REFCL Compliance Ballarat

Draft Project Assessment Report

November 2023

Contents

1 Overview

This draft project assessment report has been prepared in accordance with the Regulatory Investment Test for Distribution (**RIT-D**) requirements of the National Electricity Rules (**NER**) clause 5.17.4.

Ballarat North and Ballarat South zone substations are listed in Schedule 1 of the Electricity Safety (Bushfire Mitigation) Regulations 2023 (**Bushfire Mitigations Regulations**) where Powercor must meet the “required capacity” obligations. These zone substations supply the area of Ballarat and extend into surrounding areas to service townships including Buninyong, Beaufort, Clunes, Creswick, Daylesford and Skipton.

In 2020, Powercor introduced bushfire safety devices, known as Rapid Earth Fault Current Limiters (**REFCL**), at both Ballarat North and Ballarat South substations. Since then, network capacity has grown and is forecast to continue increasing.

This growth is being driven by new connections and demand, both of which we forecast to continue.

If not addressed, additional network growth, particularly with underground cables, will mean the existing REFCL systems’ performance will become non-compliant resulting in the systems not protecting the communities they were designed to keep safe.

The purpose of this report is to consult on the credible options that could be implemented to ensure we are complying with the Bushfire Mitigation Regulations.

Expansion of network capacity to support REFCL compliance will additionally benefit future growth in the Ballarat region arising through electrification, population increases and economic investment.

This report presents the options available to meet REFCL compliance standards most efficiently.

The preferred option has been selected to address identified needs in both zone substation locations and maximise net economic benefit in accordance with clause 5.17.1(b) of the NER.

Powercor is now seeking further feedback from stakeholders. Submissions are due by **9 January 2024**.

All submissions received in response to this draft project assessment report will be considered before a final project assessment report is prepared.

Figure 1 shows the location of Ballarat in the central area of Victoria and Figure 2 shows a more detailed view of the Ballarat distribution networks supplied by the Ballarat North and Ballarat South Zone Substations.

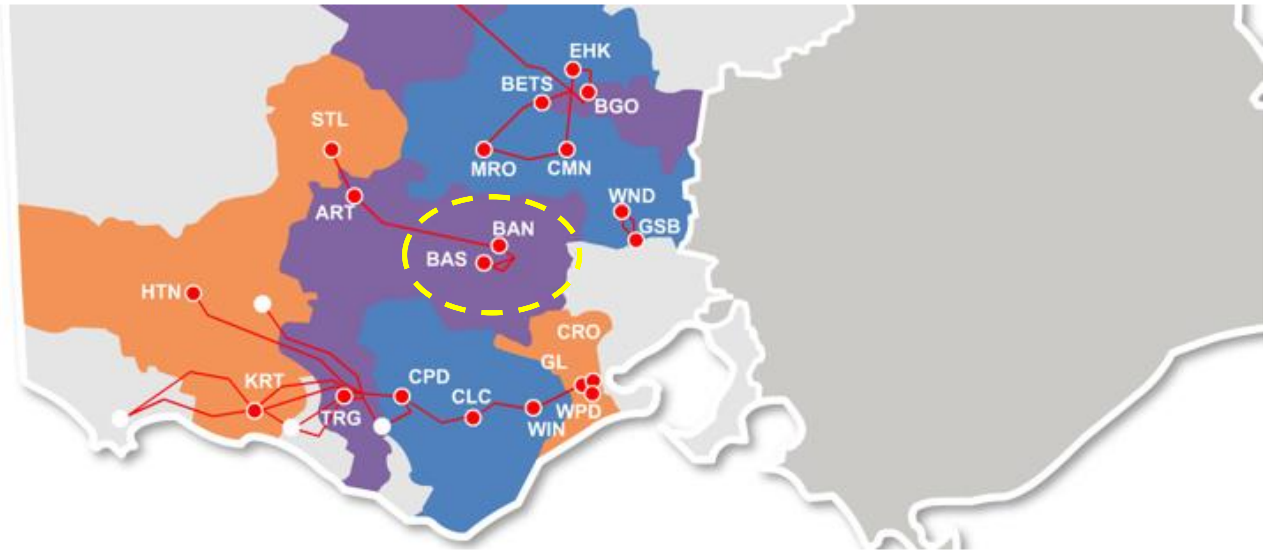

Figure 1 Map of central Victoria showing Ballarat North (BAN) and South (BAS) substations

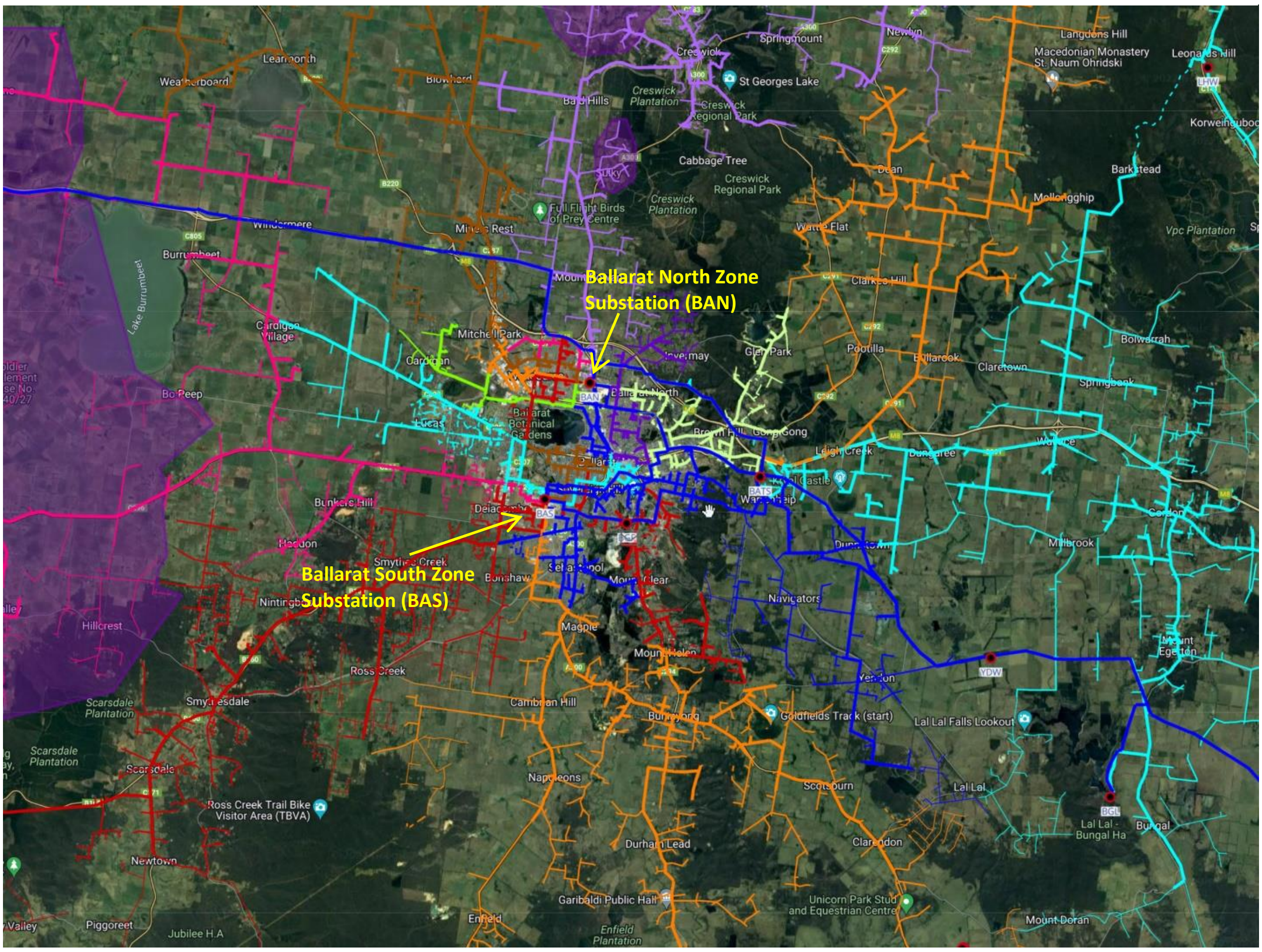

Figure 2 Ballarat substations and distribution network

2 Background

2.1 Bushfire Mitigation Regulations

The Bushfire Mitigation Regulations require Powercor's Bushfire Mitigation Plan (**BMP**) to include details of the preventative strategies and programs we will use to ensure each polyphase electric line originating from defined zone substations in our network meet "required capacity" requirements. This includes both the Ballarat North and Ballarat South substations.

