REFCL Compliance Maintained Planning Report Bairnsdale (BDL) Zone Substation

AMS – Electricity Distribution Network

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Contact

This document is the responsibility of the Regulated Energy Services division of AusNet Services.

Please contact the indicated owner of the document with any inquiries.

T Langstaff
AusNet Services
Level 31, 2 Southbank Boulevard
Melbourne Victoria 3006
Ph: (03) 9695 6000

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**), 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. The preferred option, which is the option found to be the most economically efficient and technically feasible, recommends the construction of a new REFCL protected Lakes Entrance (**LKE**) zone substation and the transfer of feeders from BDL to LKE. This option will require an exemption from the *Electricity Safety Act 1998* (the **Act**) and Regulations to transfer feeders from BDL to LKE as LKE is not listed as a REFCL zone substation.

The following works are included in the project scope:

- Construction of a new REFCL protected zone substation on land already owned by AusNet Services
- Complete the construction of the 66kV line which is currently operating at 22kV
- 22kV augmentation to replace areas currently supplied by the 66kV line
- Network reconfiguration:
    - Transfer BDL41 from pole 1900504 to LKE,
    - Transfer BDL32 from switches BD016 and BD018 to LKE

The estimated capital cost for the new REFCL ZSS and associated works is $23.1 Million ($'real, 2019).

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. 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:

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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

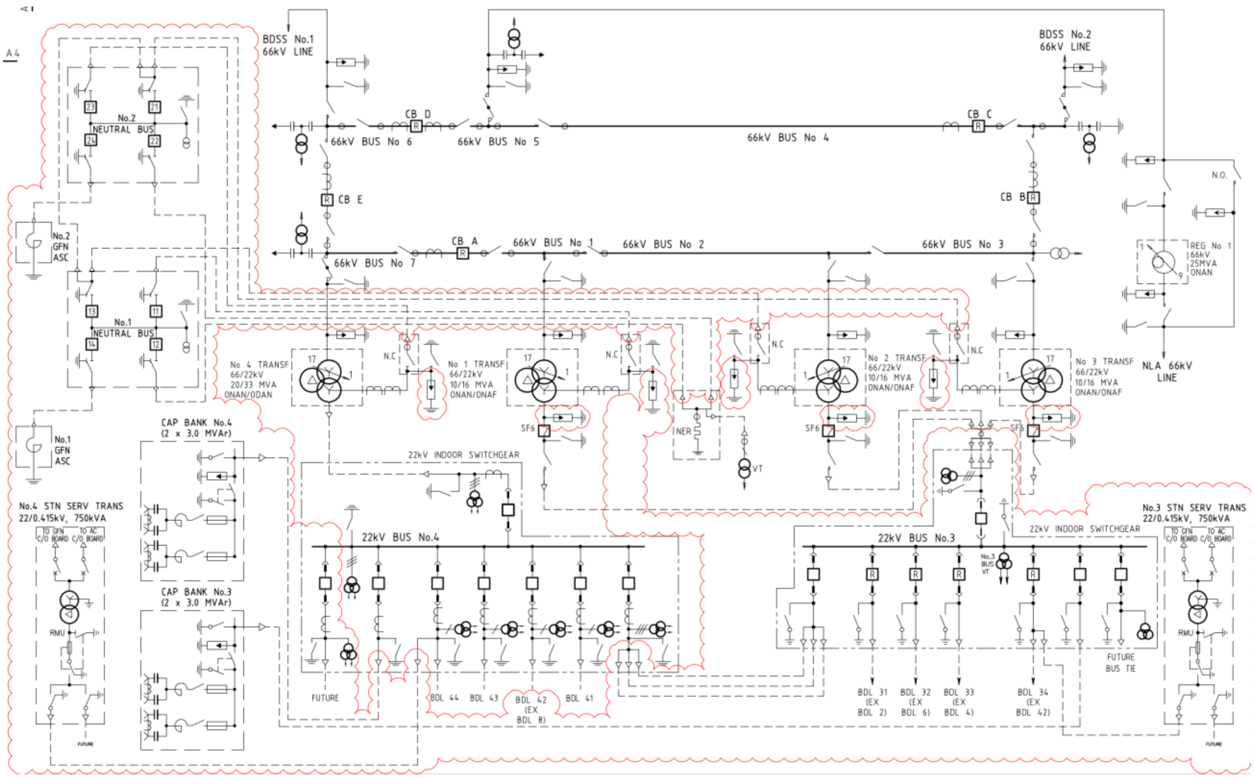
The current Bairnsdale (**BDL**) zone substation (**ZSS**) is located in the city of Bairnsdale in the Eastern Region of Victoria. It is included in Tranche 2 of the AusNet Services REFCL Program.

