REFCL Compliance Maintained Planning Report Wonthaggi (WGI) Zone Substation

AMS – Electricity Distribution Network

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Disclaimer

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1 Project overview

The Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016 came into effect on 1 May 2016 amending the *Electricity Safety (Bushfire Mitigation) Regulations 2013* (the **Regulations**). The Regulations specify the Required Capacity for Rapid Earth Fault Current Limiter performance. The Regulations also specify the 22 zone substations on AusNet Services' network that must comply with the Regulations.

The *Electricity Safety Amendment (Bushfire Mitigation Civil Penalties Scheme) Act 2017* (the **Act**) sets out the significant financial penalties enforceable for non-compliance. Refer to Appendix A for further information.

Wonthaggi (**WGI**) zone substation (**ZSS**) is included in Tranche 2 of the AusNet Services REFCL Program with compliance to be achieved by 1 May 2021[1]. This report investigates and seeks funding for the most prudent and efficient approach to maintain compliance with the Regulations at WGI during the 2022-26 regulatory control period.

WGI ZSS has had one standard Arc Suppression Coil (**ASC**) installed with a measured capacitive current limit of 148 Amperes (**A**) and measured total capacitance of 144 A[2]. If the capacitive current increases further, the limit of the ASC will be exceeded and AusNet Services will not be able to continue to demonstrate Required Capacity at WGI.

The zone substation demand is within the zone substation rating when operated with the bus tie closed, and the zone substation assets are considered to be in good condition. Hence, the increasing capacitive current is driving the need to invest to ensure AusNet Services can maintain compliance with the Regulations at WGI.

This report reviews various options considered by AusNet Services to manage the capacitance growth and local conditions in order to maintain compliance with the Regulations. The preferred option, which is the option found to be the most economically efficient and technically feasible, recommends to install a second REFCL on existing Bus 3 to continue to meet Required Capacity. In parallel, the No.3 Transformer will be replaced with one of a higher capacity to prevent it from overloading during split bus operation.

In summary, the recommended option will require the following works:

- Install a second REFCL on the existing neutral bus; and
- Replace the No.3 Transformer with a 20/33MVA transformer.

The estimated cost for the second REFCL, supply transformer and associated works is $7.03 million ($'real, 2019).

1 WGI was originally included as part of Tranche 1 of the REFCL Program however was transferred to Tranche 2 due to delays as a result of the replacement of underground cables. Funding for WGI was approved in the Tranche 1 contingent project application decision by the Australian Energy Regulator (AER)

2 The WGI REFCL was placed in service on 27 November 2019. ESV-observed initial compliance testing is scheduled for March 2020

2 Background

2.1 Purpose of this report

This report investigates any constraints that are forecast to occur at WGI, identifies and assesses potential options, and seeks funding for the preferred option. WGI is included in Schedule 1 of the *Electricity Safety (Bushfire Mitigation) Regulations 2013*, and must meet the Required Capacity defined in the Regulations.

The constraints investigated include:

- Forecast demand;
- Network constraints, and
- Capacitive current and compliance with the Regulations.

The following sections of this report describe the compliance obligations, the technologies available to achieve those obligations, constraints at the zone substation and options to mitigate any issues.

2.2 Compliance obligations

The Victorian Government has mandated, through the Regulations, that electricity distribution companies increase safety standards on specific components of their networks to reduce bushfire risk. The Regulations set challenging performance standards (the **Required Capacity**) for 22 of AusNet Services' zone substations. The dates for compliance are separated into three tranches based on a prioritising points system, and occur on 1 May 2019, 1 May 2021 and 1 May 2023. In addition, the Victorian Government has enforced timely compliance of the Regulations by introducing significant financial penalties though the *Electricity Safety Amendment (Bushfire Mitigation Civil Penalties Scheme) Act 2017* (**the Act**).

Distribution businesses have found that the Required Capacity can only be met by installing Rapid Earth Fault Current Limiters (**REFCLs**) in zone substations. In addition, the Victorian Government's Powerline Bushfire Safety Program also identified REFCLs as the preferred solution for meeting the Required Capacity[3].

The Act provides for the Governor-in Council to grant exemptions and for a Major Electricity Company to request the modification of due dates and periods.

Details of the Act, the Regulations and the penalties are in Appendix A.

2.3 REFCL technology

There are various types of technology that fall under the REFCL umbrella, however the only type of REFCL currently considered suitable by the Victorian Electric Supply Industry (**VESI**) for bushfire safety is known as the Ground Fault Neutraliser (**GFN**), a proprietary product by Swedish Neutral. Presently, the GFN is the only device that can meet the performance criteria of the Regulations. All references to REFCLs in the remainder of this document are referring to the GFN type.

REFCLs are comprised of the following key components:

- Arc Suppression Coil (**ASC**) – which is a large inductor that compensates for the capacitive current during an earth fault.

