REFCL Compliance Maintained Planning Report Bairnsdale (BDL) Zone Substation

AMS – Electricity Distribution Network

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Disclaimer

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Contents

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.

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

By the Tranche 2 compliance deadline of 1 May 2021, BDL will have two standard Arc Suppression Coils (**ASC**) installed which, for planning purposes, are assumed to have a combined capacitive current limit of 200 Amperes (**A**) or higher, beyond which it may not be able to achieve the Required Capacity. The zone substation demand is within the zone substation rating and the zone substation assets are in good condition. Hence, the increasing capacitive current is driving the need to invest in BDL to ensure AusNet Services can maintain compliance with the Regulations.

This report reviews various options considered by AusNet Services to manage the capacitance growth. It is recommended that option 4, installation of a third REFCL, is approved. In addition, replacement of the existing No.3 transformer and rearrangement of the 22 kV feeders to accommodate the ASC limitations will be required. As there will be lead time to procure and install a third REFCL and replacement transformer, it may be necessary to install a number of isolation transformers as a temporary measure, pending results from commissioning.

The expected cost for this option is $14.1 million and is the least cost, technically feasible solution with no social impact.

2 Background

2.1 Purpose of this report

This report investigates any constraints that are forecast to occur at BDL, identifies and assesses potential options, and seeks funding for the preferred option. BDL 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[1].

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.

[1] 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[2] 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. Currently, the actual damping characteristics specific to the network can only be measured once a GFN is operating. At locations where a GFN is not yet operational, an ASC planning limit of 100A is assumed to determine indicative, but conservative, augmentation timing.
- **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.

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:

[2] 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.