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.

Given the existing REFCL software allows a maximum of two REFCLs per zone substation, presently it is not possible to install any more REFCLs at this site.

Figure 3.1 BDL SLD with REFCLs



An aerial view of the 22kV feeders originating from BDL electricity distribution area is shown in **Error! Reference source not found.Error! Reference source not found.** and a close up of the city, with the highest concentration of underground cable, is 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**

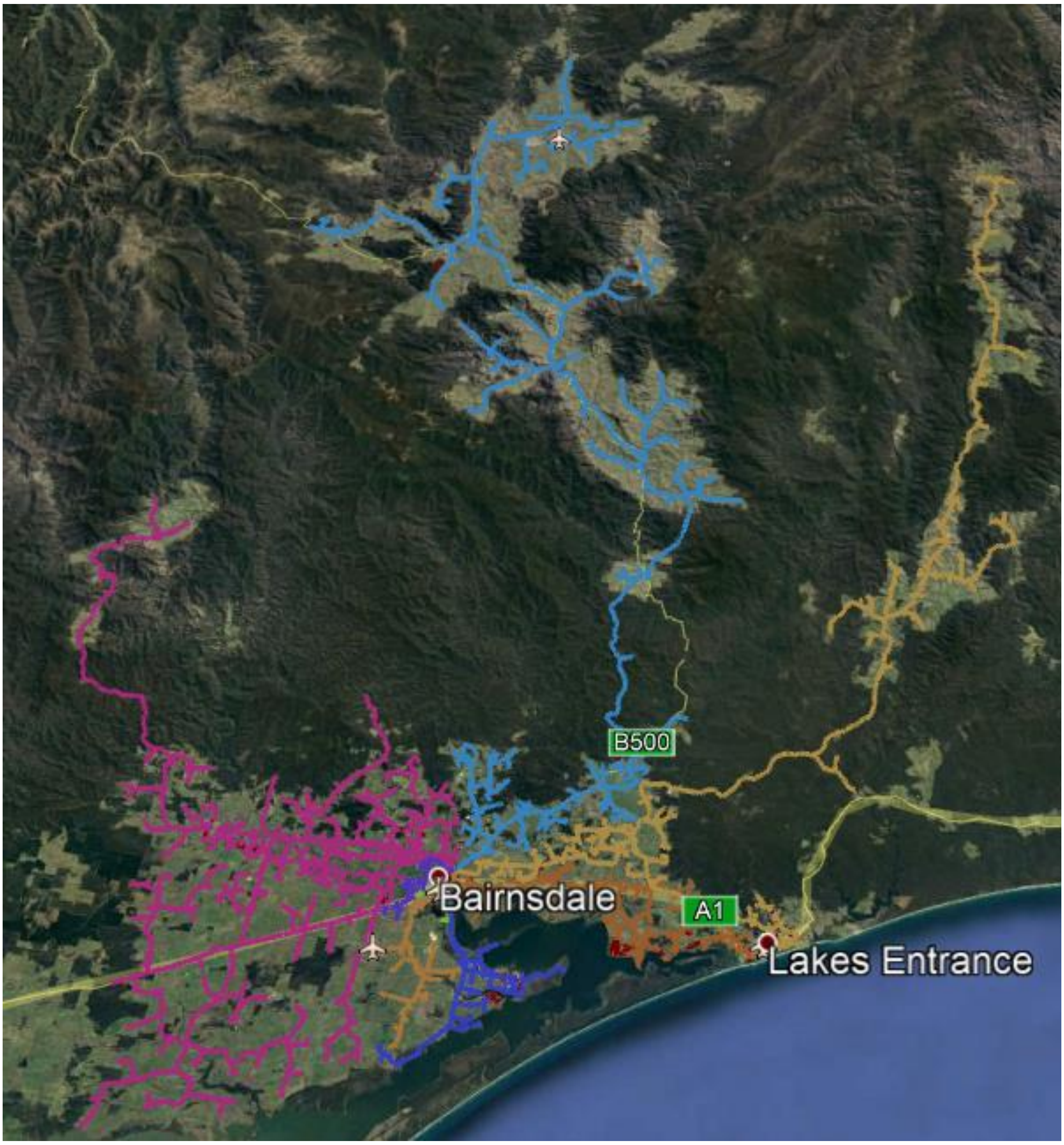


Figure 3.2: BDL ZSS Aerial Layout (underground conductor shown in dark maroon)

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

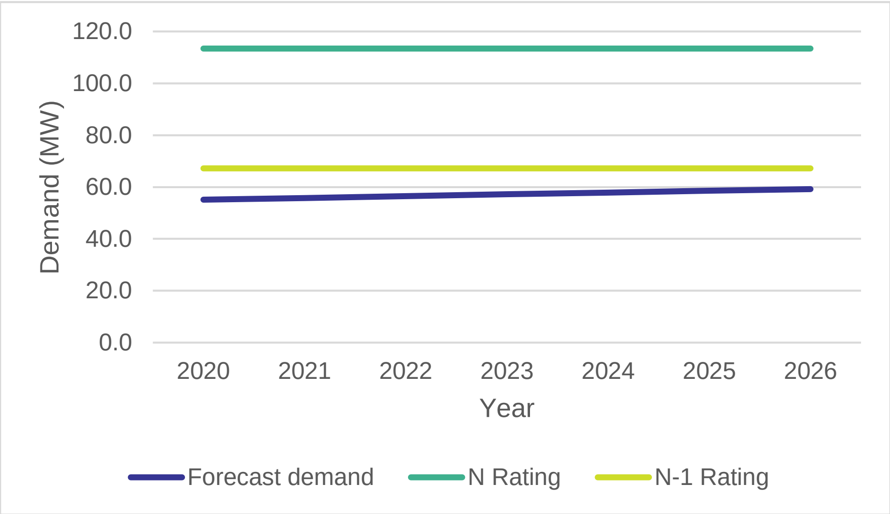
Table 3.2 shows the BDL maximum demand forecast (MVA) between 2020 and 2026. By 2026, the demand is expected to increase by approximately 1 MVA. The forecast demand will not exceed the N-1 cyclic rating of the substation within the next regulatory period as shown in Figure 3.4.

Table 3.2: Maximum Demand (MVA) Forecast for BDL – 2019 to 2026

	2020	2021	2022	2023	2024	2025	2026
BDLWinter (50POE)	49.9	50.4	50.8	51.1	51.5	51.9	52.2
BDL Summer (50POE)	54.8	55.5	56.2	56.9	57.6	58.2	58.9
BDL Winter (10POE)	54.7	54.6	54.5	54.3	54.1	54.0	53.8
BDL Summer (10POE)	55.8	56.5	57.3	57.9	58.6	59.3	60.0
BDL Consolidated Forecast[3]	55.1	55.8	56.5	57.2	57.9	58.5	59.2

[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 and both 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.