2.2 Detailed Legislative Obligations

The Bushfire Mitigation Regulations introduced new technical obligations on the Victorian Distribution Network Service Providers (**DNSPs**), including Powercor, that operate in high-risk bushfire areas.

Obligations relevant to this Regulatory Investment Test include:

- each polyphase electric line originating from a listed zone substation must have the "required capacity" specified in the Bushfire Mitigation Regulations
- testing for the "required capacity" must be undertaken before the specified bushfire risk period each year and a report detailing the results of testing submitted to Energy Safe Victoria (**ESV**)
- each new or replaced line with a nominal voltage from 1 kV to 22 kV inclusive must be covered or undergrounded from 1 May 2016 in prescribed electric line construction areas.

Further detail is included in Appendix A.

2.3 Bushfire Mitigation Civil Penalties Scheme

There are financial penalties of up to $2 million for every allocated substation point prescribed in respect to each zone substation that is not a complying zone substation. There is also a penalty up to $5,500 for each day that a contravention continues.

2.4 Compliance Activities

To comply with the Bushfire Mitigation Regulations, Powercor rolled out REFCLs throughout its network across three tranches.

Ballarat North (**BAN**) and Ballarat South (**BAS**) substations were included in Tranche 2. Both were completed in 2020.

The operation of the REFCL system is dependent on electrical characteristics including capacitive (line charging) current and damping factors. These are in turn dependent on line length and construction types. The correct performance of each REFCL system lies within defined thresholds of these parameters. To check the values of these parameters, performance of each REFCL system is tested annually. The parameters are also measured on days of a Total Fire Ban (**TFB**[1]). Both the test results and TFB measurements are reported to ESV as part of an annual compliance test process. This provides empirical data on compliance and forms the basis for forecasting future performance of the REFCL systems. Further details are shown in Appendix A.

---

[1] It is important to note that Total Fire Ban (TFB) days have specific triggers to enable this classification to be applied. The measurements in Figure 3 and Figure 4 for TFB days are indeed made in the fire danger period over summer where it is reasonable to expect the TFB days to occur, but in some cases the day scheduled for testing did not trigger a formal TFB classification.

2.5 Future REFCL Compliance

The size of the distribution network in Ballarat (and surrounding areas) continues to grow, in particular, with reticulated new subdivisions. This increases the overall length (and connected load capacity) of the network.

As line capacitive current is directly proportional to line length, it follows that increased network size will increase capacitive current. But it is the installation of underground cables with their tight conductor arrangement that is a major contributor to increasing capacitive currents, as the physical construction makes the cables highly capacitive when compared to the larger spacing of overhead lines.

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*). Known future underground residential developments (**URD**) are also factored into the network capacitance forecasts, with the growth rate calculations adjusted if a URD has been partially completed to ensure the growth rate is not exaggerated.

While testing produces measurements of charging current and damping measurements, both important for engineering analyses, it is easier to view this data as a single reference known as damping current (**DAMPs**). This is an acronym describing the product of the two inputs that can then be measured against a performance threshold[2].

The actuals and forecasts of DAMPs values for each bus at both BAN and BAS substations are shown in Figure 3 and Figure 4 respectively[3].

---

2 References include:

CitiPower and Powercor Aust., 2020, Implementation & Optimisation of Resonant Networks for Victorian REFCL Applications, https://www.aer.gov.au/system/files/REFCL2.11%20Implementation%20and%20optimisation%20of%20REFCL%20systems%20rev%200.4.pdf

https://esv.vic.gov.au/about-esv/reports/technical-reports/rapid-earth-fault-current-limiter-reports/

Finding 19 REFCL Functional Performance Review Report for Energy Safe Victoria: Power Systems Consultants Australia Pty Ltd 14/10/2020 p8. https://www.esv.vic.gov.au/sites/default/files/2022-12/REFCL-Functional-Performance-Review.pdf

Recommendation E, Rapid Earth Fault Current Limiter Functional Performance Review, Energy Safe Victoria Response to Recommendations

Victorian Electricity Supply Industry REFCL Technical Working Group Position Paper Response to Recommendation E of the 2020 REFCL Functional Performance Review

3 Figure 3 and Figure 4 are stated in years with the value aligning to the end of summer period. For example, 2026 describes the 2025/26 summer period.

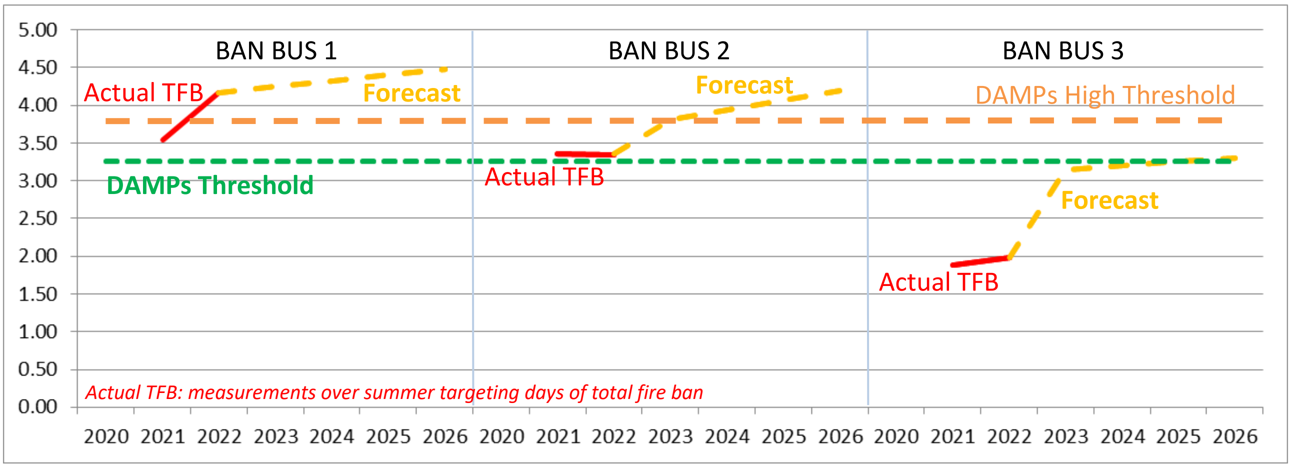

Figure 3 Damping Current values at BAN substation[3]