[3] REFCL fact sheet 2016 111216, Introducing best knowledge and technology, Powerline Bushfire Safety program, Dec 2016

- Residual Current Compensator (**RCC**) – also referred to as the inverter, which is located in the zone substation control building or switchroom. It is used to reduce fault current by compensating for the active current during an earth fault
- Control Panels and software, which control the equipment.

2.4 REFCL constraints

The REFCL's ability to successfully detect, manage and locate phase to earth (also referred to as ground) faults on the 22kV network[4] is dependent on a complex combination of network conditions which, when correctly managed, allow continued operation of the REFCL protection in compliance with the Required Capacity.

The following network conditions and physical constraints impact the continued correct operation of the REFCL and its ability to continue meeting the Required Capacity:

Network damping factor

The network damping factor is defined as the ratio of the resistive current losses to the capacitive current (I_R/I_C) measured across the zero-sequence network. A higher damping factor is undesirable as it limits the ability of the REFCL to detect a high impedance fault, and thus operate in the time required to comply with the Required Capacity. The higher the damping factor the lower the capacitive current limit of the ASC.

Network topology

Most modern residential developments are constructed using underground cables which have a higher capacitance than overhead lines. As the 22kV network grows due to increased demand, new customer connections and overhead conductor to underground cable conversions, the additional cable installations will increase the total capacitive current on the network. If the network capacitive current exceeds the capacitive current limit of the ASC, network investment is required to maintain compliance with the Regulations.

Capacitive current limit of the ASC

There are two capacitive current limits:

- **Per ASC:** The typical configuration for REFCLs is one ASC per supply transformer and therefore per bus. The limit of an ASC is dependent on the damping characteristics of the network. However, the actual damping characteristics specific to the network can only be measured once a GFN is operating. WGI has one operational REFCL with a measured ASC limit of 148A.
- **Per feeder:** To enable differentiation of the feeder experiencing a fault, the maximum capacitive current that is allowable per individual feeder is 80A.

Software limitations

Currently Swedish Neutral (manufacturer of the GFN) has not deployed a software solution that will allow the use of three GFNs at one zone substation. Hence, a planning constraint of a maximum of two REFCLs per zone substation has been used.

2.5 Prudent and efficient investment

AusNet Services has taken the approach of incremental funding requests to maintain compliance with the Regulation to ensure minimal long term cost to customers. This is prudent and efficient as it enables:

[4] SWER, which operates at 12.7kV, is excluded from the Required Capacity and is subject to its own requirements.

- Minimum works to be carried out just in time to maintain compliance with the Regulation until 2026;
- Planning to be based on the most up-to-date network growth and capacitive current information and
- Application of the latest development in REFCL technology in this rapidly developing field. For example, should Swedish Neutral deploy a software solution that enables the use of three REFCLs at a zone substation, it may enable deferral of a new zone substation.