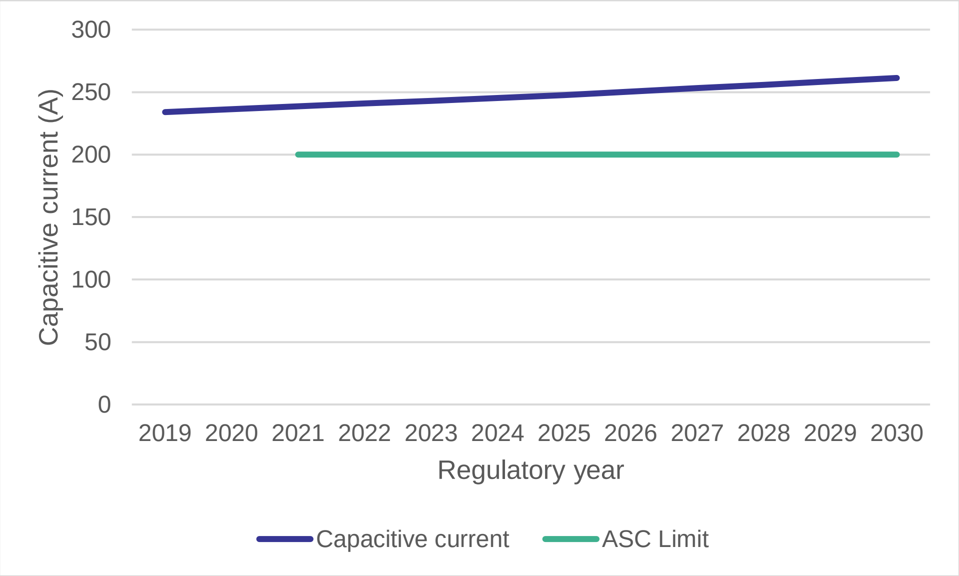
AusNet Services is acting prudently to address the network capacitive limits at each Tranche 2 zone substation by deferring investment until the network damping can be accurately measured when the REFCL is brought online whilst working on refining network damping modelling. In the event the capacitance 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 Figure 3.5, this limit is forecast to be exceeded in 2021 and is expected to be exceeded by approximately 25% by 2026.

Table 3.3 BDL capacitive current forecast

Item	2020	2021	2022	2023	2024	2025	2026
BDL capacitive current	236	239	241	243	245	248	250
ASC Limit	N/A	200	200	200	200	200	200
Excess capacitive current		39	41	43	45	48	50

Figure 3.5: Capacitive Current Forecast for BDL – 2019 to 2030



Overhead feeders contribute a lower amount of capacitive current compared to underground cables. Table 3.4 presents estimates of the 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. Importantly, the table shows:

- The I_{CO} at BDL will be greater than the planning limit of the combined two REFCLs;
- The I_{CO} is not spread evenly across the feeders with Bus 4 having 75A and Bus 3 having 175A;
- Feeder BDL32 is forecast to grown to 75A by 2026 which is approaching the 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	25.4
BDL32	75.2
BDL33	24.4
BDL34	50.4
BDL41	22.1
BDL42	6.2
BDL43	15.7
BDL44	30.8
Grand Total	**250.3**

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 may exceed its overall planning limit of 200A (two REFCLs installed);
- Bus 3 will exceed its individual planning limit of 100A; and
- Feeder BDL32 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 6, 7 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 current. Based on the technology currently available, it	N

Option	Discussion	Credible
	is not possible to install three REFCLs at a single zone substation. Therefore, this is not a credible option as it is not technically feasible at this time.	
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 and it requires and exemption from the Regulations and the Act. 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 to be eligible for an exemption. The combination of feeders with the least overhead conductor that would reduce I_{CO} to below the limit is BDL31 and BDL34. However, this would require undergrounding 400km of overhead line with an estimated cost of approximately $280 million. Therefore, this option does not present cost effective isolation opportunities and is not considered as a viable option.	N
Option 6 - Install isolation transformer and undergrounding work	This option proposes to install one or more Isolation transformers to sections of feeders. There are various underground cable sections that can be isolated. However, finding land would be difficult for the isolation transformers. This option is discussed further in section 4.1.	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 plant can be located no closer than 100m to the zone substation due to earthing issues. Issues identified with this option include the land size required of at least 30m x 30m land size in a developed urban area and cost per Remote REFCL. This option is considered credible but higher risk due to the uncertainty of purchasing land and the impact of the additional infrastructure in urban areas. This option is discussed further in section 4.2.	Y
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, estimated at $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 4.2.	Y

4.1 Option 6 – Install isolation transformer and undergrounding work

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 and it requires a S120W exemption to be granted by the Governor in Council. There is precedence in receiving exemptions for this approach and an established process.

