresponding primary and secondary plant. The installation of a REFCL also requires hardening of the surrounding feeder network.

This appendix sets out the zone substation works required for installing REFCLs at GHP zone substation (as per Option 3), as well as if REFCLs were installed at both CRO and GL zone substations (as per Option 1).

A.1 Ground fault neutraliser

The Amended Bushfire Mitigation Regulations require that each polyphase electric line originating from a selected zone substation has the 'required capacity'. The required capacity is defined as the ability to provide the following, in the event of a phase-to-ground fault on a polyphase electric line:

- to reduce the voltage on the faulted conductor in relation to the station earth when measured at the corresponding zone substation for high impedance faults to 250 volts within 2 seconds
- to reduce the voltage on the faulted conductor in relation to the station earth when measured at the corresponding zone substation for low impedance faults to:
 - 1,900 volts within 85 milliseconds
 - 750 volts within 500 milliseconds
 - 250 volts within 2 seconds
- during diagnostic tests for high impedance faults, to limit:
 - fault current to 0.5 amps or less
 - the thermal energy on the electric line to a maximum I^2t value of 0.10.¹¹

The above requirements can only be met through the use of REFCL technology—specifically, by migrating our existing systems to a resonant earthed network through the installation of a GFN. A GFN measures the shift in neutral voltage in response to an earth fault, and injects additional compensation current to reduce the faulted phase voltage to near zero. This allows the GFN to reduce earth fault current levels at a fault site to near zero.

The number of GFNs required at any zone substation is driven by a range of factors, including total system capacitance. Total system capacitance is itself a function of overhead line and underground cable length (noting the capacitance of underground cable is an order of magnitude more than 40 times that of overhead lines).

We estimate a single GFN can support the required performance standards within a range of total system capacitance of approximately 81–108A. This range has been developed with input from the REFCL technical working group, and based on our experience of installed REFCL sites to date. Our analysis indicates that a limit of 93 A of capacitive charging current is a suitable sized distribution network for GFN operation at WPD, based on results from the Winchelsea zone substation where GFN units have been installed.

A.2 Other primary plant, and protection and control

The installation of a GFN requires consequential primary plant, and protection and control at each zone substation. Primary plant includes, for example, station service transformers and capacitor banks. Protection and

¹¹ I^2t means a measure of the thermal energy associated with the current flow, where I is the current flow in amps and t is the duration of current flow in seconds.

control includes relay and protection equipment at the zone substation, and SCADA and communications infrastructure.

Our primary plant, and protection and control requirements are driven by the existing design of each zone substation, as well as whether multiple GFNs are required.

B. Order in Council

ORDERS IN COUNCIL

Electricity Safety Act 1998

EXEMPTION ORDER UNDER SECTION 120W OF THE ELECTRICITY SAFETY ACT 1998

Order in Council

The Governor in Council, under section 120W of the **Electricity Safety Act 1998** (Act), makes the following Order to exempt Powercor Australia Limited (ABN 89 064 651 109) (Powercor) from complying with section 120M of the Act on the terms and conditions specified in this Order.

1. EXEMPTIONS

Subject to Powercor's continued compliance with the conditions in clause 2 below, from the **effective date** of this Order, Powercor is exempt from the requirement to ensure that the following **zone substations** are **complying substations** under section 120M(1)(c) of the Act:

- 1.1 **Geelong (GL)**, located at Lat -38.13477, Long 144.33741 (as identified at item 16 in Schedule 1 of the Electricity Safety (Bushfire Mitigation Duties) Regulations 2017); and
- 1.2 **Corio (CRO)**, located at Lat -38.07445, Long 144.35898 (as identified at item 42 in Schedule 1 of the Electricity Safety (Bushfire Mitigation Duties) Regulations 2017).

