REFCL Compliance Maintained Planning Report Eltham (ELM) Zone Substation

AMS – Electricity Distribution Network

PUBLIC

Document number	AMS 20-405
Issue number	3
Status	Approved
Approver	Tom Langstaff
Date of approval	31/07/2020

ISSUE/AMENDMENT STATUS

Issue	Date	Description	Author	Approved
1	3/12/2019	First Issue	Networks Planning	T Langstaff
2	26/01/2020	Minor amendments	Networks	T Langstaff
3	31/07/2020	Second Issue	Networks Planning	T Langstaff

Disclaimer

This document belongs to AusNet Services and may or may not contain all available information on the subject matter this document purports to address.

The information contained in this document is subject to review and AusNet Services may amend this document at any time. Amendments will be indicated in the Amendment Table, but AusNet Services does not undertake to keep this document up to date.

To the maximum extent permitted by law, AusNet Services makes no representation or warranty (express or implied) as to the accuracy, reliability, or completeness of the information contained in this document, or its suitability for any intended purpose. AusNet Services (which, for the purposes of this disclaimer, includes all of its related bodies corporate, its officers, employees, contractors, agents and consultants, and those of its related bodies corporate) shall have no liability for any loss or damage (be it direct or indirect, including liability by reason of negligence or negligent misstatement) for any statements, opinions, information or matter (expressed or implied) arising out of, contained in, or derived from, or for any omissions from, the information in this document.

Contact

This document is the responsibility of the Network Management 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**). These 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.

Eltham (**ELM**) 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 ELM during the 2022-2026 regulatory control period.

By the Tranche 2 compliance deadline of 1 May 2021, ELM will have two standard Arc Suppression Coils (**ASC**) installed which, for planning purposes, are assumed to have a 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 ELM to ensure AusNet Services can maintain compliance with the Regulations.

AusNet Services is unable to place the ELM REFCLs in service until Metro Trains Melbourne (**MTM**) has completed all required work on their High Voltage (**HV**) electrical assets to be REFCL compatible. AusNet Services will request a time extension for ELM as the Tranche 2 compliance deadline of 1 May 2021 cannot be achieved due to delays in MTM REFCL readiness activities.

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, 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, it may be necessary to install isolation transformers as a temporary measure, pending results from commissioning.

The expected cost for this option is $9.1 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 ELM, identifies and assesses potential options, and seeks funding for the preferred option. ELM is included in Schedule 1 of the *Electricity Safety (Bushfire Mitigation) Regulations 2013*, and must meet the Required Capacity 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; and
- 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. However, 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:

- Minimum works to be carried out just in time to maintain compliance with the Regulations until 2026;

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

- 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.