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

- BDL32, Tambo Bluff – Approx. 19A reduction by installing an isolating transformer and new cable links to transfer all underground sections.
- BDL44 from switch BD195 – Approx. 15.5A reduction. Estate load is approx. 2.5MVA, installed capacity is 5.5MVA.
- BDL43 from switch 807099 – Approx. 3.5A reduction. Load is approx. 1.5MVA.
- BDL42 from switch 807076 and 807084 – Approx. 10A reduction. Requires kiosk change to IFT and approx. 800m of HV cable (2 x 400m lengths side by side). Less than 1MVA load.
- BDL42 from switch BD039 – Approx. 3A reduction. Requires retirement of 50m span of overhead line and possible kiosk substation to resupply loads.
- BDL31 from switch 807119 – Approx. 5.5A reduction. Less than 1MVA load.
- BDL32 from pole 1900967 – Approx. 2A reduction. Negligible load.
- BDL41 from switch 808346 – Approx. 3.6A reduction. Less than 1MVA load.

Due to the imbalance of capacitive current across the two 22kV buses at BDL, to ensure the capacitive current on each bus is below 100A and below 200A in total for the zone substation, all of the isolation transformers are required as well as feeder reconfiguration works to rebalance the capacitance across the buses.

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The estimated cost of the option, excluding land, is $11.5 million. Due to the cable locations within the BDL supply area being in established urban areas, there is a high risk that AusNet Services will not be able to acquire sufficient land in the necessary locations within the required timeframes.

The larger capacity isolation transformers also are significantly larger than a standard AusNet Services kiosk, with each individual isolation transformer requiring an area of 11.5 m x 5.5m. This will impact the community and visual amenity of the area due to the large new infrastructure. It is also very unlikely to find council reserve land of sufficient size which could be made available to AusNet Services.

To achieve the capacitance reduction, there is very little ability to change the location of the isolating transformer without significantly increasing the cost due to additional undergrounding.

This option has additional risks and disadvantages:

- The risk of being able to acquire land and the cost of the land in the locations required;
- A significant impact on the community through the need to install new large assets in established urban locations;
- The need to obtain a S120W exemption;
- Increased electricity losses due to the additional transformers located on the network. This results in an increased cost of operating the network.

Therefore, this option is not considered to be credible due to the risk of acquiring sufficient land in the required urban locations to install the 8 isolation transformers. This will result in a significant impact on the community. Therefore, this option is not recommended.

4.2 Option 7 – Remote REFCLs

The remote REFCL solution isolates part of a feeder and protects that isolated section with its own REFCL. This solution is currently under development by AusNet Services and is not yet a proven solution. The remote REFCL can be located no closer than 100m to the zone substation due to earthing issues.

The following is included in the scope of this option:

- Two Remote REFCL installations are required to achieve the capacitive current reduction:
  - **BDL32:** Installation of a remote REFCL on BDL32, upstream of switch BD018 to include load BD016, will reduce capacitive current by around 37A. The load at this location is approx. 8MVA.
  - **BDL34:** Installation of a remote REFCL on BDL34, upstream of switch BD005 will reduce capacitive current by around 30A. The load at this location is approx. 6MVA.
- Two parcels of land a minimum of 30m x 30m. These will need to be located in a developed urban area to be close to the already identified isolation locations.
- Reconfiguration of feeders to balance the remaining capacitive current across the two REFCLs.

This will enable a total reduction of capacitive current of approximately 67A, which leaves a spare capacity of 17A at BDL in 2026.

The total cost of this option is estimated to be $17 million, including $0.5 million of land costs.

This option has risks and disadvantages:

- This is not yet a proven solution so there are risks to delay of implementation.
- A significant impact on the community through the need to install new large assets in established urban locations.
- If the capacitive current increases faster than forecast, a third remote REFCL will be required by 2026. The additional remote REFCL will mean that the option is less cost effective than other options.
- The capacitive current reduction expected may not be sufficient, resulting in the need for additional expenditure.
- A third remote REFCL will be required by 2030.
- Larger parcels of land are required for remote REFCLs than isolation transformers. Hence, there is a higher risk of not being able to acquire land and the cost of the land increasing.
- Increased electricity losses due to the additional transformers located on the network. This results in an increased cost of operating the network.