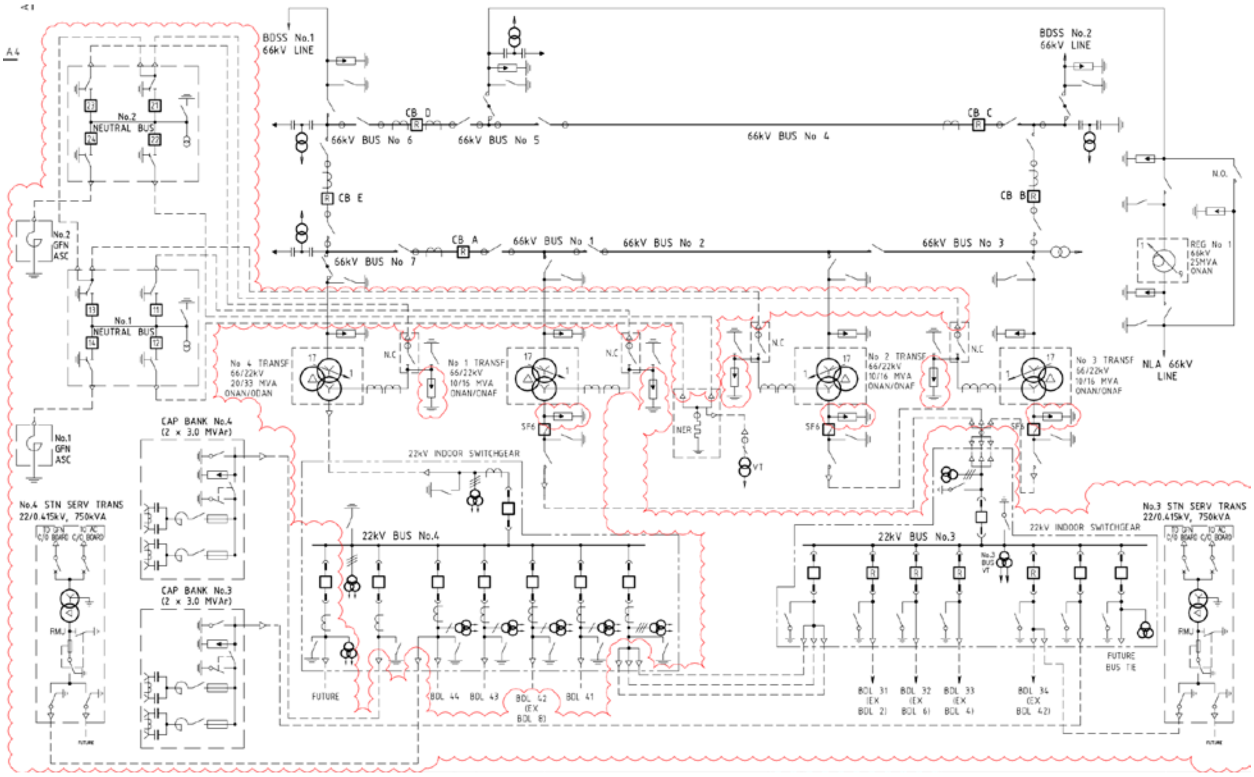
3 BDL zone substation overview

The current Bairnsdale (**BDL**) zone substation (**ZSS**) is located in the city of Bairnsdale in the Eastern Region of Victoria. It is included in Tranche 2 of the AusNet Services REFCL Program.

As shown in Figure 3.1, the zone substation consists of three 10/16 MVA transformers supplying Bus 3 and one 20/33 MVA transformer supplying Bus 4. Two REFCLs will be commissioned at BDL by 1 May 2021 as part of Tranche 2 of the AusNet Services REFCL Program to achieve compliance with the Regulations.

BDL was originally built in 1984 with some refurbishments undertaken between 2002 and 2016. The assets range in age but are generally considered to be in good condition and are not yet considered to be at the end of their serviceable lives.

Figure 3.1 BDL SLD with REFCLs



An aerial view of the 22kV feeders originating from BDL electricity distribution area is shown in

Figure 3.2 with the highest concentration of underground cable shown in Figure 3.3. The images show that the feeders are predominately overhead with the breakdown of overhead conductor and underground cable per feeder shown in Table 3.1.

The distribution area includes the urban residential areas around Bairnsdale as well as rural areas surrounding it. Review of the network diagram identifies that there are connections to Maffra (**MFA**) ZSS to the west and Newmerella (**NLA**) ZSS to the east. However, neither MFA nor NLA are included in the 22 zone substations that must comply with the Regulations, so without exemptions it is not possible to permanently transfer load to those zone substations and any transfers have been identified to suffer from voltage issues.

Table 3.1 Overhead and underground conductor lengths

Feeder	Overhead (km)	Underground (km)	Total length (km)
BDL31	31.8	4.7	36.5
BDL32	154.6	13.9	168.5
BDL33	61.7	4.5	66.2
BDL34	48.3	9.3	57.6
BDL41	342.4	4.1	346.5
BDL42	358.1	1.1	359.3
BDL43	30.1	2.9	33.0
BDL44	429.7	5.7	435.4
Grand Total	**1456.8**	**46.2**	**1503.0**