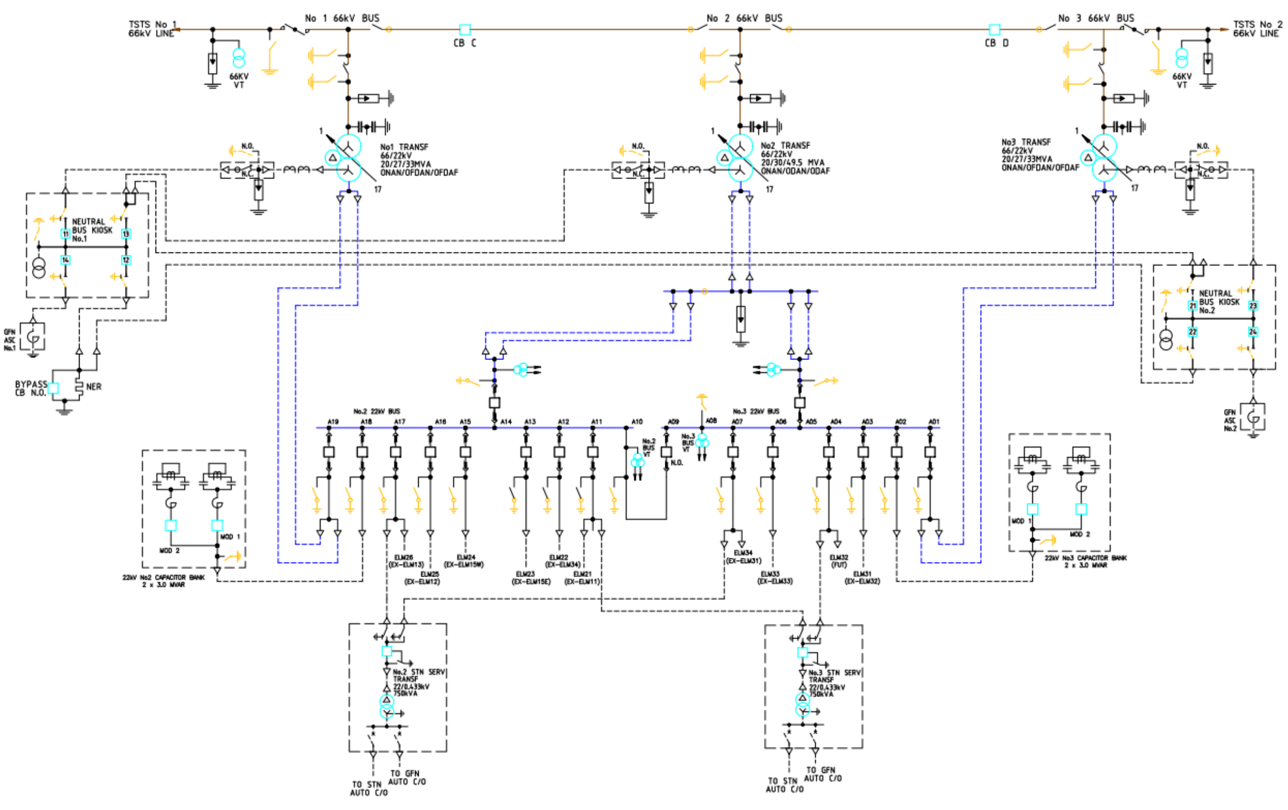
3 ELM zone substation overview

Eltham (**ELM**) Zone Substation (**ZSS**) is located in the suburb of Eltham which is approximately 19km east northeast of Melbourne. ELM was originally constructed in 1969 with two 20/33 MVA transformers. A third transformer 20/33 MVA transformer was added in 2005 and can supply both Bus 2 and Bus 3.

Two REFCLs will be commissioned at Eltham (ELM) zone substation on Bus 2 and Bus 3 by 1 May 2021 as part of Tranche 2 of the AusNet Services REFCL Program to achieve compliance with the Regulations.

The Single Line Diagram, including the future REFCLs, is shown in Figure 3.1.

Figure 3.1 ELM ZSS Single Line Diagram



Source: AusNet Services

An aerial view of the 22kV feeders originating from ELM is shown in Figure 3.2. The distribution area includes both residential and commercial suburban areas around Eltham, as well as urban and rural areas north east towards Hurstbridge that are heavily tree-covered, steep and have limited access.