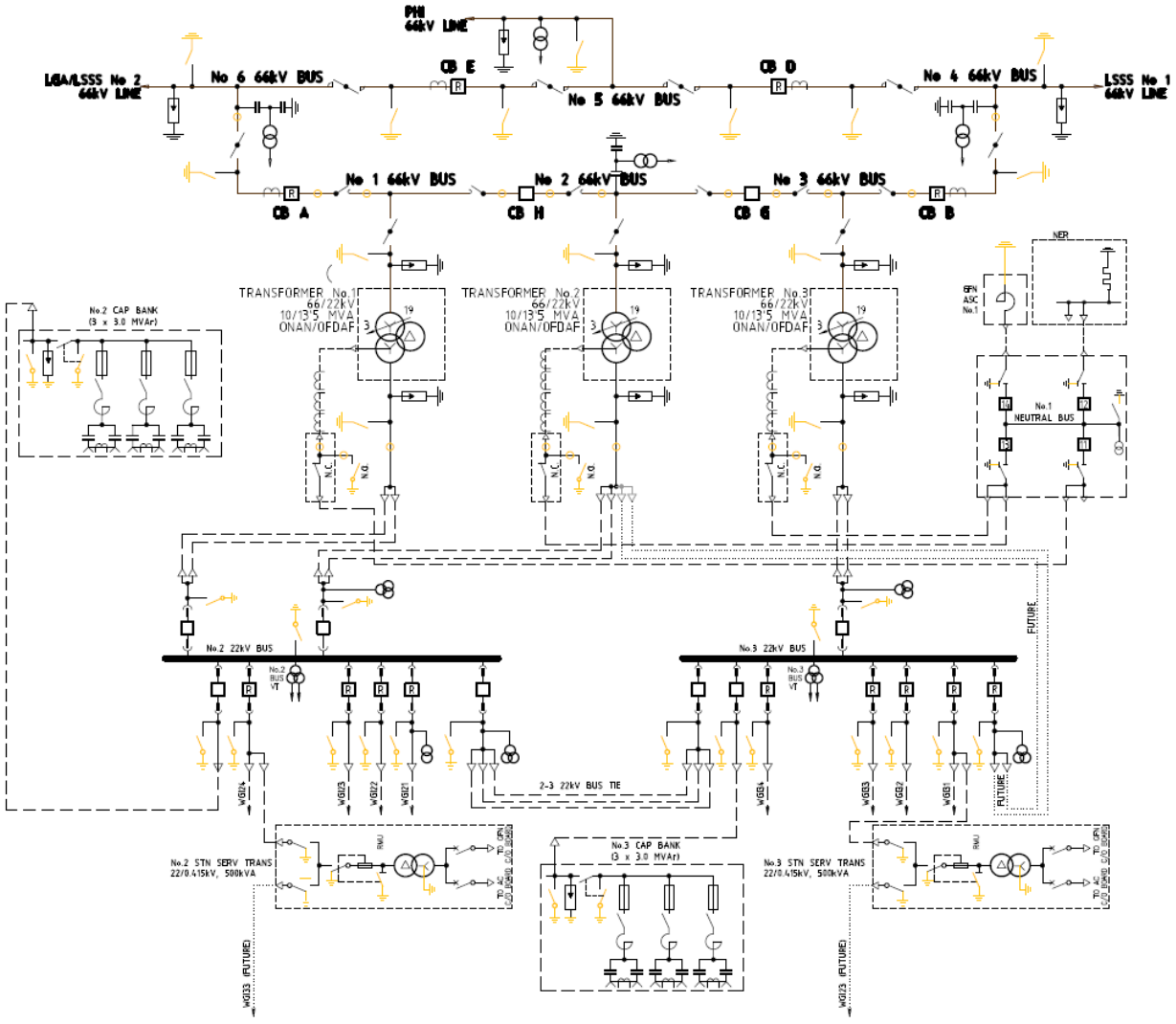
3 WGI zone substation overview

Wonthaggi (**WGI**) Zone Substation (**ZSS**) is located in the town of Wonthaggi approximately 132km east of Melbourne. It is currently comprised of three transformers feeding two buses.

Originally part of Tranche 1, the WGI REFCL was commissioned in November 2019 as part of Tranche 2 of the AusNet Services REFCL Program to achieve compliance with the Regulations.

The Single Line Diagram, including the existing REFCL, is shown in Figure 3.1. It is possible to install a second REFCL at this site.

Figure 3.1 WGI ZSS Single Line Diagram



Source: AusNet Services

An aerial view of the 22kV feeders originating from the WGI electricity distribution area is shown in Figure 3.2. The distribution area includes both residential and commercial suburban areas around Wonthaggi, as well as urban and rural areas along the coast from Phillip Island through to Venus Bay.

The image shows that the feeders are predominately overhead with the breakdown of overhead and underground conductors per feeder shown in Table 3.1. Overhead feeders contribute a lower amount of capacitive current compared to underground cables.

The underground sections are concentrated in the urban areas of Wonthaggi and Inverloch but are spread fairly evenly across multiple feeders.

Table 3.1 Overhead and underground conductor lengths

Feeder	Overhead (km)	Underground (km)	Total length (km)
WGI21	2.4	4.1	6.5
WGI22	46.2	3.1	49.3
WGI23	108.4	3.9	112.2
WGI24	110.0	1.6	111.6
WGI31	40.5	6.1	46.7
WGI32	64.9	8.4	73.3
WGI33	18.8	3.2	22.0
WGI34	205.1	1.1	206.2
Grand Total	**596.3**	**31.5**	**627.8**

There are only three interconnections to other adjacent ZSS:

- WGI32 connects to Phillip Island (PHI11) to the west;
- WGI23 and WGI34 connect to Lang Lang (LLG13) to the north; and
- WGI24 and WGI34 connect to Leongatha (LGA23) to the east.

Out of the three connecting substations listed above, only LLG is a Scheduled zone substation and is included in Tranche 3 for implementation by 1 May 2023. Hence, load transfers can only be implemented to LLG. The connections to PHI and LGA cannot be used to transfer load and capacitive current.

Figure 3.2: WGI ZSS Aerial Layout (underground conductor shown in dark maroon)

3.1 Network forecast

This section discusses the demand and capacitive current forecasts to identify if either attribute is exceeding the capacity of the zone substation and when it is expected to occur. This will identify the need and drive the type and timing of any intervention or investment that may be required.

3.1.1 Demand forecast

Table 3.2 shows the WGI maximum demand forecast (MVA) between 2020 and 2026. By 2026, the summer demand is expected to increase by approximately 3.0MVA.

Figure 3.3 shows that the forecast demand will exceed the N-1 cyclic rating of the substation within the 2022-2026 regulatory control period. These supply transformers are considered to be in good to fair condition, hence the probability of failure is low and the probability weighted value of energy at risk does not warrant capacity augmentation to be undertaken at WGI.