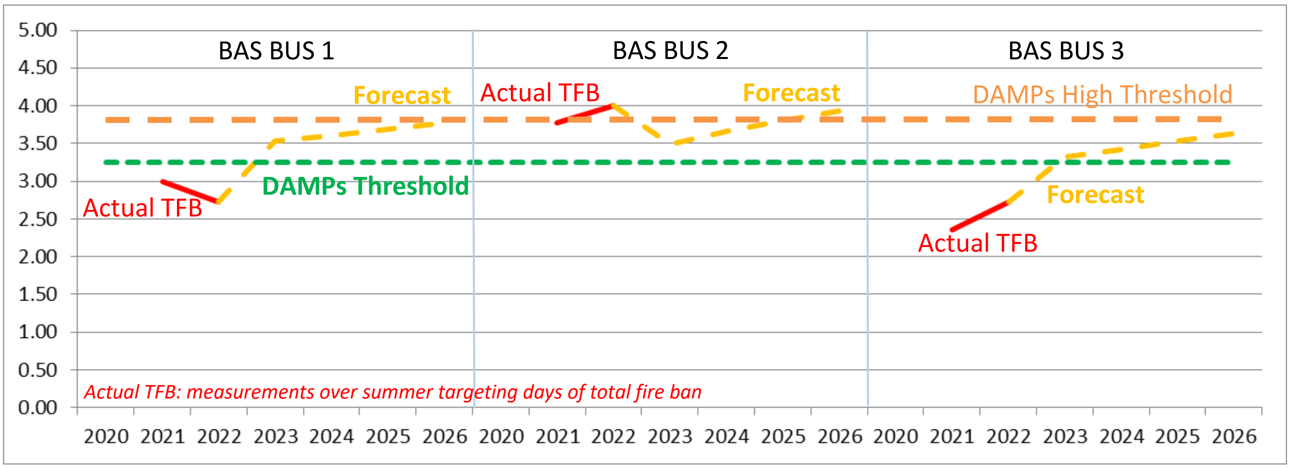

Figure 4 Damping Current values at BAS substation[3]

Note that the step changes in 2023 on Bus 3 at BAN (Figure 3) and Bus 2 at BAS (Figure 4) are the result of a load transfer from BAS to BAN. While this transfer allows more even sharing of the DAMPs between the two substations, the results indicate that the REFCL systems at both sites are still forecast to exceed the required standards.

The works previously undertaken at BAN and BAS are insufficient to provide ongoing compliance with the Bushfire Mitigation Regulations.

It is noted that actual values are above the damping current threshold for some of the buses. This occurs as REFCL control settings can be adjusted to be more sensitive to achieve the required performance criteria. However, this creates additional risk in terms of both compliance and can lead to a reduction in reliability. This is particularly prevalent for the BAN 1 and BAN 2 buses. Exceeding the damping current threshold is to be avoided, to reduce compliance risk and maintain reliability.

All six REFCLs at BAN and BAS are forecast to exceed their DAMPs threshold in 2026 and four of the six REFCLS are forecast to encroach on their DAMPs high thresholds in 2026.

Action is being taken now via the planned installation of an isolating substation on the BAS network in 2024. However further intervention is required to ensure that the network can meet compliance for the 2025/2026 bushfire season.

2.6 Load Growth Interdependency

The network in Ballarat (and its surrounds) is expanding, with new connections bringing additional demand to the network.

Future load is forecast to determine when the ratings of asset capacity will become insufficient to supply the increasing load on the network. Plans have already been made to transfer some load from BAS to BAN, driven by REFCL balancing that inherently provides an associated load transfer, and these results are included in the forecasts.

We use three different load forecasting models to provide credible scenarios:

a. High distributed energy resources (**High DER**); This model is based on Australian Energy Market Operator's (**AEMO**) strong electrification scenario, which has demand increases driven by new electrified industrial activities but are offset by a high long-term forecast of distributed photovoltaics (**PV**).

b. Step change in loads (**Step**); This model is based on AEMO's step change scenario, which is a more consumer-led transition but continues with a high forecast of distributed PV and battery storage. It has a lower growth rate than the High DER model.

c. Strong demand (**Strong**); This model is an amalgamation of AEMO's strong electrification, step change and progressive change scenarios, to show high growth in electrification with a conservative increase in distributed PV, battery storage and energy efficiency. It has a higher growth rate than the High DER model.

The combined outputs of each forecasting model for Ballarat North and South Substations are shown in Table 1:

Table 1 Combined Ballarat load forecasts (50% POE)

Year	Firm Capacity MVA	Actual Demand MVA	Forecast (50% POE) MVA		
			High DER	Step	Strong
2020*	172.4	169.3			
2021*	172.4	137.1			
2022*	172.4	149.6			
2023	172.4		165.6	166.5	172.8
2024	172.4		168.2	168.4	180.6
2025	172.4		172.1	169.3	187.2
2026	172.4		172.4	166.7	189.9
2027	172.4		172.9	164.5	192.4
2028	172.4		173.9	159.1	195.7
2029	172.4		179.0	158.9	201.7
2030	172.4		186.8	160.1	210.0
2031	172.4		194.2	161.7	218.5

2032	172.4	202.7	166.9	227.6
2033	172.4	210.0	173.7	235.6

** indicates measured demand*

Using the most conservative forecast (Step) shows that without mitigating action, our customers' load requirements under a 50% probability of exceedance (**POE**) scenario (as shown in Figure 5) may not be met from 2033 onwards.

We note that such an outcome would be inconsistent with our Electricity Distribution Code of Practice obligations to meet our customers' reasonable expectations of a reliable electricity supply.

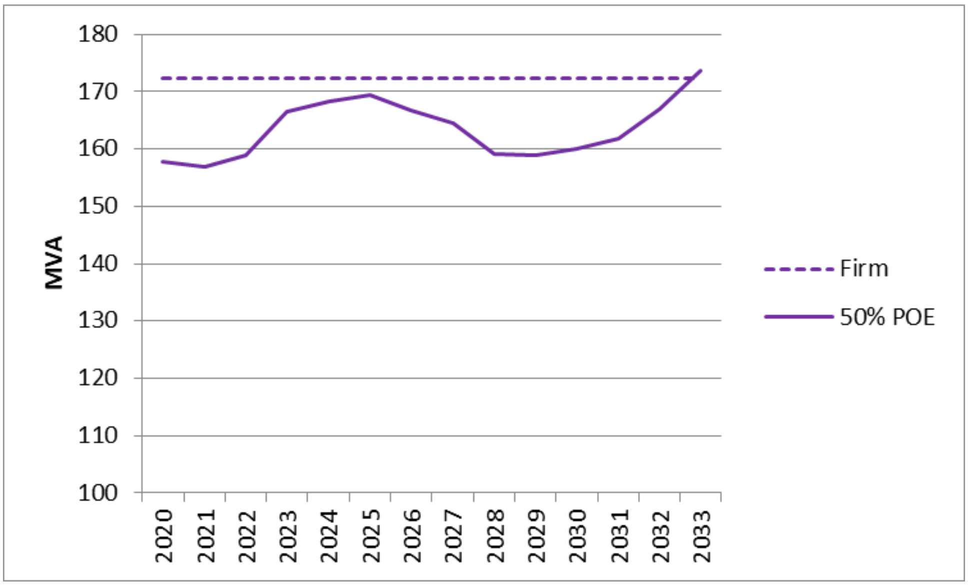

Figure 5 Load forecasts (Step) at BAN and BAS substations

The firm capacity in Figure 5 is the summer cyclic capacity available at the BAN and BAS zone substations (with one element unavailable for service at each zone substation).

For this report, it has been assumed that a load constraint in the combined Ballarat area can occur from 2033. However, based on the economic analysis in this document, a new zone substation is justified in 2035.

3 Identified Need

3.1 RIT-D Scope and Project Need

The area serviced by BAN and BAS is experiencing significant residential growth. In addition to the requirement for further distribution transformers to service the additional load, the additional underground networks associated with this growth are increasing charging current and damping values of the network because of the additional cable capacitance.

The project need is two-fold: to ensure the requirements of the Bushfire Mitigation Regulations are met into the future with a target of the work needed to maintain the "required capacity" being fully operational prior to the 2025/2026 bushfire season; and to meet the additional demand placed on it by continued load growth in the area, forecast to occur by 2033. A new substation is critical to supporting us to continue to deliver safe and reliable power to homes and businesses in the region.