2. CONDITIONS OF EXEMPTION

The exemptions in clauses 1.1 and 1.2 are granted subject to Powercor's continued compliance with the following conditions:

- 2.1 By 30 April 2023, Powercor must establish a new, **complying substation** which Powercor shall ensure is, and remains, a **complying substation** for purposes of sections 120L and 120M of the Act. Powercor shall provide details of the **new complying substation** to the Minister at least 30 days prior to commencing earth-disturbing works to construct of the substation.
- 2.2 By 30 April 2023, Powercor must transfer each **polyphase electric line segment** identified in column 2 of the table below so that the segment's electricity supply originates from the new **complying zone substation** referenced in clause 2.1 of this Order and has the **required capacity**. Alternatively, subject to Energy Safe Victoria's prior approval, Powercor may:
 - 2.2.1 supply electricity to each **polyphase electric line segment** identified in column 2 of the below table from any other **complying substation** for purposes of sections 120L and 120M of the Act, or
 - 2.2.2 replace each **polyphase electric line segment** identified in column 2 of the below table with **covered** or underground electric line.
- 2.3 From the **effective date** of this Order, Powercor must ensure that any **polyphase electric line segment** supplied from the **CRO** or **GL zone substations** not included in the below table which is located, or comes to be located, in a **hazardous bushfire risk area** shall either be **covered**, or placed underground, or have the **required capacity**.
- 2.4 From the **effective date** of this Order, Powercor must ensure that any **polyphase electric line segment** supplied from the **CRO** or **GL zone substations** that is **covered** or underground is not replaced with bare-wire, overhead conductor, unless otherwise previously approved by Energy Safe Victoria.

Table: Scope of exemptions

Column 1 Exempted zone substation	Column 2 Polyphase electric line segment to be transferred
Corio (CRO)	All parts of the polyphase electric line designated CRO013 connected from the west side of pole LIS 44022, located approximately 15 metres east of Matthews Road on Purnell Road, Corio at Lat -38.07191623, Long 144.33944240
Corio (CRO)	All parts of the polyphase electric line designated CRO022 connected from the west side of pole LIS 26786, located approximately 15 metres west of Olympic Avenue on Darebin Street, Corio at Lat -38.089760, Long 144.344754
Geelong (GL)	All parts of the polyphase electric line GL012 connected from the west side of pole LIS 42701, located approximately 15 metres west of Garlick Avenue on Aberdeen Street, Manifold Heights at Lat -38.14416574, Long 144.32475060
Geelong (GL)	All parts of the polyphase electric line GL014 connected from the west side of pole LIS 55215, located approximately 30 metres west of Graylea Avenue on Church Street, Herne Hill at Lat -38.127968, Long 144.317576
Geelong (GL)	All parts of the polyphase electric line GL015 connected from the west side of pole LIS 766218, located approximately 3 metres east of Rollins Road on Ernest Street, Bell Post Hill at Lat -38.10004914, Long 144.32328075
Geelong (GL)	All parts of the polyphase electric line GL021 connected from the west side of pole LIS 45530, located on Noble Street, Newtown at Lat -38.151848, Long 144.325977

3. INTERPRETATION

3.1 In this Order –

complying substation has the meaning given in section 120L of the Act.

covered has the meaning given in section 120N(5) of the Act.

effective date means the date this Order is published in the Government Gazette.

hazardous bushfire risk area has the meaning given in section 3 of the Act.

polyphase electric line has the meaning given in section 120K of the Act.

polyphase electric line segment means all parts of the polyphase electric line, inclusive, identified in column 2 of the table set out in clause 2 of this Order.

required capacity has the meaning given in section 120K of the Act.

zone substation means a substation prescribed in Schedule 1 of the Electricity Safety (Bushfire Mitigation Duties) Regulations 2017.

3.2 In this Order, unless the context requires otherwise, words denoting the singular include the plural, and vice versa.

4. COMMENCEMENT

This Order takes effect on the date it is published in the Government Gazette.

Dated 26 May 2020

Responsible Minister:

THE HON LILY D'AMBROSIO MP

Minister for Energy, Environment and Climate Change

CLAIRE CHISHOLM
Clerk of the Executive Council