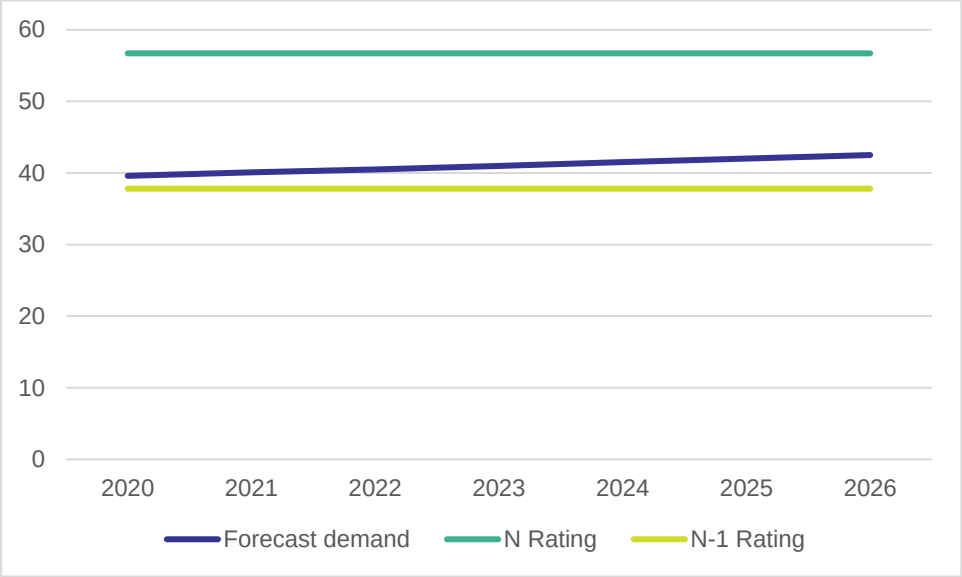
While the probability of transformer failure is unlikely and the short term cyclic rating of the transformers reduces the energy at risk, the station will need to be operated in a split bus configuration if a second REFCL is installed. When operating with a split bus, transformer 3 will be overloaded based on nameplate rating. As this would be in normal operation, the continuous rating must be considered and not the short term cyclic rating.

Table 3.2: Maximum Demand (MVA) Forecast for WGI – 2020 to 2026

	2020	2021	2022	2023	2024	2025	2026
WGI Winter (50POE)	32.0	31.8	31.5	31.2	31.0	30.7	30.4
WGI Summer (50POE)	39.2	39.7	40.1	40.6	41.1	41.6	42.1
WGI Winter (10POE)	34.4	34.1	33.9	33.6	33.3	33.0	32.7

WGI Summer (10POE)	40.5	41.0	41.5	42.0	42.5	43.0	43.5
WGI Consolidated Forecast[5]	39.6	40.1	40.5	41.0	41.5	42.0	42.5

Figure 3.3 Demand forecast



The N-1 rating shown in Figure 3.3 assumes one transformer is out of service.

3.1.2 Capacitance forecast

The network capacitance was developed based on the characteristics of each zone substation supply area, the standard topology of cables installed for underground residential developments (**URDs**) and other known network augmentation.

Since the growth in capacitance is strongly related to the growth of URDs, the forecast was made in 5 year increments as the timing of growth on an annual basis is not certain. The growth is expected to be a step function of new URDs that are being established, rather than a smooth and gradual increase each year. However, the capacitive current growth has been extrapolated to create an indicative annual trend, as shown below, to provide a indicative timing of when intervention is likely to be required.

As stated in section 2.4, the ASC limit is dependent on the damping characteristics of the network that individual zone substation supplies, including the effect of earth resistivity in the zone substation supply area and pollution (salt) on insulators. AusNet Services has attempted to model network damping to forecast ASC limits. The models were based on Tranche 1 zone substations so the outputs could be compared to measured data to test accuracy. The models developed to date have not accurately calculated the damping as measured in Tranche 1 and investigations are continuing. As a result, the actual damping characteristics specific to each network can only be measured once a REFCL installation is operating.

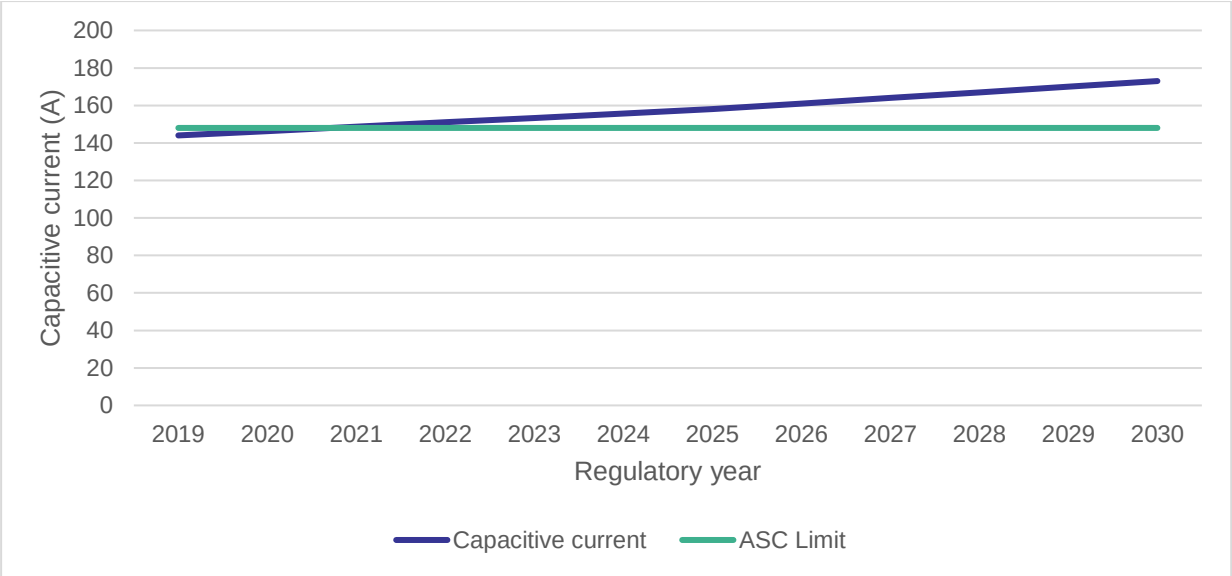
WGI has one standard ASC installed and commissioned with a measured capacitive current limit of 148A. The table and chart below demonstrate the capacitive current limit may be reached during 2021 and REFCL augmentation will be required to ensure ongoing compliance with the Regulations.

