Surf Coast supply area

PAL BUS6.01 - Surf Coast supply area - Jan2020 - Public

Regulatory proposal 2021–2026

Powercor

January 2020

Contents

1 Overview

Business	Powercor
Title	Surf Coast supply area
Project ID	PAL BUS6.01 - Surf Coast supply area - Jan2020 - Public
Category	Augmentation
Identified need	The identified need addressed by this investment is to: • ensure that Waurn Ponds zone substation meets the capacity requirements in the Amended Bushfire Mitigation Regulations within the mandated timeframes • maintain supply within the permissible voltage variations specified in the Victorian Electricity Distribution Code • meet our customers' reasonable expectations for a reliable supply of electricity in the Surf Coast supply area, in response to the projected increases in energy at risk.
Recommended option	Option 4: Install three Ground Fault Neutralisers (**GFN**s) at Waurn Ponds zone substation with six isolating substations and establish Torquay zone substation with two GFNs and three isolating substations.
Proposed start date	2021
Proposed commission date	December 2022
Supporting documents	1. PAL ATT121 - Surf coast supply area WPD scope - Jan2020 - Public 2. PAL ATT120 - Surf coast supply area TQY scope - Jan2020 - Public 3. PAL ATT218 - VBRC - Final report - Jul2010 4. PAL ATT219 - SAPN - Powerline Bushfire Safety Taskforce - Sep2011 - Public 5. PAL ATT242 - Surf Coast Shire - Economic insights 2018 - Public 6. PAL ATT213 - AER - Final decision REFCL tranche 2 - Aug2018 - Public 7. PAL MOD 6.10 - REFCL cost model - Jan2020 - Public 8. PAL MOD 6.11 - Surf coast options analysis - Jan2020 - Public

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 forecasts for preferred option ($ million, 2021)

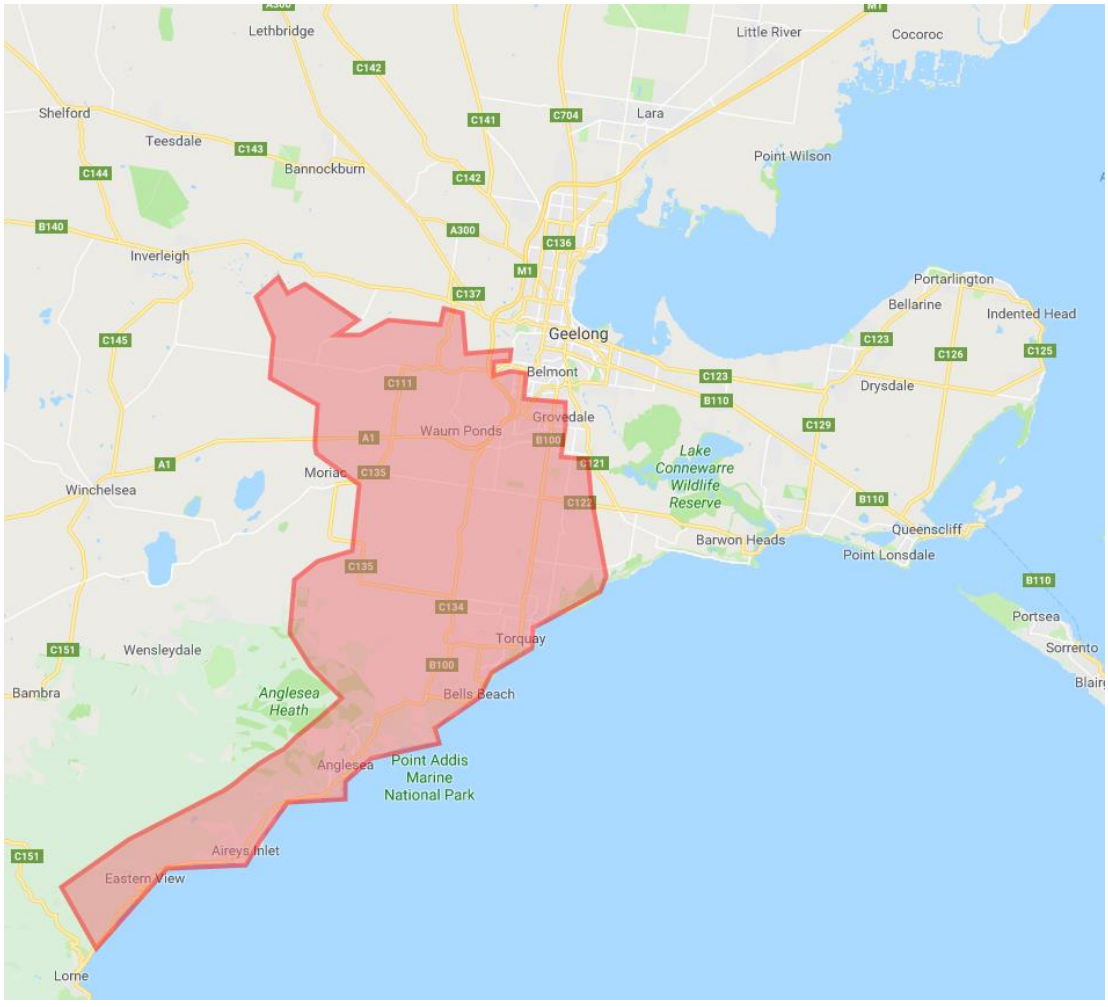
Expenditure forecast	2020	2021	2022	2023	2024	2025	2026	Total
Capital expenditure	0.33	6.83	60.20	6.17	0	0	0	73.52
Operating expenditure	0	0	0.19	0.56	0.74	0.74	0.74	2.97
Total	**0.33**	**6.83**	**60.39**	**6.73**	**0.74**	**0.74**	**0.74**	**76.49**

Source: Powercor

2 Background

Waurn Ponds (**WPD**) zone substation supplies electricity to 35,973 customers in the residential, commercial and holiday home areas in the Greater Geelong and Surf Coast areas. It supplies the southern Geelong suburbs of Waurn Ponds, Grovedale, Belmont and Highton, as well as customers in the towns of Torquay, Jan Juc, Anglesea and Lorne. A map of the WPD supply area is shown in figure 1.

Figure 1 WPD supply area



Source: Powercor

The major high voltage customers supplied from WPD zone substation include Deakin University and the Epworth Hospital. Over the next 20 years, significant new load is also expected to be supplied from WPD zone substation, as 22,000 new land lots are developed in the Armstrong Creek area.