Failure to achieve this will compromise our ability to meet the community safety expectations regarding bushfire risk management and our ability to service ongoing growth in demand for electricity in the area.

3.2 Minimum Requirements for Solutions

For any solution to be considered as feasible, it must achieve the following requirements:

i. **REFCL compliance met**

All options must be implementable in the required timeline and address the project need throughout the evaluation period.

ii. **Network to retain sufficient levels of operational flexibility so customer service levels are not unduly impacted.**

This implies that:

- There must be no loss of redundancy for each location

  If the REFCL system is out of service or lines transferred to a different REFCL system, lines that require REFCL must not have their compliance requirements compromised.

- Operating limitations on network to be avoided if possible

  Solutions should not limit power flow direction, protection reach or operational flexibility for maintenance or reactive issues required by the network.

- Equipment is to operate within thermal limits, and voltages are to remain within standards set out in the Electricity Distribution Code of Practice.

Proposed solutions must not, under any circumstances, increase the likelihood of failing to meet compliance obligations.

It is relevant to note that as more connections are made to the network, customer density per section on a number of feeders will increase. This increases the number of customers affected by any planned or unplanned outages on any given network section. The total customer minutes off supply will increase even if the system average interruption index (**SAIFI**) and system average interruption duration (**SAIDI**) remain consistent across time.

Distributors are subject to substantial penalties for not meeting reliability standards that may result from incorrect protection operation or overloaded systems.

iii. Maximise the economic benefit

The requirements for meeting compliance and demand growth must be addressed in the most efficient and prudent manner.

4 Options to Meet the Identified Needs

4.1 Screening for Non-Network Options

In accordance with clause 5.17.4 of the NER, Powercor must screen for non-network options as a solution for the identified need.

We have determined that, in accordance with clause 5.17.4 (c), a non-network options report is not required as our assessments have found there is no non-network option that constitutes a potential credible option, or that forms a significant part of a potential credible option, for the RIT-D project to address the identified need.

The notice issued is located on the Powercor website.

4.2 Methodology For Determining Options and Costs

Section 4.3 and Appendix A include a detailed consideration of the technical and regulatory requirements as well as consideration of network options that may meet the REFCL requirements. The ability of these options to address the forecast capacity requirements and the associated investment profile is modelled using the regulated WACC[4] to discount future expenditures. A scenario analysis is carried out to test results of financial analyses against movement of critical variables.

The results of this analysis are discussed in the next section.

4.3 Considered Network Options

As discussed in Section 3, the immediate identified need is to maintain the REFCL 'required capacity' at both BAN and BAS in accordance with the Bushfire Mitigation Regulations. The identified need arises because the forecast network capacitance and network damping exceed the capability of the REFCLs at those zone substations. Our objective is to identify the lowest cost option that satisfies our compliance obligations.

To achieve this objective, we have previously developed[5] five high level options, some of which may be used in combination, to address the identified need at each zone substation. The feasibility of each option will depend on the individual circumstances at each zone substation and associated networks.

Consideration of each of the five options has been applied to the needs identified in this document and discussed using six unique options in further detail below.

Option 1 - Feeder reconfiguration only

We have previously transferred some of the network and its associated load from BAS bus 2 to BAN bus 3 as illustrated in Section 2.5, to enable use of the DAMPs capacity that existed on BAN bus 3 (as the graphs in Figure 3 and Figure 4 show), however there is no remaining DAMPs capacity in the local network available to meet the REFCL capacity requirements.

---

4 NER clause 5.17.1(c)(9)(iii) Paragraphs 16 and 17 of the RIT-D state: "The present value calculations must use a commercial discount rate appropriate for the analysis of a private enterprise investment in the electricity sector. The discount rate used must be consistent with the cash flows that the RIT-D proponent is discounting."

5 *CitiPower and Powercor Aust., 2020, REFCL ongoing compliance (tranche 1&2), Attachment 1 - Powercor - Business Case 6.08 - REFCL ongoing compliance - 31 January 2020*

This option will be used in conjunction with other options to make the best use of the available capacitive and load capacity.

Option 2 - Adding a new REFCL

If more than one REFCL unit is required at a zone substation, meeting the legislated performance standard ("required capacity") requires the feeders being protected by each REFCL unit to be electrically isolated. Each segregated group of feeders requires a dedicated 66/22kV power transformer as each REFCL unit works with the earthed star point of a transformer. REFCLs can be connected in parallel but the definition of required capacity leads to compliance benefits not being realised and is therefore not being proposed as an option.

For system and operational purposes Powercor's zone substations are designed for a maximum of three power transformers, hence the maximum number of REFCL units per zone substation is also three. Both BAN and BAS have three transformers and corresponding REFCL systems in place.

Option 3 - Isolating substations.

A 22kV isolating substation may be used to electrically isolate an area of the 22kV feeder network that has wholly underground 22kV feeder sections (typically in large residential housing developments). It contains an isolating transformer, switchgear and secondary equipment.

If the section of network beyond the isolating transformer is wholly underground (and therefore representing no bushfire risk), an annual notification of exempt network sections is updated to reflect the new section of network and issued to Energy Safe Victoria and the Victorian Minister for Energy. The remaining network before the isolating transformer will place less capacity on the existing REFCLs and the required capacity may be achieved.

A number of isolating substations may be installed where the physical and electrical configuration of the network supports this (areas where significant underground cables can be connected downstream) and suitable land is available. In some instances, an isolating substation may include a REFCL (REFCL mini-grid) if there are parts of the overhead network that may be sensibly (economically) included.

The benefit of this option is that it reduces the pressure on existing REFCL systems by reducing the capacitive size of the network that an existing REFCL systems needs to protect, however by itself it does not address the forecast demand constraints. However, to make this option feasible, it will still be necessary to build a new zone substation in the future to support increased load.

Appendix A.4 Additional information on Isolating substations contains more detail on this option.

Option 4 - Mini zone substation

While BAN and BAS have limited physical or electrical capacity to install an additional REFCL-fitted power transformer, mini zone substations that are physically separate from but electrically connected to BAN and BAS zone substations may be established. This option represents essentially an extension of the 66kV bus at the existing substations to create a fourth transformer bay with a REFCL.

The cost of this option may include identifying and purchasing of additional land close to each of the existing zone substations as well as sub-transmission and distribution works to integrate each mini zone substation into the existing network.

Although a higher-cost option, this solution is considered feasible.

Option 5 - New zone substation at Powercor owned location in Ballarat East

The proximity of BAN and BAS enables a new zone substation equipped with REFCLs to be established between them, with load transfers from both sites. The REFCLs capacity and the load will be shared across the three zone substations to ensure that capacity is not exceeded.

To meet the REFCL compliance needs, the substation would need to be established by the bushfire season of 2025/2026. Refer to Figure 8 for an illustrative representation of the future network under this option.

The new zone substation option includes 22kV distribution works to enable the load transfers from BAN and BAS and is considered feasible. The advantages of this option over the mini-zone substation option in Option 4 include a lower overall cost as well as improved operational flexibility, reliability and supply security.

Appendix A.5 Additional information on a new zone substation contains more detail on this option.

Option 6 - New zone substation at an alternate location in Ballarat

An alternate location in the Ballarat area could be used for a new zone substation site. Differing locations would lead to differing expenditure requirements, to ensure the REFCL capacity and load are shared across the three zone substations and that thresholds are not exceeded.

To meet the REFCL compliance needs, the substation would need to be established by the bushfire season of 2025/2026. Refer to Figure 9 for an illustrative representation of an example area for the new zone substation to be located in.

The new zone substation option includes 22kV distribution works to enable the load transfers from BAN and BAS. This option will have a higher overall cost than Option 5 due to increased sub-transmission line works but also includes the same advantages of improved operational flexibility, reliability and supply security compared to Options 1 to 4 and is considered feasible.