5 The forecast is the weighted sum of the summer forecasts, calculated as 30% of the 10POE summer forecast plus 70% of the 50POE summer forecast.

Table 3.3 Capacitive current forecast

	2020	2021	2022	2023	2024	2025	2026
WGI Capacitive Current	146	149	151	153	156	158	161
ASC Limit	148	148	148	148	148	148	148
Excess Capacitive Current	0	1	3	5	8	10	13

Figure 3.4 Capacitive current forecast for WGI – 2019 to 2030



Overhead feeders contribute a lower amount of capacitive current compared to underground cables. To estimate the forecast capacitive current (I_{CO}) per feeder, the total current was split proportionally based on the amount of underground cable per feeder. This identifies if any feeders are expected to exceed the individual feeder limit of 80A and also where the greatest capacitive current reduction can be achieved.

Table 3.4 shows that the I_{CO} is forecast to exceed the capacity of a single ASC and the capacitive current is not split evenly across the buses with Bus 2 having 65A and Bus 3 having 97A. The capacitive current on each bus individually is forecast to remain below the measured 148A limit per ASC beyond 2026.

The forecast also identified that there are no feeders that are expected to exceed the 80A limit for individual feeders.

Table 3.4 Estimated Capacitive Current contribution per feeder

Feeder	Forecast I_{CO} (A) 2026
WGI21	20.9
WGI22	15.8
WGI23	19.7
WGI24	8.2
WGI31	31.3
WGI32	43.0
WGI33	16.6
WGI34	5.7
Grand Total	**161.2**

3.1.3 Transfer capacity

Review of the network has identified that the only adjacent zone substation is Scheduled is LLG and may have spare capacity available for transferring load. It will have 20A available from 2023, decreasing to 8A in 2030.

3.2 Identified need

As shown in section 3.1, due to expected network growth in AusNet Services network, additional works may be required to maintain compliance with the Required Capacity in the Regulations in the 2022-2026 regulatory control period.

The forecast continued residential growth, network augmentation in the WGI supply area, particularly URDs which increase the capacitive current on the network, means that the capacitive current capacity of the REFCLs at WGI may be exceeded in 2021:

- The zone substation may exceed its overall limit of 148A (one REFCL installed)
- Both buses, considered individually will remain less than 148A and no feeders are expected to exceed the 80A individual limit.

While the N-1 capacity of the substation is exceeded and presents a heightened risk, the value of the expected energy at risk due to transformer failure does not currently warrant any capacity augmentation. However, when the bus is split, the capacity of Transformer 3 will be exceeded. Split operation is required if a second REFCLs is installed.

AusNet Services needs to identify the most economic option to address the capacity and capacitive current constraints that will affect the zone substation during the 2022-2026 regulatory control period.

4 Options analysis

The options identified below are based on the best knowledge currently available on the network, including ASC limit and forecast capacitive current growth.

AusNet Services has identified eight options that could maintain compliance with the Regulations. These are summarised in Table 4.1.

Initial assessment of the eight options found that six were non-credible on a technical or cost basis. The reasons for this assessment are set out in in Table 4.1.

Two of the options (Options 3 and 5) were found to be credible and are discussed in further detail in sections 4.1 and 4.2.