2.1 Existing network characteristics

WPD zone substation comprises one 13.5 MVA 66/22kV and two 33 MVA 66/22kV transformers supplying the 22kV buses. The zone substation is a fully switched configuration so that, in the event of a transformer fault, one transformer will be isolated and the remaining units will continue to supply the station load.

WPD zone substation has electrical connectivity (distribution ties) with the four adjacent zone substations of Colac (**CLC**), Geelong (**GL**), Geelong City (**GCY**) and Geelong East (**GLE**). WPD zone substation supplies ten 22kV distribution feeders. These feeders support a mix of urban and rural residential customers, light industry and

commercial loads. Due to the increasing demand on the WPD distribution feeders, only limited transfers are available to provide load relief for WPD zone substation under emergency outage conditions.

2.2 REFCL capability

Powercor is required to install Rapid Earth Fault Current Limiters (**REFCL**s) at its WPD zone substation by 1 May 2023.

2.2.1 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:*
>
> – *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 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]

2.2.2 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, one of which is WPD, for which a mandated performance standard (the 'required capacity') 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:

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1 PAL ATT218: 2009 Victorian Bushfires Royal Commission, *Final Report, Summary*, July 2010, recommendation 27.

2 PAL ATT219: Powerline Bushfire Safety Taskforce, *Final report*, 30 September 2011, p. 5.

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

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 Voltage issues at WPD

Clause 4.2 of the Victorian Electricity Distribution Code (**Distribution Code**) prescribes voltage standards that must be met by a distributor. Specifically, clause 4.2.2 relates to allowed variations from the standard nominal voltage level (specified in clause 4.2.1 of the Code) that the distributor is required to maintain at the point of supply to a customer's electrical installation, as set out in the table below. It is noted that the phase-to-earth voltage variations on the 22kV network do not apply when a REFCL is operating, per clause 4.2.2A of the Distribution Code.

Table 2 Standard Voltage Variations

STANDARD NOMINAL VOLTAGE VARIATIONS				
Voltage Level in kV	Voltage Range for Time Periods			Impulse Voltage
	Steady State	Less than 1 minute	Less than 10 seconds	
< 1.0	+10% - 6%	+14% - 10%	Phase to Earth +50%-100% Phase to Phase +20%-100%	6 kV peak
1-6.6	± 6 % (± 10 % Rural Areas)	± 10%	Phase to Earth +80%-100% Phase to Phase +20%-100%	60 kV peak
11				95 kV peak
22				150 kV peak
66	± 10%	± 15%	Phase to Earth +50%-100% Phase to Phase +20%-100%	325 kV peak

Source: Victorian Electricity Distribution Code, Version 9A, clause 4.2.2

Our analysis shows that, in the absence of mitigating action, the WPD 22kV distribution feeders supplying the Surf Coast areas including Torquay would not meet the above voltage standards from 2025 onwards, based on projected load growth. In addition to meeting our compliance obligations in relation to the installation of REFCLs, Powercor must also ensure that it plans to operate within the voltage variations specified in the Distribution Code.

3 Identified need

In the previous section, we explained our obligations to comply with the Amended Bushfire Mitigation Regulations and the Distribution Code requirements in relation to voltage variations.

In addition to satisfying these regulatory obligations in relation WPD zone substation, we must also meet our customers' reasonable requirements for a reliable electricity supply.[3] In relation to this latter requirement, we apply a probabilistic planning approach to the distribution network so that we balance the expected costs of unserved energy against the costs of actions to improve reliability. As a consequence, the 'identified need' in relation to the WPD zone substation and the Surf Coast supply area is to:

- ensure that Waurn Ponds zone substation meets the capacity requirements in the Amended Bushfire Mitigation Regulations within the mandated timeframes
- maintain supply within the permissible voltage variations specified in the Distribution Code
- meet our customers' reasonable expectations for a reliable supply of electricity in the Surf Coast supply area, in response to the projected increases in energy at risk.

The purpose of this section is to explain the network capacitance and energy at risk issues at WPD, which are the key drivers of the augmentation requirements at WPD.

3.1 Network capacitance forecasts

As outlined in section 2.2.2, we must install REFCLs at WPD zone substation to ensure the mandated performance requirements are met by 1 May 2023, in accordance with the Amended Bushfire Mitigation Regulations. Ground Fault Neutralisers (**GFN**s) 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 93 amps of capacitive charging current is a suitable sized distribution network for each GFN operation at WPD, based on results from the Winchelsea zone substation where two GFN units have been installed.

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.

For WPD, there is presently 616km of overhead line and 129km of underground cable for an estimated network capacitance of 494 amps requiring six GFNs. However, we also need to take account of forecast increases in network capacitance, particularly given the significant underground cable growth, which is driven by development in the Armstrong Creek area.

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

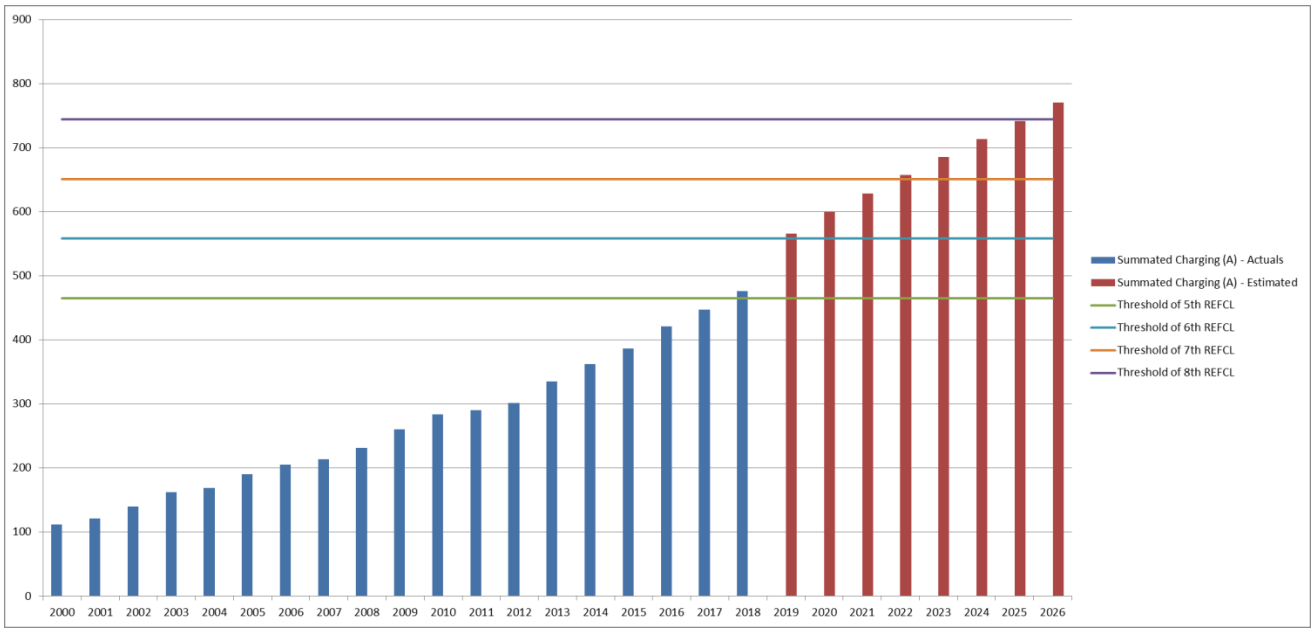
[3] Victorian Electricity Distribution Code, Version 9A, clause 5.2.