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

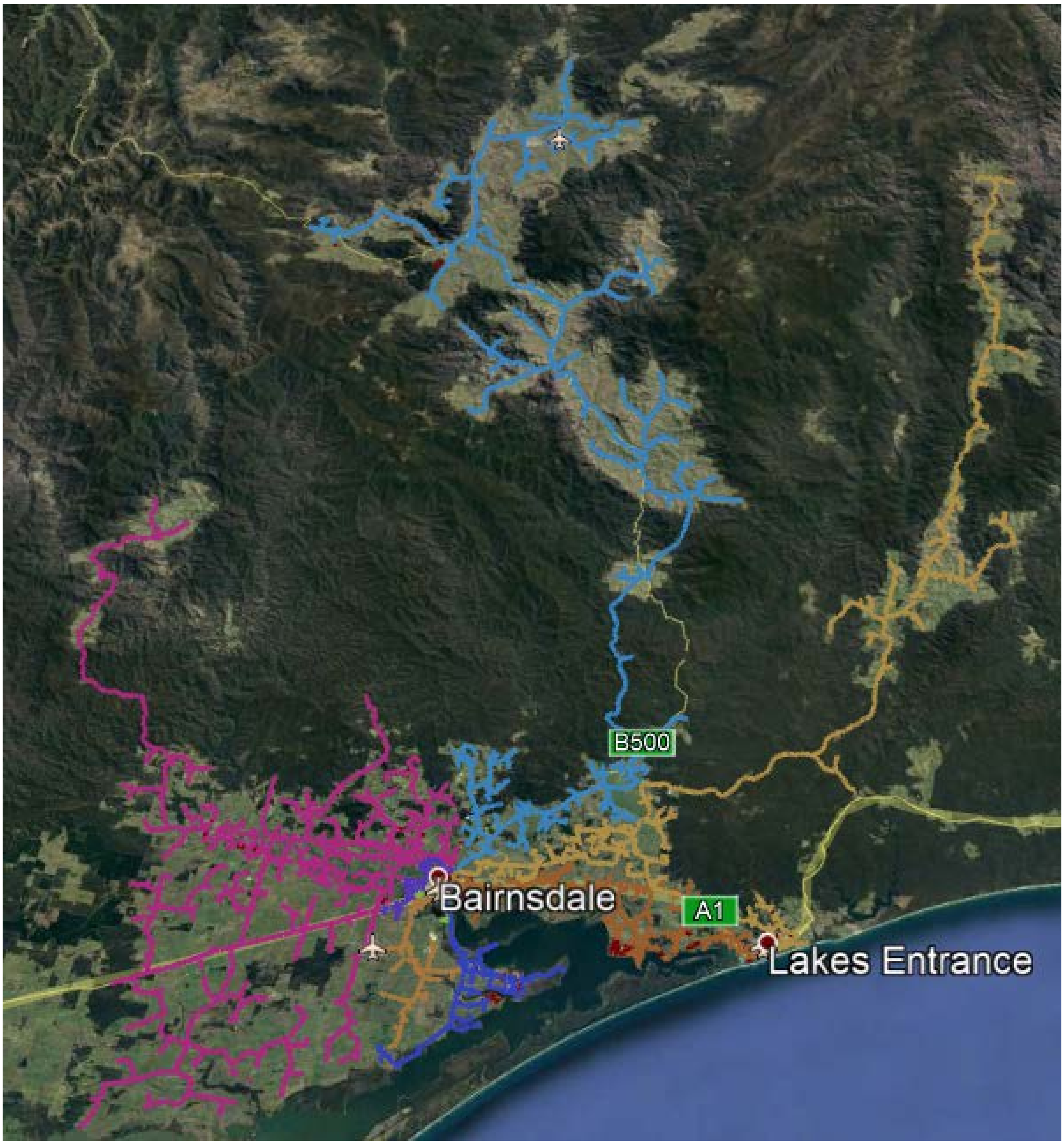


Figure 3.3: BDL ZSS Aerial Layout (underground conductor shown in dark maroon) – close up of Bairnsdale city

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

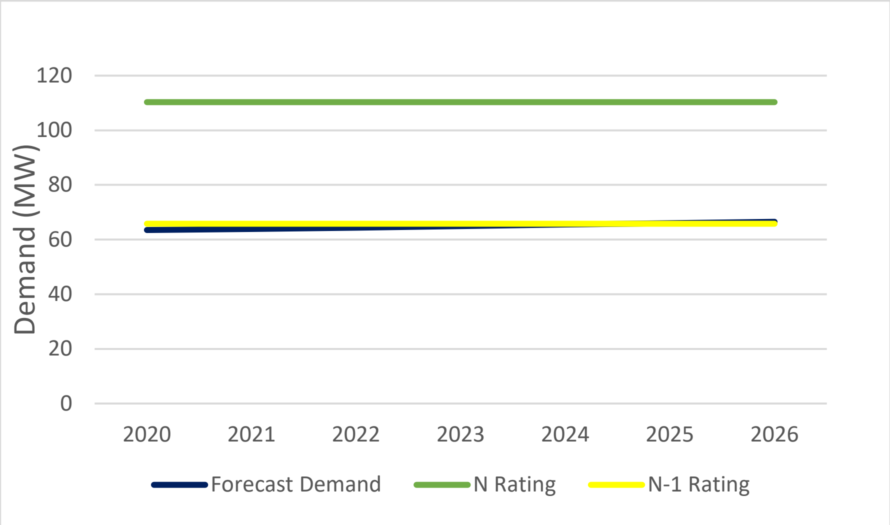
Table 3.2 shows the BDL maximum demand forecast (MVA) between 2020 and 2026. By 2026, the demand is expected to increase by approximately 3 MVA. The forecast demand will only slightly exceed the N-1 cyclic rating of the substation within the next regulatory period as shown in Figure 3.4. Hence, there is no immediate need for capacity augmentation to be undertaken.

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

	2020	2021	2022	2023	2024	2025	2026
BDL Winter (50POE)	49.9	50.4	50.8	51.1	51.5	51.9	52.2
BDL Summer (50POE)	62.3	62.7	63.2	63.7	64.3	64.8	65.3
BDL Winter (10POE)	54.7	54.6	54.5	54.3	54.1	54.0	53.8
BDL Summer (10POE)	63.5	63.9	64.4	64.9	65.5	66	66.5
BDL Consolidated Forecast[3]	62.7	63.1	63.6	64.1	64.7	65.2	65.7

[3] 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.