Appendix A.5 Additional information on a new zone substation contains more detail on this option.

4.4 Feasible Options and Timing

Three feasible options exist from the analysis in section 4.3, and they are listed with detailed timing in Table 2.

Table 2 Credible and technically feasible options

Option	Detail	Cost
(a) Isolating Substations + deferred zone substation	(i) Installation of eleven sites: four in 2024, one in 2025, one in 2026, one in 2027, one in 2028, one in 2030, one in 2032, one in 2034 (ii) Install three REFCL mini-grids: one in 2024, one in 2028, one in 2030 (iii) One feeder rearrangement to manage localised load exceedance in 2024. (iv) A new zone substation is commissioned in 2035 (v) REFCL system secondaries replaced every 20 years	$93.5 M capital expenditure, $14.9 M operational expenditure

(b)	**Two mini–Zone Substations**	(i) Installation of one mini zone substation in 2025 (ii) Followed by second mini zone substation in 2027 (iii) Both subs only have 1 transformer bay hence one REFCL system each (assuming reliability issues can be managed) (iv) Install one REFCL mini-grid in 2024 (v) Install four isolating substations: one in 2024, one in 2032, one in 2034, one in 2036 (vi) REFCL system secondaries replaced every 20 years	$68.5 M capital expenditure, $13.9 M operational expenditure
(c)	**New Zone Substation at Powercor owned location in Ballarat East**	(i) Installation of first transformer and REFCL in 2025 (ii) Installation of second transformer and REFCL in 2027 (iii) Install four isolating substations: one in 2024, one in 2032, one in 2034, one in 2036 (iv) REFCL system secondaries replaced every 20 years	$52.1 M capital expenditure, $10.7 M operational expenditure
(d)	**New Zone Substation at an alternate Ballarat location**	(i) Installation of first transformer and REFCL in 2025 (ii) Installation of second transformer and REFCL in 2027 (iii) Install four isolating substations: one in 2024, one in 2032, one in 2034, one in 2036 (iv) Install one REFCL mini-grid in 2024* (v) REFCL system secondaries replaced every 20 years	$67.3 M capital expenditure, $13.8 M operational expenditure

** The REFCL mini-grid requirement is dependent on the chosen location of the new zone substation.*

Of the six network options considered, all have been incorporated as part of the feasible solutions in Table 2.

Whilst a feeder reconfiguration (Option 1) is incorporated into Option (a), for all other options the feasibility depends on the capacity of the existing REFCL units. A feeder reconfiguration is only feasible if there are at least two REFCLs for reconfigurations that stay on a specific zone substation. Whilst both BAN and BAS have three units and meet that criteria, the capacity of the REFCL units limits the use of this as an option.

Adding a new REFCL (Option 2) feasibility is dependent on whether the existing zone substation design is able to accommodate the additional REFCL(s) required. For BAN and BAS, this option would also necessitate the addition of a new zone substation transformer. With that additional work required, it is not suitable as a sole option but has been instead incorporated into the solutions through Options 4, 5 and 6.

4.5 Options Benefits

Each of the four options listed meet the required network need:

- the REFCL compliance will be met
- capacity constraints will be managed to provide security of supply into the foreseeable future.

Benefits that are unique to one option or the other, such as enhanced operational flexibility are minor in comparison to the capital cost differences between the options.

As such, financial modelling in this Regulatory Investment Test is presented as net present value (**NPV**) with a target of finding the least negative net present value option to maintain compliance. The penalties (benefits) associated with non-compliance are common for all options. Hence, they have not been included in the assessment.

4.6 Modelling Results

The modelled financial results and subsequent preference ranking of the four options are shown in Table 3.

Table 3 Model results for 2.75% discount rate and zone substation deferred to 2035 in option (a)

Option		NPV	Ranking
(a)	Isolating substations and deferred zone substation	($ 15.7 M)	4
(b)	Two mini zone substations	($ 10.7 M)	2
(c)	New zone substation in Ballarat East	($ 8.4 M)	1
(d)	New zone substation at an alternate Ballarat location	($ 10.9 M)	3

4.7 Credible Scenarios Applied to Options

The results of modelling shown could be influenced by changes in assumptions used within the financial evaluation model. As a result, the robustness of assumptions will be tested through scenario modelling.

(i) Changing the discount rate in response to national economic conditions. Two steps incrementing by 1 % pa each have been used as shown in Table 4.

Table 4 Scenario results for varying Discount Rate

Option	Discount rate:	2.75%	3.75%	4.75%	Ranking
(a)	Isolating substations and deferred zone substation	($ 15.7 M)	($ 13.7 M)	($ 12.0 M)	4
(b)	Two mini–zone substations	($ 10.7 M)	($ 9.6 M)	($ 8.6 M)	3
(c)	New zone substation at Ballarat East	($ 8.4 M)	($ 7.5 M)	($ 6.6 M)	1
(d)	New zone substation at an alternate Ballarat location	($ 10.9 M)	($ 9.5 M)	($ 8.5 M)	2

It is concluded that only the ranking between options (b) and (d) is altered with credible movement of the discount rate.

(ii) Returning the discount rate to 2.75%, the next variable to be modified is the load constraint timing. Table 5 shows the effects on option (a) by decreasing deferral of the zone substation to 2030 and then increasing deferral by 10 years to 2045 to address a deferred timing of constraint; (the other three options are not dependent on this variable).

Table 5 Scenario results for increased deferment of load constraint timing in option (a)

Option	deferred to:	2030	2035	2045	Ranking
(a)	Isolating substations and deferred zone substation	($ 18.1 M)	($ 15.7 M)	($ 9.0 M)	2

(b)	Two mini–zone substations	($ 10.7 M)	3
(c)	New zone substation at Ballarat East	($ 8.4 M)	1
(d)	New Zone Substation at an alternate Ballarat location	($ 10.9 M)	4

Option (c) remains the preferred option under any reasonably expected scenario that delays the growth in load and therefore deferred establishment of a new zone substation.

(iii) Altering cost inputs for zone substation construction (new, mini and deferred) to allow for 20% variation either way from the base case used for Table 3 is shown in Table 6. The rankings of option (c) as the lowest remains unchanged from the base case.

Table 6 Scenario results for variations in cost inputs

Option	Cost base variation:	-20%	0%	+20%	Ranking
(a)	Isolating substations and deferred zone substation	($ 12.5 M)	($ 15.7 M)	($ 18.8 M)	4
(b)	Two mini zone substations	($ 8.7 M)	($ 10.7 M)	($ 13.0 M)	3
(c)	New zone substation at Ballarat East	($ 6.7 M)	($ 8.4 M)	($ 10.1 M)	1
(d)	New zone substation at an alternate Ballarat location	($ 8.6 M)	($ 10.9 M)	($ 12.9 M)	2

4.8 Preferred Option

Clause 5.17.1 (b) of the NER defines the principle that the preferred option is to:

> *"maximise the present value of the net economic benefit to all those that produce, consume and transport electricity in the National Electricity Market"*

> and further that

> *"a preferred option may, in the relevant circumstances, have a negative net economic benefit (that is, a net economic cost) where the identified need is for reliability corrective action"*

The base case and all scenarios highlight that Option (c) is the lowest cost option for the range of variables used.

Therefore, **Option (c) is identified as the preferred option** which meets both the mandatory requirements of the Bushfire Mitigation Regulations and emerging interdependent load constraints, and of the credible and technically feasible options, minimises the net economic cost.

5 Satisfaction of RIT-D

The preferred option, summarised in Section 4, satisfies the RIT-D. This statement is made based on the detailed analysis set out in this report.