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 Energy Safe Victoria (**ESV**). The Technical Working Group did not recommend any changes to the methodology, which we regard as a reasonable approach for estimating network capacitance.

Our forecasts show that the network capacitance at WPD is expected be 685 amps in 2023, increasing to 770 amps by the end of the regulatory period in 2026. This significant increase is due to the large amount of underground cable growth being driven by growth in the Armstrong Creek development area. Figure 2 presents the forecast network capacitance, which indicates that nine GFNs would be required at WPD in the absence of any other measures to reduce the network capacitance at WPD.

Figure 2: WPD Network Charging Current Forecast Per Year



Source: Powercor

3.2 Forecast demand

The WPD zone substation is a summer critical zone substation. Our maximum demand forecasts indicate an annual average compound growth rate of 3.0% in the WPD supply area up to 2028. Whilst this projected growth is significantly above the average for Powercor's network, it is relatively conservative given the particular characteristics and demographics of the Surf Coast supply area.

In particular, the projected growth in electricity demand is driven primarily by rapid population growth in both the Surf Coast and Armstrong Creek areas. For example, a report by the Surf Coast Shire forecasts annual population growth of over 3.3% during the 2021–2026 period for the Torquay area.[4] Significant new loads are

[4] PAL ATT242: Surf Coast Shire, *Economic Insights*, 2018.

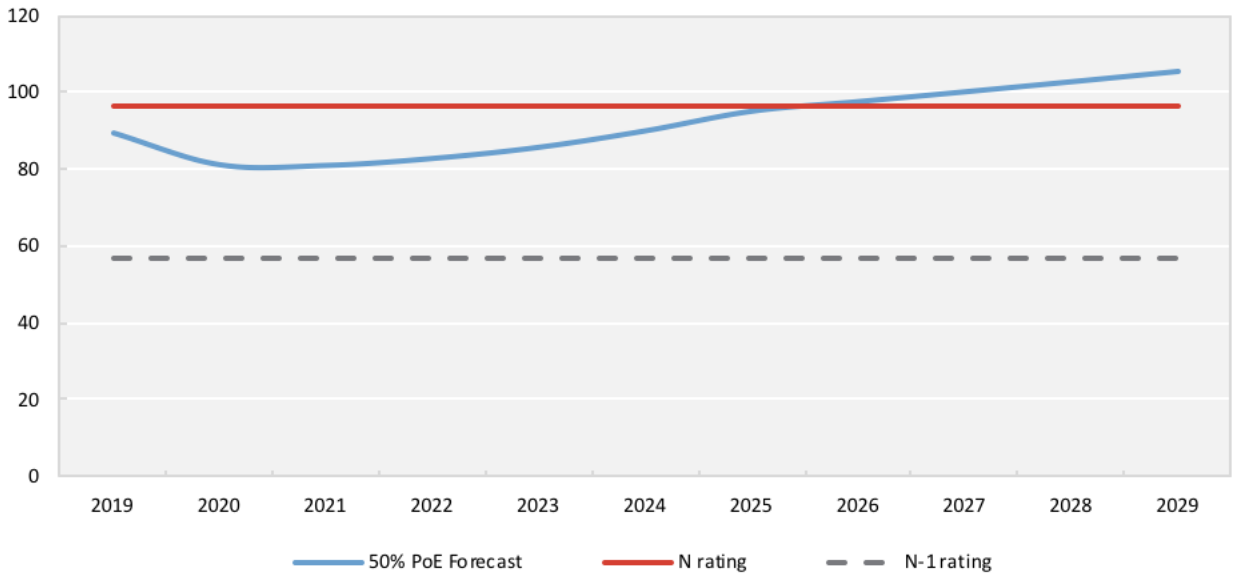
also expected as 22,000 new land lots are developed in the Armstrong Creek urban growth corridor. Our projected growth in electricity demand is in line with historical growth rates, which have substantially exceeded average growth across the State.

Further detail on this demand growth is set out in appendix A and B.

3.2.1 Zone substation maximum demand

WPD zone substation is currently operating above its (N-1) summer cyclic rating. Forecast demand is expected to continue to exceed its summer N-1 cyclic capacity at a 50% probability of exceedance (**PoE**).[5] By 2026, however, WPD zone substation is forecast to exceed its N cyclic rating, as shown in the figure below.

Figure 3 WPD zone substation maximum demand at 50% probability of exceedance (MVA)



Source: Powercor

In light of the above figure, in the absence of mitigating action, our customers' load requirements would not be met from 2026 onwards. Powercor notes that such an outcome would be inconsistent with our Distribution Code obligations to meet our customers reasonable expectations of a reliable electricity supply.

As explained in further detail below, our analysis below shows the value of expected unserved energy at WPD in the absence of any mitigating action.

Table 3 Value of expected unserved energy at WPD ($ million, 2021)

	2021	2022	2023	2024	2025	2026	2027
Value of expected unserved energy	0.11	0.26	0.45	0.94	1.72	1.94	2.60

Source: Powercor

[5] 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.

3.2.2 Feeder utilisation

Consistent with our planning policies, we review both thermal and planning capacity constraints when assessing feeder utilisation. Distribution feeders can be operated above their planning capacity, although this reduces operational flexibility as loads cannot be transferred under contingency conditions. Distribution feeders, however, are not designed to exceed their thermal capacity rating.

The thermal ratings of the 22kV distribution feeders to the Surf Coast areas are forecast to approach their thermal ratings by 2025, as shown in table 4 below.

Table 4 22kV distribution feeder forecasts to the Surf Coast areas in 2025: thermal capacity constraints

Feeder	Forecast Load (50% POE)	Thermal Rating	Load % of Rating
WPD14	286 A	320 A	89%
WPD21	303 A	320 A	95%
WPD22	306 A	320 A	96%
WPD24	311 A	315 A	99%
WPD32	307 A	315 A	98%

Source: Powercor

Each of the 22kV distribution feeders to the Surf Coast areas are forecast to exceed their planning ratings by 2023, and in 2025 are forecast to be more than 110% overloaded as shown below in table 5.