Table 4.1 Options Reviewed

Option	Discussion	Credible
Option 1 - Business as Usual	The Business as Usual option maintains the status quo at WGI which will entail no additional investment at WGI to manage the impact of the capacitive current. With an increasing capacitive current forecast, WGI may become non-compliant with the Regulations, the community served by the WGI zone substation would be exposed to increased risk of fire starts from 22kV phase-to-earth faults, and AusNet Services will be subject to penalties under the Act. On this basis, Option 1 is not a credible option.	N
Option 2 - Capacitance/Load Transfer	Investigation of the network found that there are three options for transferring load away from WGI, however, only one is to another Scheduled zone substation. Assuming the best-case scenario, WGI23 and WGI34 could transfer a maximum of 31.6A of capacitive current to LLG13.	N

Option	Discussion	Credible
	However, LLG will only have capacity to accept up to 24A in 2023 when it must become compliant with the Regulation. This is not enough to maintain compliance at WGI without creating a compliance issue at LLG (i.e., just moving the capacitance issue to a different location). Hence, this option is not technically feasible and therefore a non-credible option.	
Option 3 – Install second REFCL on existing bus	WGI has space for a second REFCL and the technology allows two REFCLs at a single zone substation. This is a credible option and is discussed further in section 4.1.	Y
Option 4 - Install Isolation transformer on feeder	This option proposes to install an Isolation Transformer to isolate an entire feeder. Use of Isolation Transformers requires that all conductors downstream of the isolation transformer are underground cables and it requires an exemption to be granted by the Governor in Council. The WGI network is comprised of large rural feeders with overhead and underground sections. Hence significant undergrounding of lines would be required for this option to be eligible for an exemption. To achieve the required capacitance reduction, WGI21, WGI32 and WGI33 would all need to be undergrounded for a total of 4km of overhead converted to underground cable. This option is estimated to cost approximately $298 million. Therefore, this option does not present cost effective isolation opportunities and is not considered as a viable option.	N
Option 5 - Install isolation transformer and undergrounding work	This option proposes to install an Isolation Transformer to a section of a feeder(s). There are various underground cable sections that can be isolated. This option is discussed further in section 4.2	Y
Option 6 - Remote REFCL	The remote REFCL solution is currently under development by AusNet Services. It isolates part of a feeder and protects that isolated section with its own REFCL. The plant can be located no closer than 100m to the zone substation due to earthing issues. The following issues were identified with this option: - they require at least 30m x 35m land size in a rural area which will be difficult and expensive to acquire - to reduce the capacitive current sufficiently at WGI two Remote REFCLs would be required in 2021. Likely candidate feeders are WGI31 and WGI21 plus some feeder reconfiguration works. This results in a cost of $14 million (real 2020 dollars) plus the cost of land acquisition and feeder reconfiguration. Therefore, this option is considered non-credible due to difficulty and risk of purchasing land and high cost.	N
Option 7 - Undergrounding of overhead in HBRA areas and seek ESV exemption for ZSS	WGI is comprised of 2,977 km of overhead line. The cost, including converting overhead distribution transformers and switches to underground assets, is estimated at $2,038 million, and therefore is not a credible option.	N
Option 8 - New Zone Substation	Installing a new zone substation to reduce the capacitive current at WGI is a technically viable option. However, the cost of a new single transformer ZSS (with REFCL) is a minimum of $20 million depending on the location and proximity to a sub transmission line and its load. There would also be a significant negative social impact due to the land area required to accommodate a new zone substation and given that this is an established area it will be very difficult to find available land for the ZSS. Hence, this option is considered non-credible due to the cost	N

4.1 Option 3 – Install second REFCL on existing neutral bus and replace transformer

To meet the performance criteria set out in the *Electricity Safety (Bushfire Mitigation) Regulations 2013*, installation of a second REFCL has been identified as an option. This option will result in an increase in capacitive current that can be managed at WGI from 148A to 296A, as shown in Figure 4.1. This will allow the zone substation to operate in a bus-tie open configuration while not exceeding ASC limits until at least 2030 based on current forecasts.

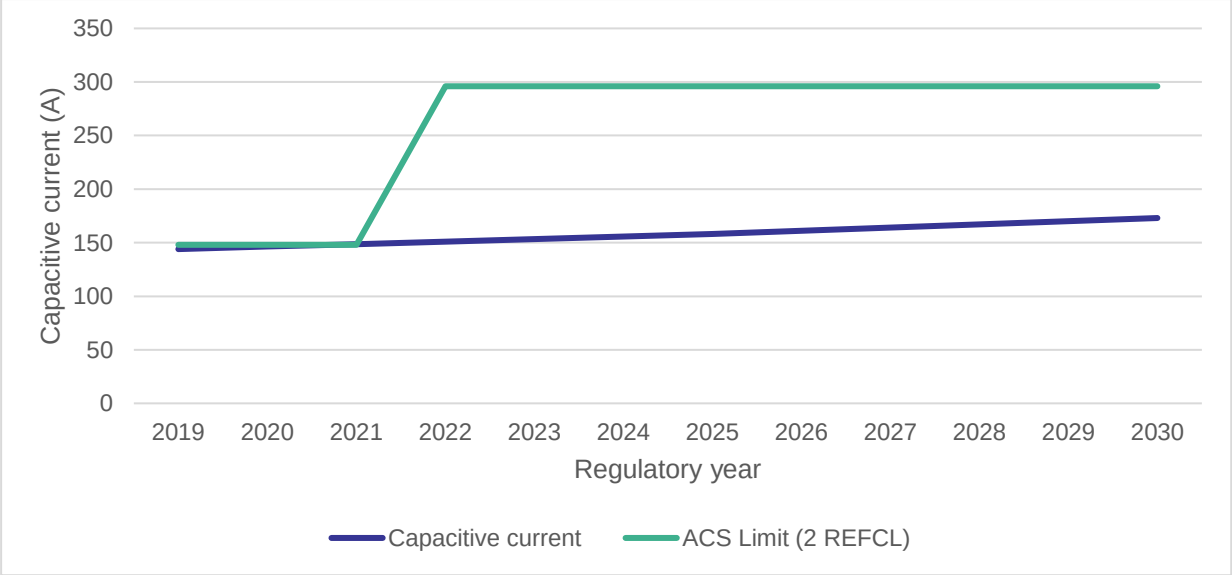
Review of the bus and transformer loading identified that there is a risk of overloading the No.3 Transformer under reverse power as a result of local weather conditions when a cool change occurs during hot summer days with the following scenario:

- Wonthaggi Wind Farm generating at full capacity;
- high residential solar photovoltaic (**PV**) generation; and
- reduction of air-conditioner load.

The weather patterns in the Wonthaggi area makes this scenario more likely, due to correlation between high winds and high solar output. The current feeder allocation will overload the No.3 Transformer under split bus operation. Therefore, to mitigate this and allow for the successful operation of the second REFCL, this option will require replacing the No.3 Transformer with one of a higher capacity.

Current figures show there is a buffer of approximately 3.5MVA, but the solar forecast shows an additional 5.8MW of PV being installed on the network by 2025. Hence, it is prudent to replace the No.3 Transformer with a larger capacity transformer to ensure reliability of supply when a second REFCL is installed.

Figure 4.1 Increased total capacitive limit at WGI with second REFCL



The *Electricity Safety (Bushfire Mitigation Civil Penalties Scheme) Act 2017* provides for penalties to be applied based on a points system that is assigned in Schedule 2 of the regulations and for each day that each of the Scheduled zone substations is not compliant. When including the assessment of the cost of non-compliance and assuming a range of probabilities of non-compliance occurring, we found that it is most efficient to implement this option as soon as possible with the NPC increasing as the project is delayed due to increasing penalties.

Hence, it is recommended that the installation of the second REFCL under this option is planned for as early in the 2022-2026 regulatory control period as possible to mitigate the risk of non-compliance.

The associated works for this option will include:

- Install a second REFCL on the existing neutral bus; and
- Replace the No.3 Transformer with a 20/33MVA transformer.

This option has the least risk as it is a known asset type and does not require the purchase of any new land or installation of new assets in urban areas. This also minimises the potential for any negative social impacts.

If required, temporary transfers to LLG or a time extension could be used to manage increases in capacitive current until the second REFCL is commissioned.

Capital expenditure for the installation of a second REFCL and associated works is $7.03 million with a NPC of $5.8 million $'real, 2019).

This option is recommended.

4.2 Option 5 – Install isolation transformers and undergrounding work

This option proposes to install isolation transformers to reduce the capacitive current the ASC is subjected to. The requirement for this approach is that all conductors downstream of the isolation transformer are underground cables and it requires a technical exemption to be granted by the Governor in Council. There is precedence in receiving exemptions for this approach and an established process.

The scope of work to implement this option is:

- isolation transformers located at the start of WGI21 plus undergrounding 11.7km of overhead line
- isolation transformer located on WGI31 in three locations around Inverloch plus undergrounding of 5.0km of overhead line:
    - just south of Bambrook Road and undergrounding all downstream overhead line;
    - near the corner of Toorak Road and Goroke Street and undergrounding all downstream overhead line; and
    - Near the former of Albert Ruttle Drive and Toorak Road.
- appropriately located land (not costed)

The estimated cost of the option, excluding land, is $19.7 million. In addition, there is high risk of being unable to acquire the land in the necessary locations and there is very little ability to change the location and still achieve the same current reduction or without significantly increasing the cost.

The location of four isolation transformers in established rural and urban areas will impact the visual amenity and is likely to result in an adverse reaction from the residents.

Based on the high cost of $19.7 million with NPC of $16.3 million ($'real, 2019) and risk of acquiring the land, this option it is not recommended.

4.3 Option comparison

The two viable options studied in this report are summarised below. The comparison of the options shows that option 3 is the preferred option.

Table 4.2 Feasible Options Comparison

Option	Technical feasibility	Cost	NPC	Maintains Compliance	Social impact	Preferred
Option 3 - Install	Yes	$7.03 M		Yes	No	Yes

additional GFN on existing neutral bus and replace transformer			$5.8 M			
Option 5 - Install isolation transformer and undergrounding work	Yes	Approx. $19.7 M	$16.3 M	Needs exemption	Minor	No

5 Recommendation

It is recommended that Option 4 (install second REFCL on existing bus and replace supply transformer) be approved.