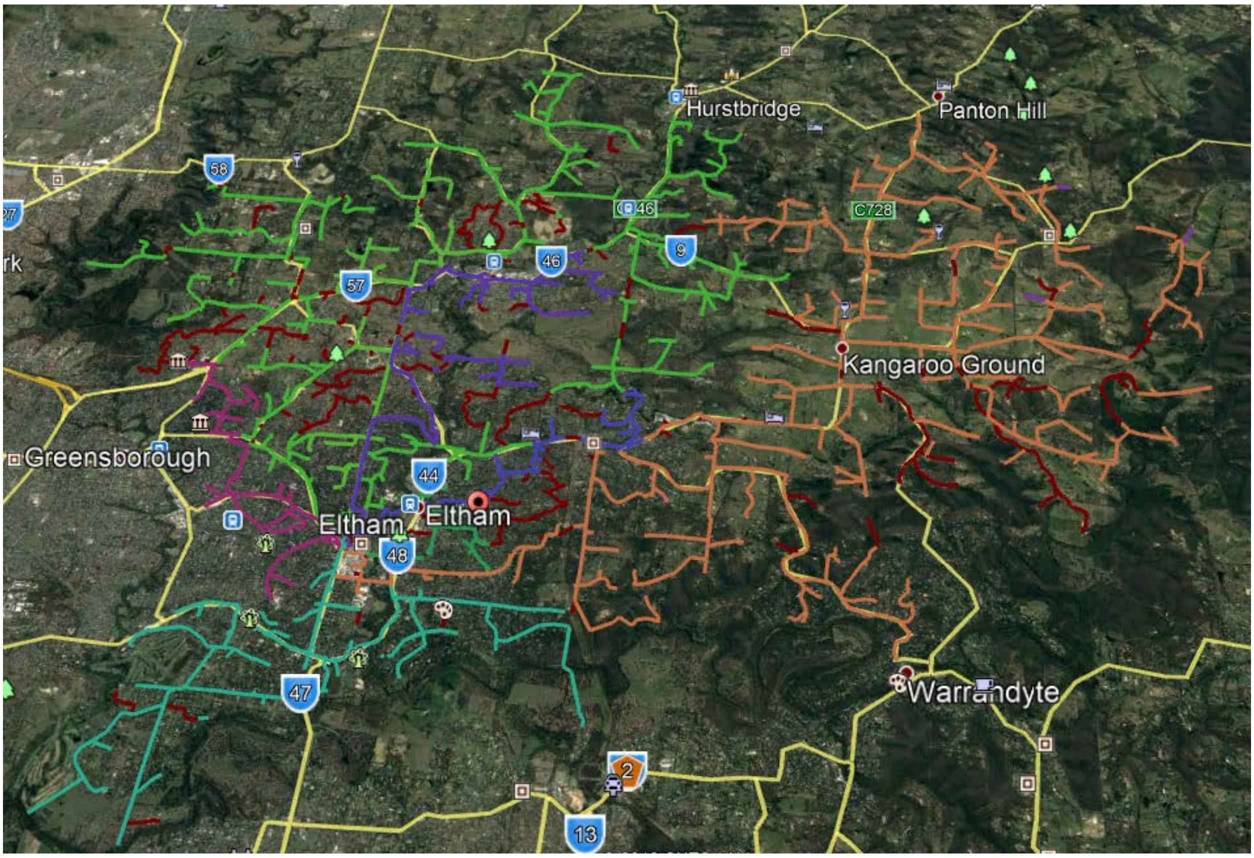
The image shows that the feeders are predominately overhead with the breakdown of overhead and underground conductors per feeder shown in Table 3.1. Overhead feeders contribute a lower amount of capacitive current compared to underground cables.

Table 3.1 Overhead and underground conductor lengths

Old Feeder Name	New Feeder Name	Overhead (km)	Underground (km)	Total length (km)
ELM11	ELM21	6.9	4.3	11.1
ELM12	ELM24	20.9	7.2	28.0
ELM13	ELM25	9.2	2.0	11.2
ELM15	ELM23 & 26	71.3	13.5	84.8
ELM31	ELM34	14.6	5.2	19.7
ELM32	ELM33	21.1	5.5	26.6
ELM33	ELM32	66.6	5.4	72.0
ELM34	ELM22	30.5	2.1	32.6
	Grand Total	**241.0**	**45.1**	**286.1**

The area map shows that there are no individual sections of feeders that are comprised significantly of underground cable and that it is spread throughout the network area in relatively small sections.

Figure 3.2 ELM ZSS Aerial Layout (underground cable is shown in dark maroon)



Source: AusNet Services

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.