Table 5 22kV distribution feeder forecasts to the Surf Coast areas in 2025 planning capacity constraints

Feeder	Forecast Load (50% POE)	Planning Rating	Load % of Rating
WPD14	286 A	256 A	112%
WPD21	303 A	256 A	118%
WPD22	306 A	256 A	119%
WPD24	311 A	252 A	123%
WPD32	307 A	252 A	122%

Source: Powercor

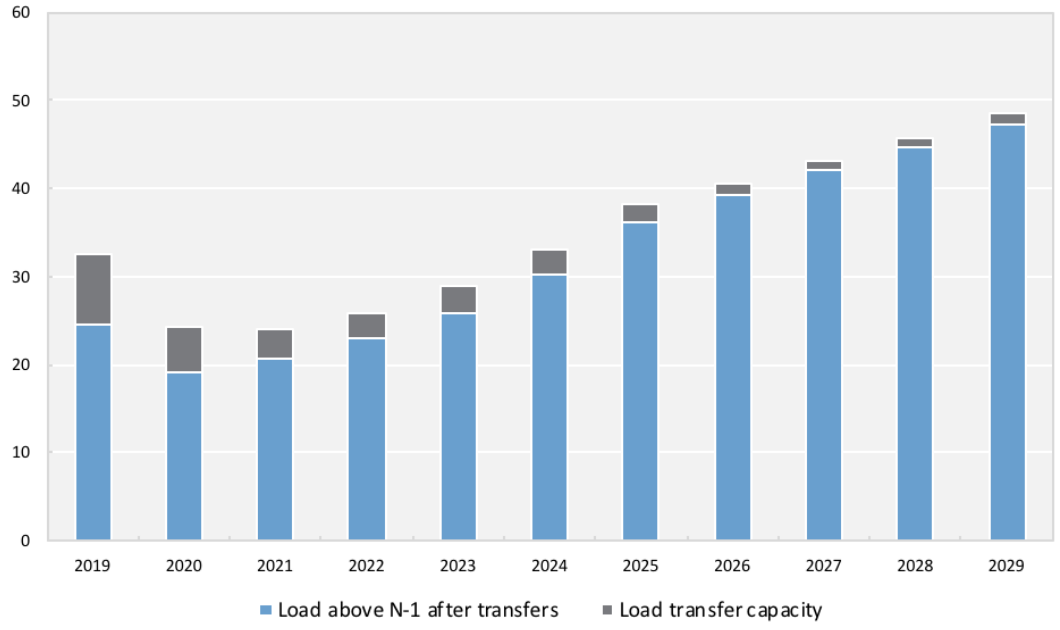
3.3 Energy at risk

Consistent with our probabilistic planning approach, the quantity and value of energy at risk is a critical parameter in assessing prospective network investment or other action in response to an emerging constraint.

3.3.1 Load transfer capacity

The expected energy at risk following a major outage of one of the transformers at WPD zone substation during peak demand conditions is shown in figure 4. After load transfers, a shortfall in capacity of approximately 41 MVA is forecast in 2026, which equates to the loss of supply for approximately 13,224 customers.

Figure 4 Forecast energy at risk and load transfers (MVA)

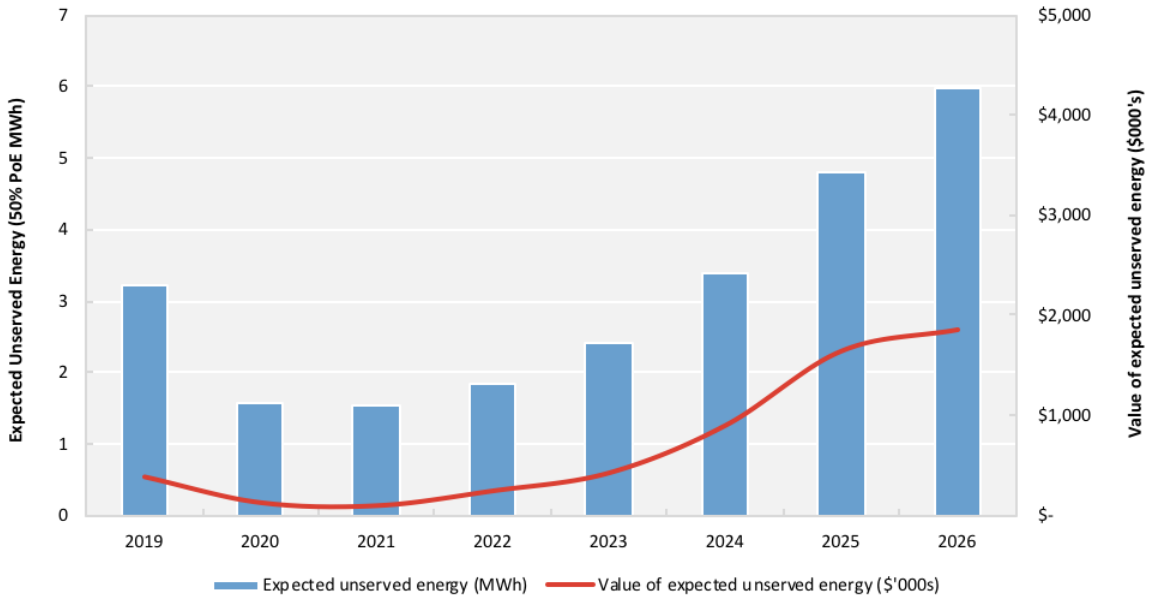


Source: Powercor

3.3.2 Expected cost of unserved energy

The expected cost of unserved at WPD zone substation is shown in figure 5, under N-1 conditions. The expected cost of this unserved energy is estimated using a standard weighting of 30% of the 10% PoE risk and 70% of the 50% PoE risk. The calculation reflects the cost of energy at risk multiplied by the low probability of a transformer failure at WPD zone substation.

Figure 5 Expected energy at risk (MWh) and expected cost of unserved energy ($'000s)



Source: Powercor

The amount of energy at risk for a transformer failure at WPD zone substation is relatively high due to the high demand on the zone substation. WPD has a plant protection scheme in place due to this high demand. Under this scheme, if the load on the WPD zone substation is above the ratings of the other two transformers after a transformer failure, load shedding of distribution feeders will take place. A significant number of connected customers will be off-supply until load transfers are established.