Installation of a second REFCL is an established solution which has already been implemented at other zone substations and will enable continued compliance with the Regulations. Replacing the No.3 Transformer with a larger capacity transformer will ensure sufficient capacity is available at the zone substation to supply existing and forecast demand under split bus arrangements.

In summary, following approval, AusNet Services will complete the following works:

- Install a second REFCL on a new neutral bus kiosk and associated secondary protection;
- Install one (1) REFCL Type 3 Room;
- Relocate existing RCC inverter and Grid Balancing unit from the existing REFCL Type 1 Room into the new REFCL Type 3 Room;
- Install two (2) 750kVA Kiosk Type substations; and
- Replace Transformer No. 3 with a 20/33MVA transformer.

The estimated cost for the REFCL, transformer and associated works is $7.03 million ($'real, 2019).

6 Appendix A

6.1 The Regulation stipulates the requirements

AusNet Services' network's geographical location means that it is exposed to extreme bushfire risk. These conditions warrant significant investment to mitigate the risk of bushfires that may occur following earth faults on the distribution network.

The Victorian Bushfire Royal Commission, established in 2009, made several recommendations with respect to fires initiated from electricity distribution networks. Subsequently, the Victorian Government established the Powerline Bushfire Safety Taskforce (**PBST**) to investigate new cost efficient and effective technologies and operational practices to reduce catastrophic bushfire risk.

The PBST identified Rapid Earth Fault Current Limiters (**REFCLs**) installed in zone substations as an efficient and effective technology.

The *Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016* (**Amended Bushfire Mitigation Regulations**), which came into operation on 1 May 2016, set out new requirements for major electricity companies including the requirement for Polyphase Electric Lines (defined as multiphase distribution between 1 kV and 22 kV) at selected zone substations to have the following abilities:

- to reduce the voltage on the faulted conductor for high impedance faults to 250 volts within 2 seconds
- to reduce the voltage on the faulted conductor 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
- Demonstrate 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 that resulting from a maximum I^2t value of 0.10 A^2s;

The Amended Bushfire Mitigation Regulations define the low and high impedance faults as follows:

- High impedance = a resistance value in ohms that is twice the nominal phase-to-ground voltage. This is equal to 25.4 kilohms or a fault current of 0.5 amps on a 22 kV network.
- Low impedance = resistance value in Ohms that is the nominal phase-to-ground network voltage divided by 31.75. This is equal to 400 Ohms or a fault current of 31.75 Amps on a 22 kV network.

6.2 The Act stipulates non-compliance penalties

The penalties for not complying with the requirements set out in the Regulations are set out in the *Electricity Safety Act 1998* (the **Act**). The Act states that there will be a fine of up to $2 million for each point less than the prescribed number of points that must be achieved at each of the three specified dates and an ongoing fine of $5,500 per day that compliance is not achieved.

The detail of the fines is set out in Clause 120M (3) which states a major electricity company is liable to pay:

a *if subsection (1)(a) or (b) [(1)(a) - A major electricity company must ensure that for the initial period, a sufficient number of zone substations in its supply network are complying substations so that the total number of allocated substation points prescribed in respect of all of the complying substations is not less than 30 (the period 1 minimum points); and (1)(b) for the intermediate period, a sufficient number of zone substations I its supply network are complying substations so that the total number of allocated substation points prescribed in respect of all of the complying substation is not less than 55 (the period 2 minimum points)] is contravened, a pecuniary penalty not exceeding $2 000 000 for every point forming the difference between the total number of allocated substation points prescribed in respect of all of the complying substations and, as the case require:*

i *the period 1 minimum points; or*

ii *the period 2 minimum points; and*

b *if subsection (1)(c) [on or after 1 May 2023, of if Energy Safe Victoria specifies a later date under section 120X, that date, all zone substations in its supply network are complying substations] is contravened, a pecuniary penalty not exceeding $2 000 000 for every allocated substation point prescribed in respect of each zone substation that is not a complying substation; and*

c *if there is a continuing contravention of subsection (1)(a), (b) or (c), a pecuniary penalty that is a daily amount not exceeding $5500 for each day that contravention continues after service on the major electricity company by Energy Safe Victoria of notice of that contravention.*

6.3 Exemptions and time extensions

Electricity businesses can seek an exemption from both the Act and Regulations.

Exemption from the Act can be sought under section 120W of the Act from the requirements under section 120M of the Act. An exemption requires the Director of ESV to consult with the Minister for Energy, Environment & Climate Change and Governor in Council approval. The process can take up to 6 months.

Clause 13 of the Regulations allows for the electricity businesses to apply for exemptions from complying with the requirements of (7)(1)(ha) and (7)(1)(hb).

13 Exemptions

2 *Energy Safe Victoria may, in writing, exempt a specified operator or major electricity company from any of the requirements of these Regulations.*

3 *An exemption under subregulation (1) may specify conditions to which the exemption is subject.*

Time extension requests under S120X of the Act can be made to the Director of Energy Safe Victoria clearly stating the reasons for the request.