Table 7 checklist of regulatory compliance

Rules clause	Requirement	Section of this report
5.17.4(j)(1)	Description of the identified need for the investment	Section 3
5.17.4(j)(2)	The assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, reasons that the RIT-D proponent considers reliability corrective action is necessary)	Section 3
5.17.4(j)(3)	If applicable, a summary of, and commentary on, the submissions on the non-network options report	Section 4.1
5.17.4(j)(4)	Description of each credible option assessed	Section 4.3
5.17.4(j)(5)	Where a Distribution Network Service Provider has quantified market benefits in accordance with clause 5.17.1(d), a quantification of each applicable market benefit for each credible option	Not applicable
5.17.4(j)(6)	A quantification of each applicable cost for each credible option, including a breakdown of operating and capital expenditure	Section 4.4 & Section A.6
5.17.4(j)(7)	A detailed description of the methodologies used in quantifying each class of cost and market benefit	Section 3
5.17.4(j)(8)	Where relevant, the reasons why the RIT-D proponent has determined that a class or classes of market benefits or costs do not apply to a credible option	Not applicable
5.17.4(j)(9)	The results of a net present value analysis of each credible option and accompanying explanatory statements regarding the results	Section 4.6
5.17.4(j)(10)	The identification of the proposed preferred option	Section 4.8
5.17.4(j)(11)	For the proposed preferred option, the RIT-D proponent must provide: • details of the technical characteristics • the estimated construction timetable and commissioning date (where relevant) • the indicative capital and operating cost (where relevant) • a statement and accompanying detailed analysis that the proposed preferred option satisfies the regulatory investment test for distribution • if the proposed preferred option is for reliability corrective action and that option has a proponent, the name of the proponent	Table 2, Table 8 & Section 5 Not applicable
5.17.4(j)(12)	Contact details for a suitably qualified staff member of the RIT-D proponent to whom queries on the draft report may be directed	Section 6

6 Lodging a submission

Powercor invites written submissions on the preferred solution identified in this report from any interested party. Our aim is to develop the distribution network in a manner that maximises net economic benefits to all those who produce, consume and transport electricity in the National Electricity Market. We welcome submissions that may assist in this regard.

Submissions can be provided electronically to the email address provided below:

ritdenquiries@powercor.com.au

Alternatively, submissions may be lodged by mail to the following address:

Daniel Garvey

Manager – Distribution Planning & Connections

CitiPower and Powercor

Locked Bag 14090 Melbourne Vic 8001.

Submissions may be published on Powercor's website (or other sites as appropriate). If you do not want your submission to be published, please state this at the time of lodgement.

All submissions are due on or before 17:00 on 9 January 2024.

Following review by Powercor of any submissions made, the option chosen to address the identified need will be set out in the final project assessment report. That report will represent the final stage of the RIT-D assessment process.

Powercor intends to complete our review of submissions and the selection of the final project assessment report by 16 February 2024.

7 APPENDICES

A Supporting technical detail

B Glossary of terms

A Supporting technical detail

Detailed information to support the Project Assessment

A.1 Earth faults in an electricity network

Australian electricity networks utilise star windings with an earthed neutral, consequently any unwanted connection between a phase conductor and earth will generate a current from that phase to earth. This is a condition is known as a fault, and logically described as an earth fault.

An earth fault current will generate heat across a resistive load including contact such as a wire in contact with a tree or the ground. While this current flow is used to operate protection equipment, the energy level at the fault site may be adequate to provide a source of bushfire ignition in some conditions. A method of minimising the energy at an earth fault site (and hence ignition risk) is using resonant earthing technology by employing REFCL devices, the theory of which is described comprehensively in other publicly available sources such as Implementation & Optimisation of Resonant Networks for Victorian REFCL Applications, CitiPower & Powercor, 2020[6].

Review of the theory shows that two key measurable components underpinning the design and operation of REFCL are most relevant to this report; charging currents and network damping (damping).

Charging currents are a dependent on factors such as system voltage and capacitance, the latter being a function of conductor geometry, spacing of conductors to earth, properties of various dielectric materials and, importantly, length. They are one way of measuring network size.

Damping can be viewed as a resistive component that reduces or damps charging current. Measured in ohms or more often expressed as a percentage of network size, it can be more difficult to predict. Damping comes from three sources:

- resistive losses from the arc suppression coil
- resistive leakage to earth of all network components (insulators, surge arrestors etc). While these are generally fixed, they can be influenced by high humidity and rainfall
- series losses supplying (capacitive) charging current of the network. The greater the charging current and greater the line impedance, the greater impact on network damping.

6 CitiPower and Powercor Australia, 2020. Document Number CP_PAL_REFCL_001; Implementation & Optimisation of Resonant Networks for Victorian REFCL Applications. R0.5

A.2 Detailed legislative obligations

The Bushfire Mitigation Regulations impose technical obligations on the Victorian Distribution Network Service Providers that operate in high-risk bushfire areas, and this includes Powercor.

Obligations relevant to this Regulatory Investment Test include:

- each polyphase electric line originating from a listed zone substation must have the "required capacity" specified in the Bushfire Mitigation Regulations
- testing for the "required capacity" must be undertaken before the specified bushfire risk period each year and a report detailing the results of testing submitted to Energy Safe Victoria
- each new or replaced line with a nominal voltage from 1 kV to 22 kV inclusive must be covered or undergrounded from 1 May 2016 in 33 prescribed electric line construction areas.

Schedule 1 of the legislation defines 22 selected zone substations in the Powercor area and assigns a point value to each site based on the level of bushfire risk. Powercor must meet the "required capacity" obligations for selected zone substations where 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".

The "required capacity" for a polyphase line originating from a selected zone substation is defined by the legislation[7] as:

'…in the event of a phase-to-ground fault on a polyphase electric line, the ability—

(a) to reduce the voltage on the faulted conductor in relation to the station earth when measured at the corresponding zone substation for high impedance fault to 250 volts within 2 seconds; and

(b) 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—
(i) 1900 volts within 85 milliseconds; and
(ii) 750 volts within 500 milliseconds; and
(iii) 250 volts within 2 seconds; and

(c) during diagnostic tests for high impedance faults, to limit—
(i) fault current to 0.5 amps or less; and
(ii) the thermal energy on the electric line to a maximum I^2t value of 0.10 units

7 Electricity Safety (Bushfire Mitigation) Regulations 2023 (VIC), Definitions

A.3 Measurement of REFCL parameters

Powercor measures REFCL performance using a constraint parameter that has been termed damping current (DAMPs). DAMPs are calculated by combining system capacitance and network damping parameters to create single constraint parameter. DAMP has a threshold of 3.25.

Testing of REFCL systems is required to demonstrate compliance. Tests are carried out each year, and readings are also measured on Total Fire Ban (TFB) days and reported to ESV as part of an annual compliance test process. This provides empirical data on compliance and forms the basis for forecasting future performance of the REFCL systems.

A.4 Additional information on Isolating substations

Eleven (11) isolating substations are required to remove enough cabled network from BAN and BAS to achieve compliance at those sites, 12 potential sites for those are shown in Figure 6.