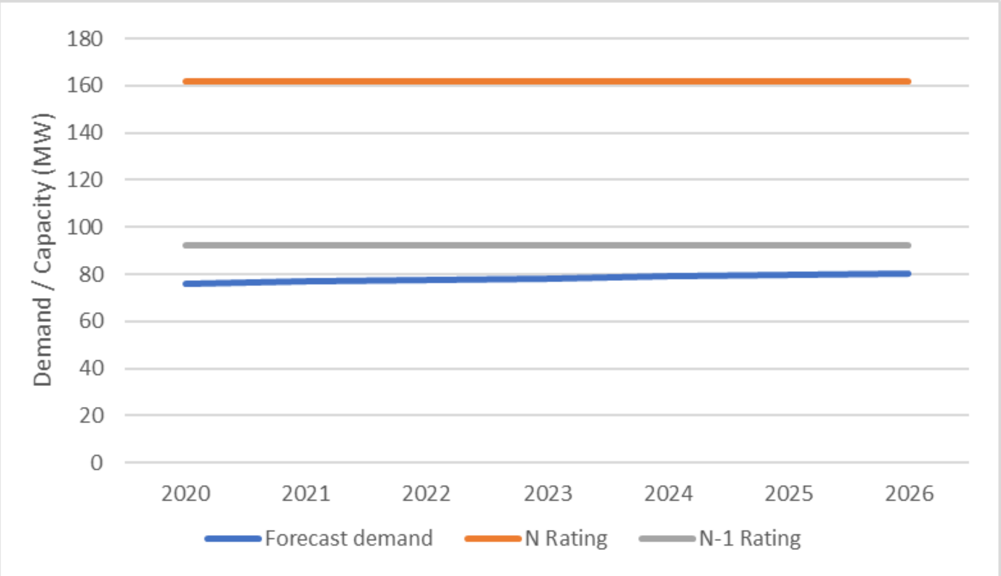
3.1.1 Demand forecast

The table below shows the ELM maximum demand forecast (MVA) between 2020 and 2026. By 2026, the summer demand is expected to increase by approximately 4.3 MVA. However, the forecast demand approaches, but is not expected to exceed, the N-1 cyclic rating of the substation within the 2022-2026 regulatory control period. In addition, these transformers are considered to be in good condition with a low probability of failure, hence there is no need for capacity augmentation to be undertaken.

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

	2020	2021	2022	2023	2024	2025	2026
ELM Winter (50POE)	45.2	45.0	44.7	44.4	44.1	43.7	43.4
ELM Summer (50POE)	74.3	75.1	75.9	76.5	77.2	77.9	78.6
ELM Winter (10POE)	48.7	48.5	48.2	47.9	47.6	47.2	46.9
ELM Summer (10POE)	80.1	80.9	81.8	82.5	83.2	84.0	84.7
ELM Consolidated Forecast[3]	76.1	76.8	77.6	78.3	79.0	79.7	80.4

Figure 3.3 Demand forecast



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

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.

Since the growth in capacitance is strongly related to the growth of URD, 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 view 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.

ELM will have two standard ASCs installed which will each have a capacitive current limit of 100A, for a total zone substation limit of 200A, as shown in Table 3.3 and Figure 3.4. ELM is forecast to exceed the capacitive current capacity of the two ASCs in 2021. The capacitive current will continue to increase due to the continued installation of cables to supply new residential estates.

Table 3.3 Capacitive current forecast

	2020	2021	2022	2023	2024	2025	2026
ELM capacitive current	204	211	217	224	230	237	244
ASC Limit	N/A	200	200	200	200	200	200
Excess capacitive current		11	17	24	30	37	44