Advantages of this option are:

- Fewer locations are required than for isolation transformers.
- No S120W exemption is required.

Therefore, while this option is considered credible, it has a high cost of $15 million (excluding land), a high level of risk due to the uncertainty of purchasing land, the impact of the additional infrastructure in urban areas and the cost impact if capacitive current increases more quickly than forecast.

The net present cost (NPC) of this option is $14.1 million ($real, 2019).

To provide a more accurate view on the long-term benefit to customers, we assessed this option over a longer timeframe. Option 7 requires two remote REFCLs in the 2021-2026 period and then another intervention in 2030. Based on the current demand forecast, the likely solution in 2030 would be a third REFCL. Including the third REFCL (to provide a solution more equivalent to Option 9) results in an NPC of $18.4 million ($real, 2019).

This option has a similar customer cost impact to Option 9, but has significantly higher risk, regarding the ability to acquire the required land and impact on the community, and a lower long-term benefit in network flexibility regarding the ability to accommodate increased capacitive current and demand. Therefore, this option is not recommended.

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 $23.1 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 BDL41 starting at pole 1900504 to LKE, transfer BDL32 starting at switches BD016 and BD018 to LKE. This will provide approximately 67A reduction in capacitive current.
- 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.

This option has risks and disadvantages:

- Additional capacity (demand MW) is not currently required.
- As BDL feeders will be transferred to this new REFCL-protected zone substation, a S120W exemption is required.

Advantages of this option are:

- The land for the new ZSS is already owned by AusNet Services.
- The 66kV line is already partially constructed (operating at 22kV).
- Provides the real option for additional capacitive current capacity if required in the future.

The NPC of this option is $19.2 million ($real, 2019).

To provide a better view on the long-term benefit to customers, we assessed this option over a longer timeframe. Option 9 requires a new zone substation to be installed in the 2022-2026 period which will address the capacitive current requirements until 2040 at which point the substation can be augmented with a second REFCL at low cost. Option 9 results in an NPC of $19.2 million ($real, 2019). It also has a much lower risk profile and certain outcome.

Therefore, this option is considered credible and lower risk compared to the other options.

4.4 Option comparison

The three viable options studied in this report are summarised below. The long-term assessment of Option 7 and Option 9 shows that although Option 9 has a higher up front capital cost, it has a lower long term cost to customers. Therefore, Option 9 is the preferred option.

Table 4-2 shows a comparison of the options. Although the NPC of Option 7 is slightly lower than Option 9, there is significantly higher risk and community impact with Option 7 and it results in a less optimal network topology. Hence it is prudent for Option 9 to be selected as the preferred option.

Table 4-2: Feasible Options Comparison

Option	Technical feasibility	Cost	NPC	Regulatory feasibility	Social impact	Preferred
Option 6 - Install isolation transformer and undergrounding work	Yes, but high risk to implementation of all sites	N/A	N/A	Yes	Yes	No
Option 7 – Remote REFCL	Yes, but risk to implementation	$15M	$14.1 M (minimum	Yes	Yes	No

	due to land acquisition and achieving capacitive current reduction required		of $18.4 M over longer timeframe)				
Option 9 - New Zone Substation	Yes	$23.1M	$19.2 M	Yes	No	Yes

5 Recommendation

It is recommended that the new REFCL protected Lakes Entrance (**LKE**) zone substation is constructed in the 2022-2026 period with an estimated cost of $23.1 million. A S120W exemption will be required to transfer BDL feeders to LKE.

The following works are included in the project scope:

- Construction of a new REFCL protected zone substation on land already owned by AusNet Services.
- Complete the construction of the 66kV line which is currently operating at 22kV.
- 22kV augmentation to continue supplying areas currently supplied by the 66kV line.
- Network reconfiguration:
  - Transfer BDL41 starting at pole 1900504 to LKE.
  - Transfer BDL32 starting at switches BD016 and BD018 to LKE.

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.