When the available load transfer capability is insufficient to supply the total connected demand, the reliability risks increase as the customers will remain off-supply until either: load transfers become available; the total connected demand reduces below the station ratings; or a replacement transformer can be installed. While the probability of a transformer failure is low, the energy at risk for such an event is high because customers may be affected for an extended period of time.

4 Options analysis

4.1 Cost benefit assessment

As explained in section 3, the identified need in relation to the Surf Coast supply area is driven by our compliance obligations and reliability issues.

As already noted, the installation of GFNs is the only technically feasible solution currently available that is capable of satisfying the performance requirements specified in the Amended Bushfire Mitigation Regulations. However, depending on the particular network and load characteristics, the work required to achieve compliance is not limited to the installation of a single GFN at each zone substation. In particular, further investment will be required to address performance issues relating to network hardening, capacitive balancing, harmonics and damping. These technical issues have been explained in detail in our contingent project applications, and for the sake of brevity are not repeated in this business case.

The table below shows the four options that we have examined in response to the identified need for the Surf Coast supply area. A 'do nothing' option was not considered because it would fail to address Powercor's compliance obligations. The table below shows the net economic benefit for each option, which reflects the benefit from any reduction in expected unserved energy minus the cost of the investment (including investment to meet our compliance obligations). For the purposes of the analysis, incremental asset maintenance costs have been included in the evaluation. It shows that Option 4 has the highest net economic benefit and therefore is the preferred option.

Table 6 Summary of net economic benefits ($ million, 2021)

	Option	Net economic benefit
1	Install nine Ground Fault Neutralisers (GFNs) at WPD zone substation	$35.9
2	install five GFNs at WPD with ten isolating substations	$47.0
3	Install three GFNs at WPD, establish Torquay (TQY) and Charlemont (CMT) zone substations each with three GFNs	$41.0
4	Install three GFNs at WPD with six isolating substations, and establish TQY zone substation with two GFNs and three isolating substations	$55.0

Source: Powercor

It is noted that in order to meet the Amended Bushfire Mitigation Regulations , the timing of the works for all options must be completed, including all commissioning and testing, by end of 2022, so that summer 2022/23 is used to prepare the GFNs for performance compliance by 1 May 2023. The costs of each option have been prepared on the same basis as our recent contingent project application provided to the Australian Energy Regulator (**AER**).[6] The analysis supporting our assessment of alternative options, including relevant assumptions, is included in the attached model.[7]

Two of the four options include the use of isolating substations. Isolating substations can be used to electrically separate a section of network from other areas of the network to reduce the amount of compensation (i.e.

[6] PAL ATT213: AER, *Final decision, Powercor Australia Contingent Project, Installation of Rapid Earth Fault Current Limiters (REFCLs) – tranche two*, 31 August 2018.

[7] PAL MOD 6.11 - Surf coast options analysis - Jan2020 - Public

current injected into the transformer neutral to cancel the residual active fault current) that the GFN must provide to reduce the voltage on the broken conductor to almost zero. However, as the polyphase electric lines portion of the network covered by the isolation substation will not be covered by the GFN, the GFN will not achieve required capacity mandated by the Amended Bushfire Mitigation Regulations. In these circumstances, Powercor would be required to apply to Energy Safe Victoria (**ESV**) for an exemption in accordance with Regulation 13. It is worth noting that the areas of the network where isolating substation may be used are to be wholly underground to ensure that the bushfire risk is minimised.

Each option considered is discussed in further detail below. The preferred option will be subject to a regulatory investment test for distribution (**RIT–D**), which will allow for further stakeholder consultation. However, it should be noted that there are no non-network alternatives to the installation of GFNs.

4.1.1 Option 1: install 9 GFNs at WPD zone substation

This option achieves compliance with the Amended Bushfire Mitigation Regulations at WPD by installing GFNs only. Based on the characteristics of the WPD supply area (particularly the extent of the underground network), our WPD zone substation will require nine Ground Fault Neutralisers (**GFNs**) to comply with the capacity requirements specified in the Amended Bushfire Mitigation Regulations.[8]

The installation of such a significant number of GFNs would require substantial site works and supporting network assets, including:

- the installation of six transformers, the extension of the 66kV bus with six transformer bays and the inclusion of seven new 66kV circuit breakers
- five feeder rearrangements as well as the construction of three new WPD feeders
- a new indoor switchroom will need to be constructed to house 22 new circuit breakers, comprising seven new feeder circuit breakers; six new transformer circuit breakers; six new bus tie circuit breakers; and three capacitor banks circuit breakers.

Currently, there is not enough space at the zone substation to house the above equipment. In theory, the buffer zone land between the zone substation and adjacent residential housing could be purchased and indicative costs have been included in our assessment. In practice, however, the land is unlikely to be available. It is therefore doubtful whether this option can be regarded as credible.

A summary of the market benefits and costs[9] of this option are shown in table 7.

Table 7 Option 1: benefits assessment ($ million, 2021)

Option	NPV costs	NPV benefits	Net economic benefits
Install nine GFNs at WPD zone substation	57.3	93.2	35.9

Source: Powercor

[8] The installation of REFCL technology works 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.

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

4.1.2 Option 2: install five GFNs at WPD with ten isolating substations

This option modifies Option 1 by reducing the number of GFNs required at WPD zone substation by installing isolating substations on the feeder network to reduce the capacitance loading on the GFNs. ESV exemptions would be required for this option.

In addition to installing five GFNs at WPD, this option would require the following site works:

- two new 25/33 MVA transformers
- the 66kV bus would need to be extended to include two new transformer bays, as well as include three new 66kV circuit breakers
- five feeder rearrangements, as well as the construction of a new WPD feeder
- a new indoor switchroom would need to be constructed to house two buses, five feeders and 11 new circuit breakers, comprising: five new feeder circuit breakers; two new transformer circuit breakers; two new bus tie circuit breakers; and one capacitor bank circuit breaker.

This option also involves the construction of ten new 6MVA isolation substations, which would need to be built on the feeder network:

- four on WPD22 (Two for the Torquay Underground Residential Development (**URD**) and two for the Warralily URD)
- six on WPD024 (Two for Warralily URD, Armstrong Creek URD and Torquay URD).

A concern with this option is the availability of land for the new switchroom, as noted in relation to Option 1, and also for the isolating substations on the feeder network.

Table 8 Option 2: benefits assessment ($ million, 2021)

Option	NPV costs	NPV benefits	Net economic benefits
install five GFNs at WPD with ten isolating substations	46.1	93.2	47.0

Source: Powercor

4.1.3 Option 3: Install three GFNs at WPD, establish Torquay (TQY) and Charlemont (CMT) zone substations each with three GFNs

This option involves the construction of two new zone substations, namely Torquay (**TQY**) and Charlemont (**CMT**) to house GFNs, in addition to works at WPD to install three GFNs. This option would satisfy our compliance obligations at WPD zone substation, whilst also mitigating fire risk at the two new zone substations. The installation of GFNs at these zone substations is likely to be an ESV requirement in order for the residual fire risk to be no higher than Option 1.