Figure 3.4 Capacitive current forecast for ELM – 2020 to 2026

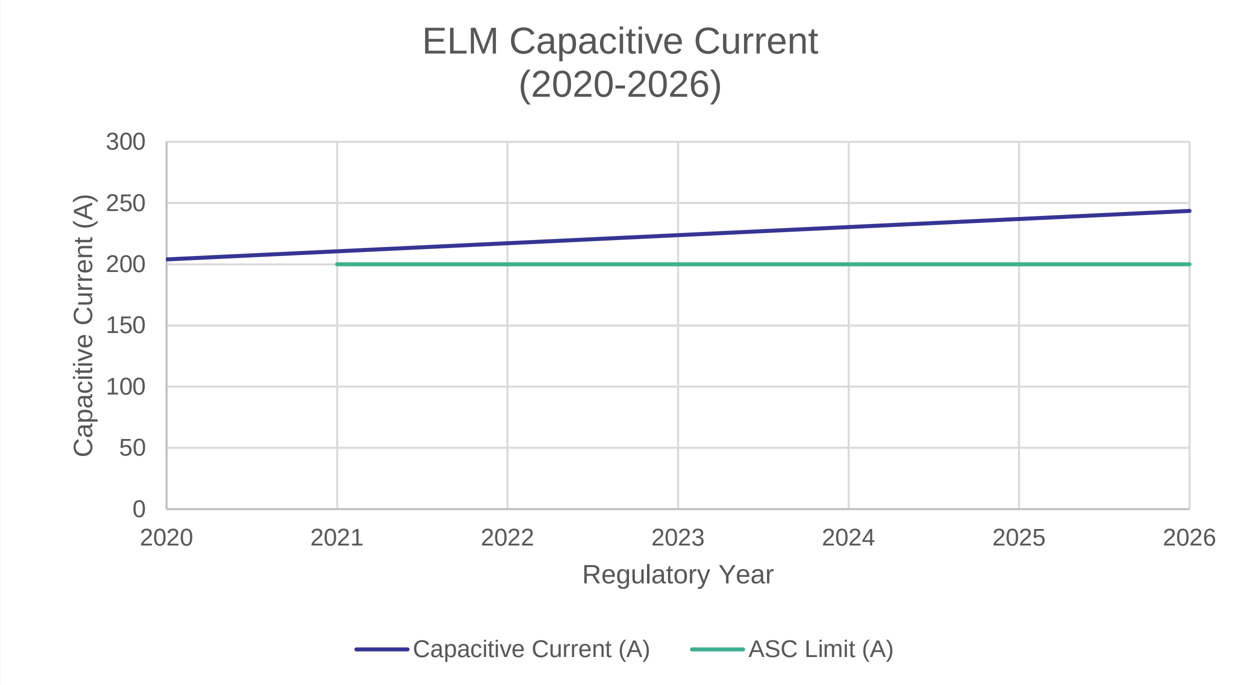


Table 3.4 presents the estimated capacitive current (I_{CO}) per feeder and per bus. This identifies if any feeders are expected to exceed the individual feeder limit of 80A and also where the greatest capacitive current reduction can be achieved.

Table 3.4 shows that no individual feeder exceeds the 80A feeder limit. However, it can be seen that the I_{CO} is not split evenly across the buses. Bus 2 is forecast to reach 133A, which is above the 100A planning limit for an individual ASC, and Bus 3 is forecast to reach 111A which is also above the 100A planning limit for an individual ASC.

Table 3.4 Estimated Capacitive Current contribution per feeder

Old Feeder Name	New Feeder Name	Forecast I_{CO} (A) 2026
ELM11	ELM21	21
ELM12	ELM24	29
ELM34	ELM22	9
ELM15E	ELM23	37
ELM15W	ELM26	28
ELM13	ELM25	9
	Total Bus 2	**133**
ELM31	ELM34	26
ELM32	ELM33	23
ELM33	ELM32	62
	Total Bus 3	**111**
	Grand Total	**244**

3.1.3 Transfer capacity

Review of the network has identified that there are no adjacent zone substations that have capacity available for transferring load.

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 as per the Regulations during the 2022-2026 regulatory control period.

The demand growth is not identified to be a constraint for the zone substation.

The forecast of continued residential growth and network augmentation in the ELM supply area, particularly URDs which increase the capacitive current on the network, means that the capacitive current capacity of the two REFCLs at ELM is forested to exceed in 2021.

- The zone substation is forecasted to exceed its overall planning limit of 200A (two REFCLs installed);
- Bus 2 and Bus 3 is forecasted exceed its individual planning limit of 100A.

AusNet Services needs to identify the most economic option to address the capacitive current constraints.

While the constraints are forecasted to occur from 2021, we note that AusNet Services' ability to comply with the Regulations at ELM is being impacted by MTM REFCL readiness. MTM have three HV connection points on the ELM network and as a result of the lead time for funding approvals and required construction/commissioning activities, MTM are unable to meet the REFCL readiness dates required to enable the REFCLs to be placed in service and compliance demonstrated by the Tranche 2 compliance deadline of 1 May 2021. A time extension for ELM is being prepared.

4 Options analysis

The options identified below are based on the best knowledge currently available on the network, including ASC planning limits 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 five were non-credible on a technical or cost basis. The reasons for this assessment are set out in in Table 4.1. Key constraints identified in the initial options assessment are:

- No feeder transfers are available to adjacent Scheduled zone substations due to loading and capacitive current constraints.
- The Eltham network is a geographically diverse mix between overhead and underground in an established area. Acquiring land for any solutions outside of the ZSS will be difficult and expensive.
- ELM33 has been extensively augmented by the Powerline Replacement Fund (**PRF**) program replacing 22kV open wire with High Voltage (**HV**) Aerial Bundled Cable (**ABC**) and hybrid systems, which has greatly increased capacitance.

Three of the options (options 3, 5, and 8) were found to be credible and are discussed in further detail in sections 4.1 to 4.3.