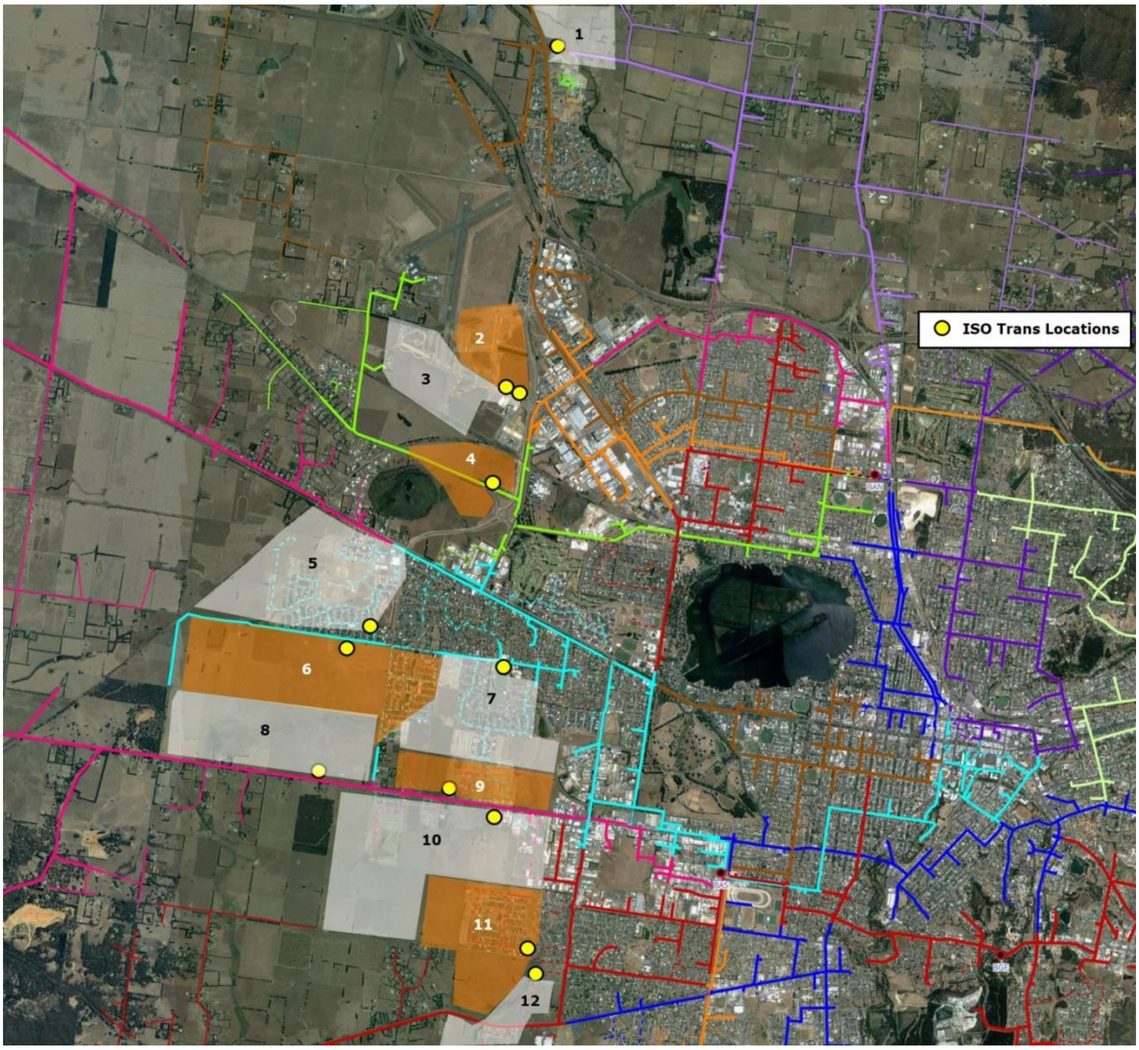

Figure 6 Proposed locations for Isolating substations

In addition, installation of a set of three (3) more isolating substations with REFCL systems is required by 2030. Situated to the north-east of Ballarat, the proposed locations are shown in Figure 7. The additional costs of a REFCL fitted isolating transformer over a normal isolating transformer has been taken into account in this investment test.

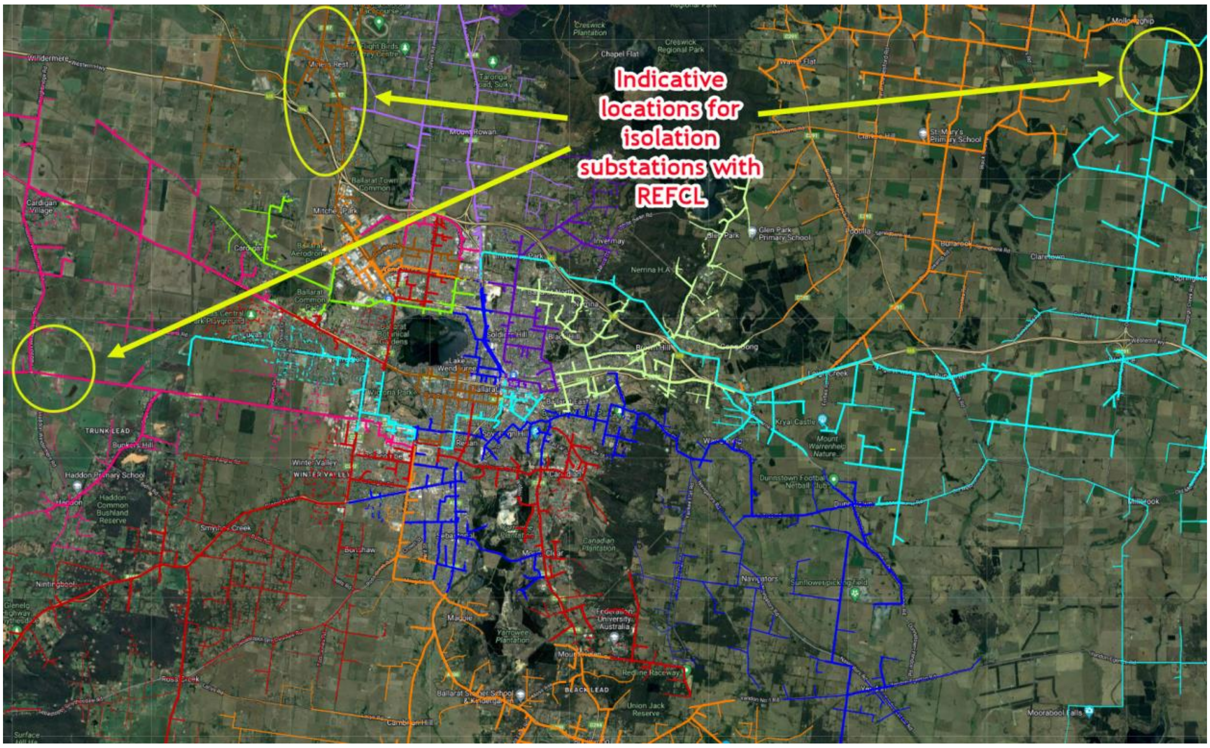

Figure 7 Proposed location of Isolating substations 12, 13 and 14 by 2030

As the network continues to grow, connected load continues to grow and the increased length of underground cables will increase capacitive currents that challenge REFCL operation. Hence, there is a subsequent need to install more isolating substations in the future and as additional isolating substations are installed, impacts to operational flexibility and reliability will occur.

A.5 Additional information on a new zone substation

Figure 8 shows how the sub-transmission network and distribution network provide opportunity to place a new zone substation into the network with minimised connection costs.

Ballarat East is considered a prudent zone substation location as Powercor already owns the site, it has 66kV sub-transmission lines running past the site and it is close to the existing 22kV feeder networks from BAS and BAN. This reduces the costs significantly compared to locating the zone substation at another location. Other sites (shown in Figure 9) incur increased costs through additional sub-transmission work or distribution work, the purchase of land and likely pose timing risks for completion before the 2025/2026 bushfire season. They would also still likely require new lines in residential areas and may require the procurement of easements in rural areas.