This option would require the following works:

- installation of three GFNs at WPD substation before the end of 2022
- three 66kV sub-transmission line exits, connecting to the loop with TQY and to CMT
- four 66kV circuit breakers (**CB**s) would need to be installed in the bus ring, as well as relocating the position of the 66kV CB 'A' within that ring

- two feeder rearrangements at WPD.

To address the reliability issues in the Surf Coast area, approximately 41 MVA of load would be transferred from the overloaded WPD zone substation to the new TQY and CMT zone substations. The required works at TQY and CMT would include:

At TQY:

- the installation of three GFNs
- the installation of three 25/33 MVA transformers
- five distribution feeders connected to three 22kV buses
- a 66kV sub-transmission loop from the existing WPD zone substation
- four 66kV circuit breakers would need to be installed in the bus ring for TQY.

At CMT:

- the installation of three GFNs
- the installation of three 10/13 MVA transformers
- three distribution feeders connected to three 22kV buses
- a 66kV sub-transmission line linking CMT with both WPD and Geelong East (**GLE**) zone substations
- four 66kV circuit breakers (CBs) would need to be installed in the bus ring for CMT
- land purchase would also be required at CMT.

In addition to the above works, a new 66kV CB would need to be installed at GLE to terminate the new GLE-CMT 66kV sub-transmission line.

A summary of the market benefits and costs of this option are shown in the table below.

Table 9 Option 3: benefits assessment ($ million, 2021)

Option	NPV costs	NPV benefits	Net economic benefits
Install three GFNs at WPD, establish TQY and CMT zone substations each with three GFNs	52.1	93.1	41.0

Source: Powercor

4.1.4 Option 4: install three GFNs at WPD with six isolating substations, and establish TQY zone substation with two GFNs and three isolating substations

This option involves the installation of three GFNs at WPD zone substation with six isolating substations in the feeder network. In addition, TQY zone substation would be established with two GFNs, and three isolating substations in the feeder network. ESV exemptions would be required for this option.

This option would require the following works:

At WPD:

- three new 66kV circuit breakers would need to be installed in the bus ring
- the position of the 66kV CB 'A" in the bus ring would need to be relocated

- two new 66kV sub-transmission line exits would need to be installed for the sub-transmission loop to TQY zone substation
- six isolating substations would need to be installed in the feeder network, comprising two on WPD22 (two for Warralily URD); and four on WPD024 (two for Warralily URD, two for Armstrong Creek URD)
- two feeder rearrangements at WPD.

At TQY:

- TQY zone substation would need to be constructed with two GFNs
- two new 25/33 MVA transformers
- three 66kV circuit breakers in the 66kV bus ring, which would also require completion of the 66kV sub-transmission loop with WPD
- a new switch room with four 22kV feeders over two buses would need to be constructed, with 13 circuit breakers comprising: eight new 22kV feeder circuit breakers; two new transformer circuit breakers; two new bus tie circuit breakers; and one capacitor bank circuit breaker
- one new four x 3MVar capacitor bank
- three isolating substations on the TQY feeder network. Three 6MVA isolating substations would be needed for the TQY URD served by TQY012 feeder.

Similar concerns arise for this option in relation to the availability of land for the isolating substations on the WPD and TQY feeder networks. In addition, ESV would need to grant exemptions and allow the extensive use of isolating substations in order for this option to be feasible.

A summary of the market benefits and costs of this option are shown in the table below.

Table 10 Option 4: benefits assessment ($ million, 2021)

Option	NPV costs	NPV benefits	Net economic benefits
Install three GFNs at WPD with six isolating substations, and establish TQY zone substation with two GFNs and three isolating substations	37.74	92.78	55.04

Source: Powercor

4.1.5 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:

- **Install ten GFNs at WPD and install four new feeders to supply the Torquay/Surf Coast area**. The lack of overhead feeder line route options requires at least 37 km of underground 22kV cable, which makes the cost of this option prohibitive. The long length of underground cable is one of the reasons ten GFNs are required at WPD.
- **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 Sensitivity analysis

The cost-benefit analysis shows that Option 4 provides a significantly higher net benefit 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 the sensitivity analysis.

5 Recommendation

As shown in Table 6 in section 4, Option 4 is preferred because it addresses the identified need and provides the highest net economic benefit by:

- providing a feasible solution for achieving our compliance obligations in relation to the Amended Bushfire Mitigation Regulations at WPD zone substation and addressing the voltage variation issues
- reducing the expected costs of unserved energy in the Surf Coast supply area.

This option involves:

- the installation of three GFNs at WPD zone substation with six isolating substations in the feeder network
- the establishment of TQY zone substation with two GFNs and three isolating substations in the feeder network.

The proposed design of the new TQY zone substation and distribution feeder network is shown in appendix D and E. To meet the timeframes required under the Amended Bushfire Mitigation Regulations, the proposed works should be completed by end of 2022, so that summer 2022/23 is used to prepare the GFNs for performance compliance by 1 May 2023.

The forecast capital expenditure requirements for the 2021–2026 regulatory period are outlined in table 11. The operating expenditure forecasts for the ongoing costs of annual performance testing and maintaining compliance are covered by a separate operating expenditure step change submission.

Table 11 Expenditure forecasts for the preferred option ($ million, 2021)

Expenditure forecast	2020	2021	2022	2023	2024	2025	2026	Total
Capital expenditure	0.33	6.83	60.20	6.17	0	0	0	73.52
Operating expenditure	0	0	0.19	0.56	0.74	0.74	0.74	2.97
Total	**0.33**	**6.83**	**60.39**	**6.73**	**0.74**	**0.74**	**0.74**	**76.49**

Source: Powercor

A Surf Coast area peak population summary

In 2018, the Surf Coast Shire published its Economic Insights report. The report highlighted the expected strong population growth in the region, as well the challenges associated with significant summer holiday populations.

For example, during the summer period, the population of the Surf Coast Shire is estimated nearly triple from its usual population of around 29,000 to over 86,000. A summary of the areas peak overnight population forecasts are shown in the table below.