Figure 3.4 Demand forecast



The N-1 rating is based on loss of the largest (33 MVA) transformer. N and N-1 rating are shown based on the cyclic rating of 1.4 times nameplate capacity.

3.1.2 Capacitance forecast

The network capacitance forecast 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 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.

The ASC limit of 100A that is used for planning purposes is based on learnings from the Tranche 1 installations and consideration of differences with the Tranche 2 zone substation network supply areas. However, it is noted zone substations in rural areas can have higher damping characteristics and there is a high probability that BDL ZSS ASC limitations will be higher than 100A.

AusNet Services is acting prudently to address the network capacitive limits at each Tranche 2 zone substation by deferring investment until the network damping can be accurately measured when the REFCL is brought online whilst working on refining network damping modelling. In the event the capacitance is identified to be greater than the ASC limit and compliance with the Regulatory obligations cannot be met, AusNet Services will utilise the time extension provisions in the Regulations to implement solutions to achieve the Required Capacity.

By 31 May 2021, BDL will have two standard ASCs installed which, for planning purposes, is assumed to provide a capacitive current limit of 200A. As shown in Table 3.3 and Figure 3.5, this limit is forecast to be exceeded in 2021 and will continue to increase.

Table 3.3 BDL capacitive current forecast

Item	2020	2021	2022	2023	2024	2025	2026
BDL capacitive current	244	247	249	252	255	258	260
ASC Limit	N/A	200	200	200	200	200	200
Excess capacitive current		47	49	52	55	58	60

Figure 3.5 Capacitive Current Forecast for BDL – 2020 to 2026

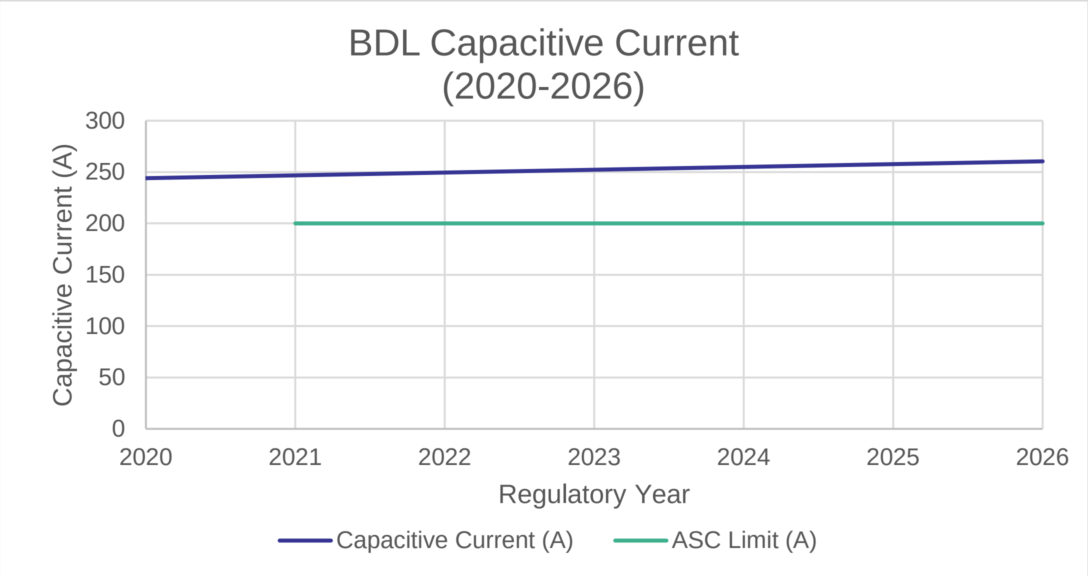


Table 3.4 presents estimates of the capacitive current (I_{CO}) per feeder and per bus. This identifies if any feeders are expected to exceed the individual feeder limit of 80A and also where the greatest capacitive current reduction can be achieved. Importantly, the table shows:

- The I_{CO} at BDL will be greater than the planning limit of the combined two REFCLs;
- I_{CO} on each bus is forecasted to be above the 100A planning limit for an individual ASC;
- Feeder BDL34 is forecast to grown to 64A by 2026 which is approaching the 80A limit for individual feeders.