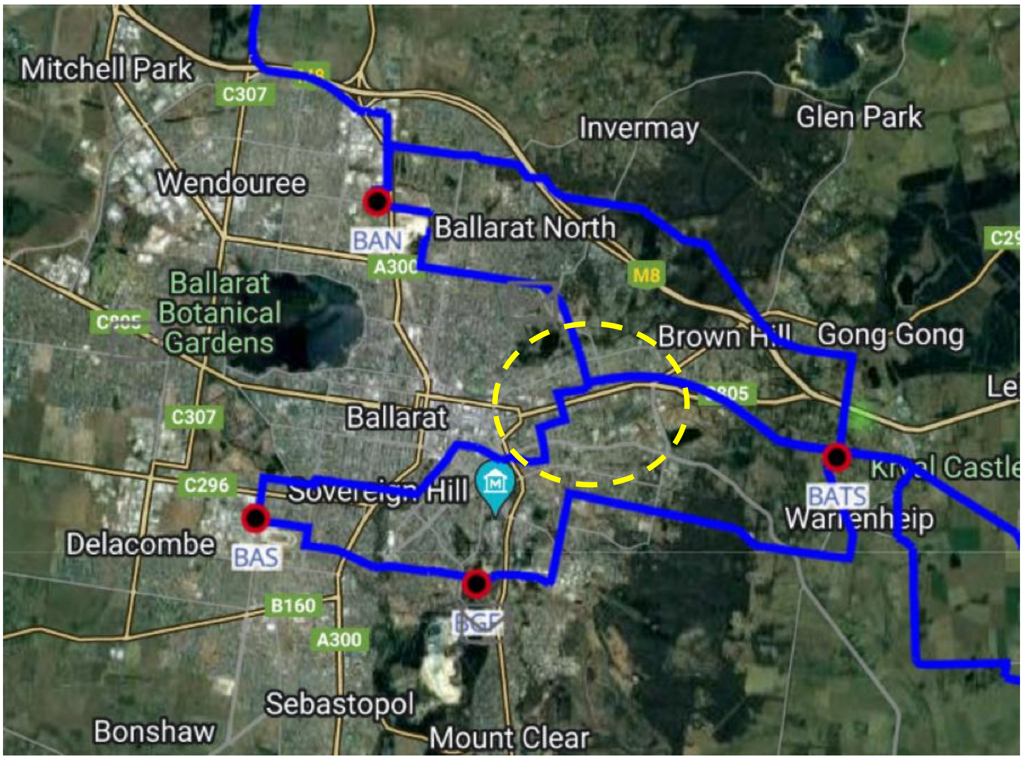

Figure 8 Possible location of a new zone substation Ballarat East (BAE)

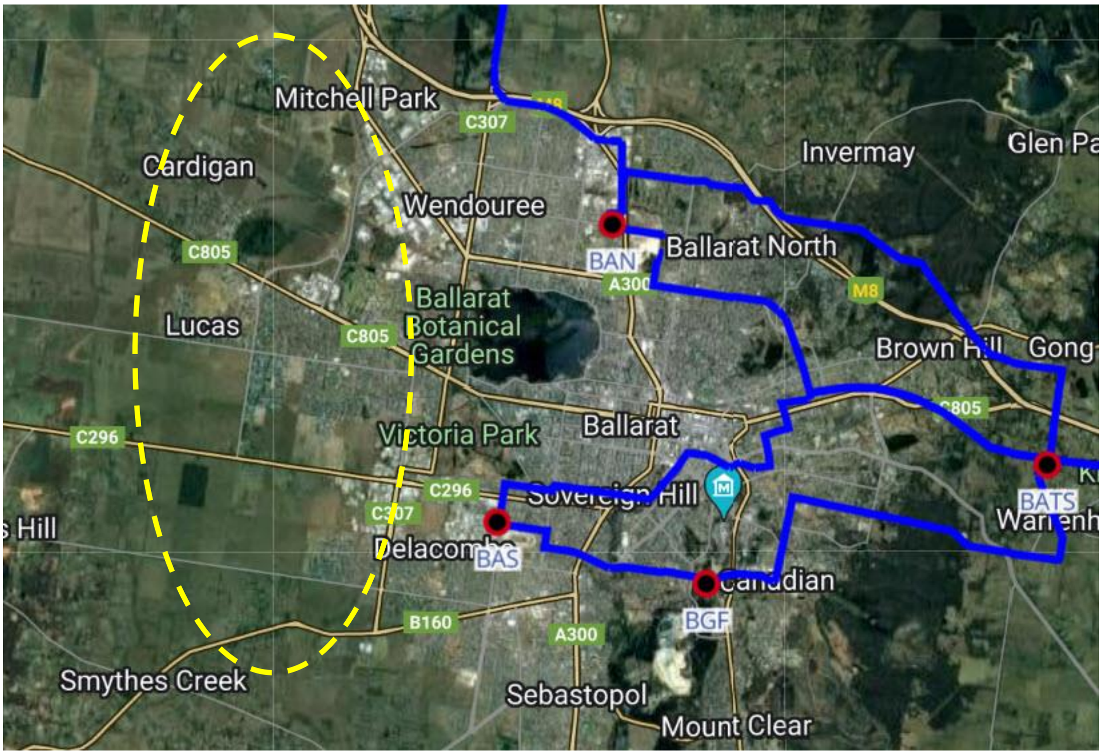

Figure 9   Possible location of an alternate new Ballarat substation

The BGF customer owned site has been considered as an alternate location but ruled out as a feasible option. It requires the purchase of land as the existing site is not large enough to accommodate the required new REFCL infrastructure, the customers transformers operate at a different voltage level which would require the installation of new transformers, higher costs are incurred to connect into the 22kV distribution network from that site as interconnection and roadway access is not as prevalent, the site and future line routes are surrounded by vegetation, biodiversity and heritage areas of significance.

A.6 Building block costs for financial modelling

Table 8 Cost building blocks (2023 pricing, capital costs unless noted otherwise)

Item	Unit cost	Comments	Life
Isolating substation	$ 1.6 M	6MVA 22/22 kV DYn transformer switchgear, land, earthing, connections	40+ years
REFCL unit for Isolating substations	$ 6.2 M	$0.5 M secondaries $5.7 M primary	20 years 40+ years
Mini zone substation	$ 26 M*	1 x 35 MVA transformer with REFCL (Secondary /Primary) Switchgear, land, fencing, HV & LV connections	40+ years 20/40+ years 40+ years
Zone substation	$ 45 M*	2 x 35 MVA transformer with REFCLs (Secondary /Primary) Switchgear, land, fencing, HV & LV connections	40+ years 20/40+ years 40+ years
Testing and maintenance	1% of capital expenditure	Testing of REFCLs and other plant assets plus associated maintenance	Opex

** Costs can differ depending on site locations as there are variations in the sub-transmission and distribution line costs required to build the asset.*

B Glossary of terms

Term	Definition
“required capacity”	Electricity Safety (Bushfire Mitigation) Regulations 2023 - regulation 5 Definitions for “required capacity”
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
Bushfire Mitigation Regulations	Electricity Safety (Bushfire Mitigation) Regulations 2023
BAE	Ballarat East Zone substation - a possible solution in this report
BAN	Ballarat North Zone substation
BAS	Ballarat South Zone substation
BMP	Bushfire Mitigation Plan
DAMPs	Damping current – a measure for REFCL performance
DNSPs	Distribution Network Service Providers
Electricity Distribution Code of Practice	Electricity Distribution Code of Practice, version 2, 1 May 2023, Essential Services Commission
ESV	Energy Safe Victoria
Firm Capacity	Summer cyclic capacity available with network operating with one element unavailable for service per zone substation
HV	High Voltage
NER	National Electricity Rules
NPV	Net Present Value
PBST	Powerline Bushfire Safety Taskforce
PoE 50	The 50% PoE demand forecast relates to maximum demand corresponding to an average maximum temperature that will be exceeded, on average, once every two years
REFCL	Rapid Earth Fault Current Limiter
RIT-D	Regulatory Investment Test for Distribution

Term	Definition
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
TFB	Total Fire Ban
VBRC	Victorian Bushfire Royal Commission
VCR	Value of customer reliability
WACC	Weighted average cost of capital