Table 12: Surf Coast Shire: peak overnight population

Peak Overnight Population

Area	Permanent Population	Population Holiday Homes	Population Caravan Parks, Cabins & Camping Sites	Population Hotels, Motels, Apartments, Units & B&Bs	Peak Overnight Population (i)
SURF COAST SHIRE					
Aireys Inlet/Fairhaven/ Moggs Creek	1,191	5,749	362	237	7,539
Anglesea	2,548	9,986	1,676	205	14,415
Deans Marsh	265	344	N/A	15	624
Jan Juc	3,681	3,079	1,441	38	8,239
Lorne and District	1,111	7,562	4,650	1,948	15,271
Torquay (Including Bellbrae & Bells Beach)	14,259	10,461	4,722	1,763	31,205
Winchelsea (Including Winchelsea South)	2,127	683	0	46	2,856
Rural Balance	3,441	2157	206	124	5,928
Total Surf Coast Shire	**29,402**	**40,022**	**13,057**	**4,376**	**86,077**

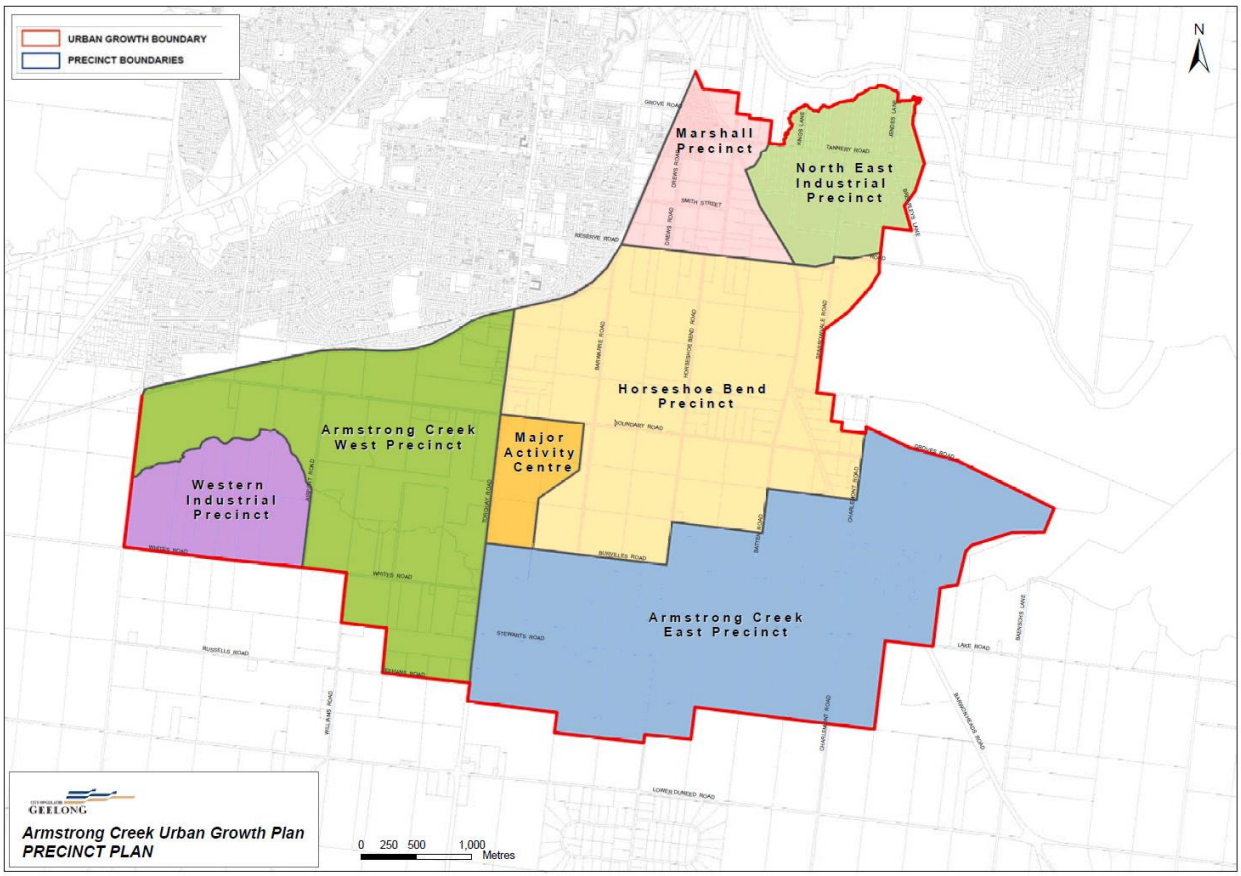
Source: Surf Coast Shire, *Economic Insights*, 2018.

The towns listed in Table 12 that are expected to be supplied by the TQY zone substation include Aireys Inlet, Fairhaven, Moggs Creek, Anglesea, Jan Juc and Torquay (include Bellbrae and Bells Beach).

B Armstrong Creek growth area

Armstrong Creek is a major urban development of the 2,600 hectares of farming land that is expected to accommodate the bulk of Geelong and the region's growth in the near future. An outline of the Armstrong Creek urban growth plan, including the separate precincts, is shown in figure 6.

Figure 6 **Armstrong Creek urban growth area**



Source: City of Greater Geelong

An aerial view of the development that has occurred up to 2018 is shown in figure 7.

Figure 7 Aerial view of Armstrong Creek development to 2018

Source: Google Maps

C REFCL requirements

The installation of a REFCL requires changes to the electrical operating characteristics of a zone substation. 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 WPD zone substation (as per Options 1 and 2), as well as if REFCLs were installed at both WPD and TQY zone substations (as per Option 4).

C.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.[10]

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.

C.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

[10] 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.