Possible mitigation measures to address this are discussed in section 4.

Table 3.4 Estimated Capacitive Current contribution per feeder

Feeder	Forecast I_{CO} (A) 2026
BDL31	12
BDL32	47
BDL33	10
BDL34	64
Total Bus 3	**133**
BDL41	38
BDL42	27
BDL43	8
BDL44	53
Total Bus 4	**127**
Grand Total	**260**

3.2 Identified need

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

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

- The zone substation is forecasted to exceed its overall planning limit of 200A (two REFCLs installed);
- Bus 3 and Bus 4 will exceed their individual planning limits of 100A; and
- Feeder BDL34 will be approaching its individual limit of 80A.

As the demand growth and asset condition are not identified to be constraints for the zone substation, AusNet Services needs to identify the most economic option to address the capacitive current constraints that will affect compliance with the Regulations 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.

Nine options were considered for this project as summarised in Table 4.1. Three of these options (options 4, 6 and 9) were assessed as technically viable and are discussed further in section 4.1, 4.2 and 4.3. Discussion on the non-credible options is included in Table 4.1.

Table 4.1 Options Reviewed

Option	Discussion	Credible
Option 1 - Business as Usual	The Business as Usual option maintains the status quo at BDL which will entail no additional investment at BDL to manage the impact of the capacitive current. With an increasing capacitive current forecast, BDL may become non-compliant with the Regulations, the community served by the BDL 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	This option proposed to transfer capacitance/load to an adjacent zone substation. However, review of the network has identified that there are no adjacent zone substations that are suitable for load and capacitive current. On this basis, capacitance/load transfer is not considered as a viable option.	N
Option 3 – Feeder Transfer	This option proposes to transfer a feeder that supplies an urban area with low bushfire risk from a REFCL protected bus to a non-REFCL protected bus and seek an exemption under S120W of the Act. Investigation of the feeders found that none of the transfer options move enough capacitance and the probability of obtaining an exemption for such an application was considered extremely low (with no precedence). Therefore, this is not considered as a viable option.	N
Option 4 - Install a third REFCL	This option proposes to install a third REFCL on an existing bus to manage the increased capacitive	Y

Option	Discussion	Credible
	current. There has been ongoing investigation into using three REFCLs in zone substations. While this solution has not been deployed and tested, studies are positive. Accordingly, three REFCL solution for BDL ZSS is considered a viable option at this time. This option is discussed further in section 4.1.	
Option 5 – Install isolation transformer on feeder	This option proposes to underground an entire feeder and install an Isolation Transformer to isolate the entire feeder. Use of Isolation Transformers requires that all conductors downstream of the isolation transformer are underground cables. The BDL network is comprised of large rural feeders with overhead and underground sections. Hence significant undergrounding of lines would be required for this option. The combination of feeders that would reduce I_{CO} to below the limit on each bus is BDL33 and BDL42. However, this would require undergrounding 420km of overhead line with an estimated cost of approximately $295 million. Therefore, this option does not present cost effective isolation opportunities and is not considered as a viable option.	N
Option 6 - Install isolation transformers and network augmentation	This option proposes to install one or more Isolation transformers to sections of feeders and network augmentation. There are various underground cable sections that can be isolated. This option is discussed further in section 4.2.	Y
Option 7 – 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 remote REFCL can be located no closer than 100m to the zone substation due to earthing issues. The following issues were identified with this option: • each remote REFCL requires at least 22m x 11m land size in a developed urban area which will be difficult and expensive to acquire • to reduce the capacitive current sufficiently at BDL, two Remote REFCLs would be required in 2021, one on each bus. This results in a cost of approximately $20 million, therefore, a relatively expensive solution. This option is higher risk due to the uncertainty of purchasing land and the impact of the additional infrastructure in urban areas. Also, it is a relatively expensive option, therefore, is not considered as a viable option.	N
Option 8 - Undergrounding Over Head in Hazardous Bush Fire Risk Area	BDL is comprised of 1,457 km of overhead line. The cost, including converting overhead distribution transformers and switches to underground assets is estimated to cost $1 billion and therefore is not a credible option.	N
Option 9 - New Zone Substation	This is a viable option and is discussed further in section 4.3.	Y

4.1 Option 4– Install a Third REFCL

To meet the performance criteria set out in the Electricity Safety (Bushfire Mitigation) Regulations 2013, installation of a third REFCL has been identified as a viable option. This option will result in an increase in capacitive current that can be managed at BDL from a theoretical 200A to 300A. This will allow the zone substation to operate in an all bus-tie open configuration while not exceeding ASC limits until at least 2030 based on current forecasts.