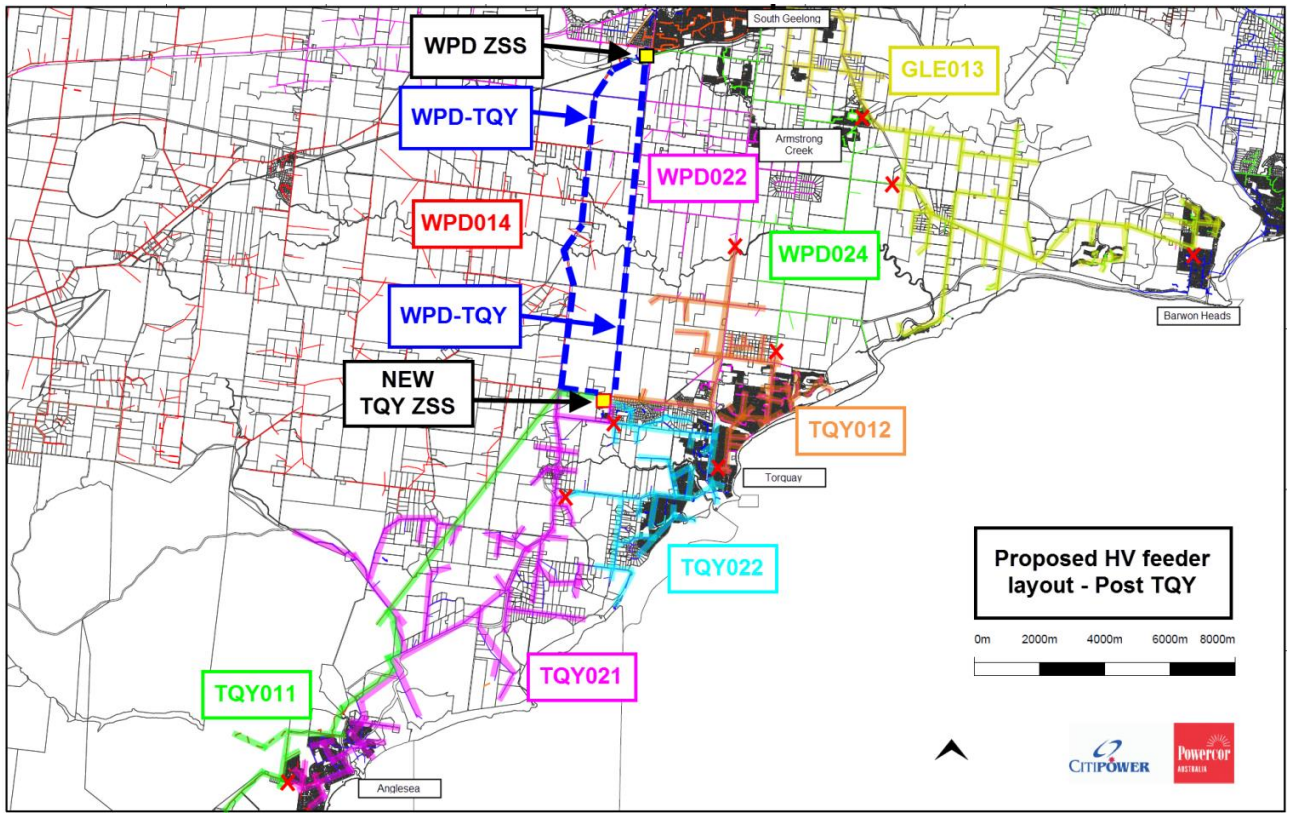
Our primary plant, and protection and control requirements are driven by the existing design of each zone substation, as well as whether multiple GFNs are required.

To manage the high total system capacitance requires the installation of nine GFNs at WPD zone substation, six transformers, six new 22 kV 22kV buses, 66kV bus modifications and 22kV feeder rearrangements would be required. These requirements are because there are only three 22kV buses today. Additional land would also be required to accommodate this equipment on the site.

Alternatively, if only three GFNs are required at WPD zone substation (i.e. a REFCL-compliant TQY zone substation is established), the corresponding works can largely be accommodated with the existing site characteristics. That is, the additional transformer, bus and bus modifications, feeder rearrangements and land purchase would likely be avoided.

D TQY zone substation feeders

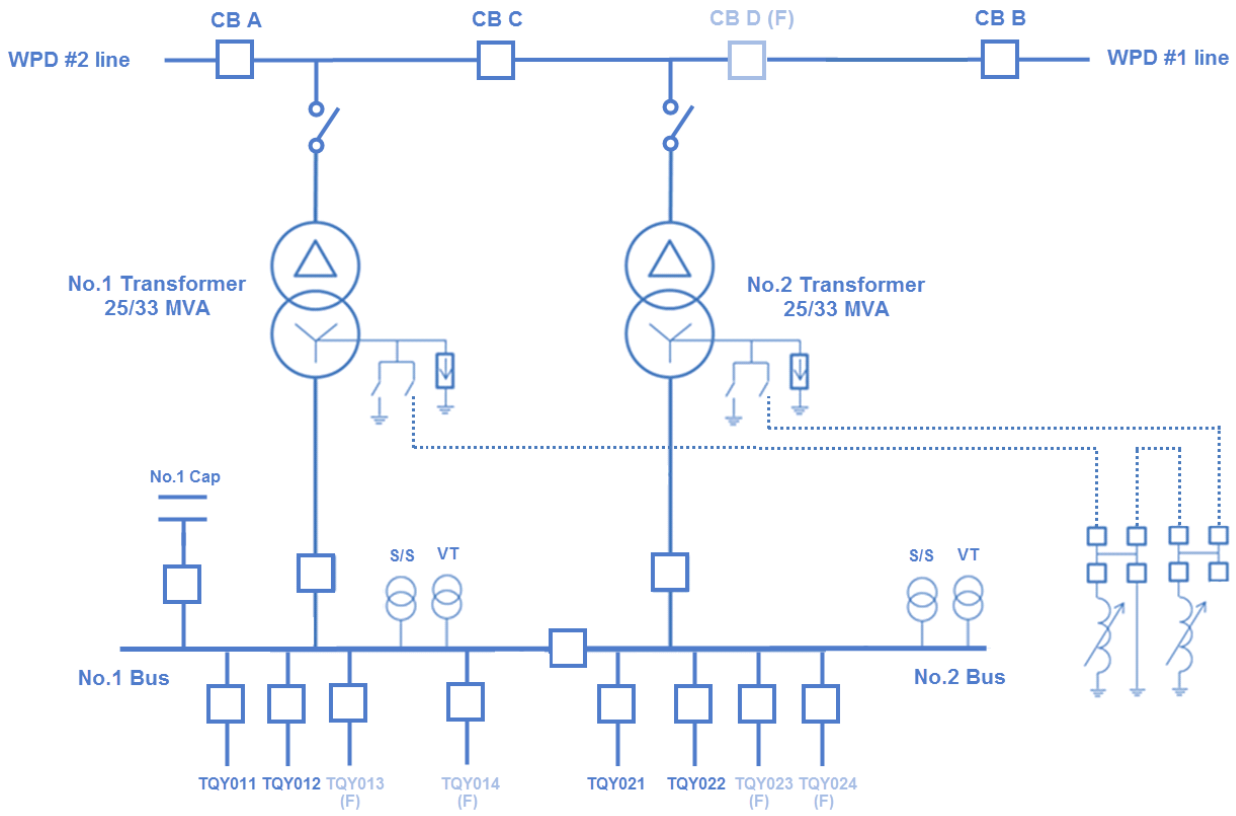
Figure 8 **Proposed TQY zone substation feeder layout**



Source: Powercor

E TQY zone substation diagram

Figure 9 Schematic: TQY zone substation



Source: Powercor