Considering the fact that the capacitive current loading at the BDL ZSS is already over the ASC limit of 100A for both buses, it is recommended that the installation of the third 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 following feeder arrangement is recommended for the three bus configuration.

Table 4.2 Capacitive forecast for a three bus arrangement

Feeder	Forecast I_{CO} (A) 2026
BDL42	27
BDL31	12
BDL41	38
Total Bus 1	**77**
BDL43	8
BDL33	10
BDL34	64
Total Bus 2	**82**
BDL32	47
BDL44	53
Total Bus 3 [Note]	**100**

Note: Bus 3 will require further isolations if growth exceeds forecast.

The associated works for this option will include:

- Install a third REFCL
- Replace the existing 10/16 MVA 66/22 kV No.3 Transformer with a new 20/33 MVA 66/22 kV transformer.
- Re-arrange feeders as indicated in Table 4.2 to manage capacitance and load growth.

This option does not require the purchase of any new land or installation of new assets in urban areas. It also minimises the potential for any negative social impacts. However, this solution has not been deployed and tested elsewhere, therefore, there is potential for unforeseen implementation and operational risks.

This option is recommended, and the estimated cost is $14.1 million. However, as there will be lead time to procure and install a third REFCL and replacement transformer, it may be necessary to install a number of isolation transformers as discussed in section 4.2, to manage increases in capacitive current until the third REFCL is commissioned.

4.2 Option 6 – Install isolation transformers and network augmentation

This option proposes to install isolation transformers to reduce the capacitive current the ASC is subject to. The requirement for this approach is that all conductors downstream of the isolation transformer are underground cables.

The following twelve locations have been identified to provide sufficient reduction in I_{CO} through the use of isolation transformers:

- Location 1 - Installation of a 7.5MVA isolation transformer in the park next to Flinn Grange padmount substation. Also, the following network re-configuration is recommended:
    - there is an open switch at Balmoral-Morekana substation to separate the BDL34 and BDL31 underground feeders. The recommendation is to close this switch (807326) and install a new open switch at the intersection of Howitt Ave and Bullumwaal Rd (near switch 807119). This will transfer the BDL31 underground section onto BDL34 feeder and allow a further isolation of 5.6A using the same proposed 7.5MVA new isolation transformer.

  This solution will result in approximately 21A reduction on BDL34.
- Location 2 - Installation of a 1MVA pole top isolation near switch LE057. Isolating this cable is expected to reduce the capacitive current by 9.5A ON BDL32.
- Location 3 - Installation of a 300kVA isolation transformer on pole 1614642. Isolating at this point is expected to reduce the capacitive current by 5.5A on BDL32.
- Location 4 - Installation of a 300kVA isolation transformer on pole 1911106. Isolating at this point is expected to reduce the capacitive current by 3.7A on BDL32.
- Location 5 - Installation of a 300kVA isolation transformer on pole 1900818. Isolating at this point is expected to reduce the capacitive current by 3.2A on BDL32.
- Location 6 - Installation of a 1MVA pole top isolation transformer at the intersection of Thorpes Lane and Stirling Drive (switch 808346). Isolating at this point is expected to reduce the capacitive current by 3.6A on BDL41.
- Location 7 - Installation of a 300kVA isolation transformer on pole 1612248. Isolating at this point is expected to reduce the capacitive current by 1.9A on BDL41.
- Location 8 - Installation of a 300kVA isolating transformer on pole 1610829. Isolating at this point is expected to reduce the capacitive current by 2.3A on BDL33.
- Location 9 - Installation of a 300kVA isolating transformer on pole 1609233. Isolating at this point is expected to reduce the capacitive current by 4.5A on BDL34.
- Location 10 - Installation of a 300kVA isolating transformer on pole 1605610. Isolating at this point is expected to reduce the capacitive current by 2.2A on BDL44.
- Location 11 - Installation of a 300kVA isolating transformer on pole 5679586. Isolating at this point is expected to reduce the capacitive current by 1.1A on BDL44.
- Location 12 - Installation of a 300kVA isolating transformer on pole 1608812. Isolating at this point is expected to reduce the capacitive current by 1.8A on BDL34.

Installation of isolation transformers at the twelve proposed locations will reduce the total capacitive current at BDL by approximately 60A. With these isolations in place, the updated capacitive current per feeder in 2026 is summarised in the following table.

Table 4.3 Estimated Capacitive Current contribution per feeder

Feeder	Forecast I_{CO} (A) 2026	Capacitance Reduction	Revised Forecast I_{CO} (A) 2026
BDL31	12		12
BDL32	47	-22	25
BDL33	10	-2	8
BDL34	64	-27	37
Total Bus 3	**133**		**82**
BDL41	38	-6	32
BDL42	27		27
BDL43	8		8
BDL44	53	-3	50
Total Bus 4	**127**		**117**
Grand Total	**260**		**198**

As per Table 4.3, there is imbalance of capacitive current across the two 22kV buses at BDL. To ensure the capacitive current on each bus is below 100A, all of the isolation transformers are required as well as feeder reconfiguration works to rebalance the capacitance across the buses. This option will still have 2026 forecast total capacitive currents over the theoretical ASC limits for Bus 4. The two GFNs at BDL ZSS are expected to be commissioned in April 2021 and it will give accurate allowable ASC values for each GFN based on measurement of the network parameters. Considering BDL ZSS has feeders with predominantly overhead conductors, it can be reasonably expected that the ASC limit to be more than 100A for each GFN.

The estimated cost of this option, including land and reconfiguration, is $4 million. However, as this option does not give the acceptable level of lowering of the capacitive currents, it is not the recommended permanent solution. The following risks also exist:

- For installation, 7.5MVA isolation transformer in location 1 requires approximately 13m x 19m land parcel. Preliminary desktop investigation has found the risk to acquire or lease land from the council to be high;
- There will be a negative impact on the community through the installation of new large infrastructure in residential areas; and
- The additional transformers create an additional maintenance item in the network.

4.3 Option 9 – New Zone Substation

Installing a new REFCL protected zone substation is a technically viable option. The cost of a new REFCL-protected ZSS is $23 million.

The scope of this option will include:

- Construction of the Lakes Entrance (**LKE**) Zone Substation. This zone substation has been in planning for some time. AusNet Services owns land in Kalimna, and part of the 66kV line to the site has been constructed (currently operating at 22kV as part of BDL41).
- Transfer sufficient load and capacitance from Bus 3 and Bus 4 to LKE.
- This will require completion of the 66kV line construction, construction of the ZSS, possible 22kV construction to replace areas that are being converted to 66kV.

Advantages of this option are that the land for the new ZSS is already owned by AusNet Services and the 66kV line is already partially constructed (operating at 22kV).

However, this option has risks and disadvantages:

- Additional capacity (demand MW) is not currently required in the 2022-2026 regulatory control period based on current load forecast.
- As BDL feeders will be transferred to this new REFCL-protected zone substation, a S120W exemption is required.
- High cost – approximately $23 million.
- Long lead time.

Therefore, although this option is considered credible, it is not recommended due to the highlighted key disadvantages.

4.4 Option comparison

The three viable options studied in this report are summarised below. The comparison of the options shows that option 4 is the preferred option as it is technically feasible with no social impact.

Table 4.4 Feasible Options Comparison

Option	Technical feasibility	Estimated Cost (real $ 2020)	Regulatory feasibility	Social impact	Preferred
Option 4 - Install a third REFCL	Yes, but solution has not been deployed and tested elsewhere	$14.1 M	Yes	No	Yes
Option 6 - Install isolation transformers and network augmentation	Partly feasible. Bus 4 capacitance is still above 100A planning limit	$4 M	Yes	Yes	No
Option 9 - New Zone Substation	Yes	$23.1M	Yes	Yes	No

5 Recommendation

It is recommended that option 4, installation of a third REFCL, is approved. In addition, replacement of the existing No.3 transformer and rearrangement of the 22 kV feeders to accommodate the ASC limitations will be required. As there will be lead time to procure and install a third REFCL and replacement transformer, it may be necessary to install a number of isolation transformers as a temporary measure, pending results from commissioning.

The expected cost for this option is $14.1 million and is the least cost, technically feasible solution with no social impact.

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 Order in Council approval. The process can take up to 6 months or longer depending on the complexity of the exemption.

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.