Table 4.1 Options Reviewed

Option	Discussion	Credible
Option 1 - Business as Usual	The Business as Usual option maintains the status quo at ELM which will entail no additional investment at ELM to manage the impact of the capacitive current. With an increasing capacitive current forecast, ELM may become non-compliant with the Regulations, the community served by the ELM zone substation would	N

Option	Discussion	Credible
	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.	
Option 2 – Capacitance/Load Transfer	This option proposes 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. Feeders can only be transferred from a Scheduled zone substation to another Scheduled zone substation and there are no adjacent Scheduled zone substations that have sufficient spare capacitive current capacity. On this basis, capacitance/load transfer is not considered as a viable option.	N
Option 3 - Install a third REFCL	This option proposes to install a third REFCL on an existing bus to manage the increased capacitive 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 ELM ZSS is considered a viable option at this time. This option is discussed further in section 4.1	Y
Option 4 – 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 ELM network is comprised of large rural feeders with overhead and underground sections. Significant undergrounding of lines would be required for this option. 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 on 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 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 • the cost of each REFCL is expected to be $9.6 million which is more expensive than other options. • to reduce the capacitive current sufficiently at ELM, 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	N

Option	Discussion	Credible
	expensive option, therefore, is not considered as a viable option.	
Option 7 - Undergrounding Over Head in High Bush Fire Risk Area	ELM is comprised of 241 km of overhead line. The cost, including converting overhead distribution transformers and switches to underground assets, estimated at $169 million and therefore is not a credible option.	N
Option 8 - New Zone Substation	This is a viable option and is discussed further in section 4.3	Y

4.1 Option 3 – 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 ELM 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 beyond the EDPR period. The following feeder arrangement is recommended for the three bus configuration.

Table 4.2 Capacitive forecast for a three bus arrangement

Old Feeder Name	New Feeder Name	Forecast I_{CO} (A) 2026
ELM13	ELM25	9
ELM15E	ELM23	37
ELM31	ELM34	26
	Total Bus 1	**72**
ELM11	ELM21	21
ELM12	ELM24	29
ELM15W	ELM26	28
ELM34	ELM22	9
	Total Bus 2	**87**
ELM32	ELM33	23
ELM33	ELM32	62
	Total Bus 3	**85**
	Grand Total	**244**

Note: this arrangement is pending review of summer 2021 load figures

The associated works for this option will include:

- Install a third REFCL
- Re-arrange feeders as indicated in Table 4.2 to manage capacitance and load growth
- Feeder augmentation maybe required after review of P10 load forecasting

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 $9.1 million. However, as there will be lead time to procure and install a third REFCL and associated works, 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 5 – Install isolation transformer and undergrounding work

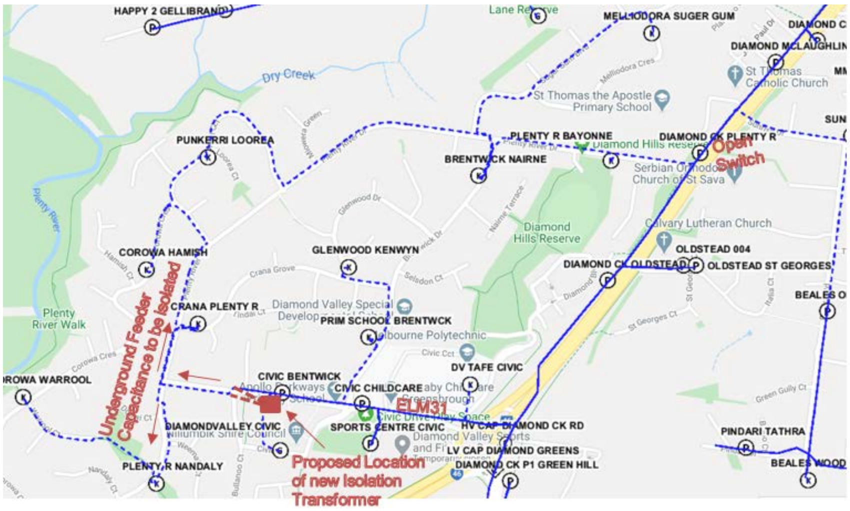
This option proposes to install isolation transformers to reduce the capacitive current the ASC is subjected to. The requirement for this approach is that all conductors downstream of the isolation transformer are underground cables.

After carrying out a high level assessment of the network, three locations described below were found suitable for the installation of 7.5MVA isolation transformers. Installation of isolation transformers in these three locations will reduce the total capacitive current at ELM by approximately 40A.

Location 1 (7.5MVA isolation transformer on ELM31 (now ELM34))

Capacitance on ELM31 (now ELM34) is mostly in one underground section around the Nillumbik Shire Council civic centre and Diamond Hills Reserve. Both areas provide potential options for an isolation transformer with minimal community impact. Installation of a 7.5MVA isolation transformer at the proposed location shown in Figure 4.1 is expected to reduce the capacitive current by 15.1A after isolating approximately 4.2km of underground cable of various sizes.

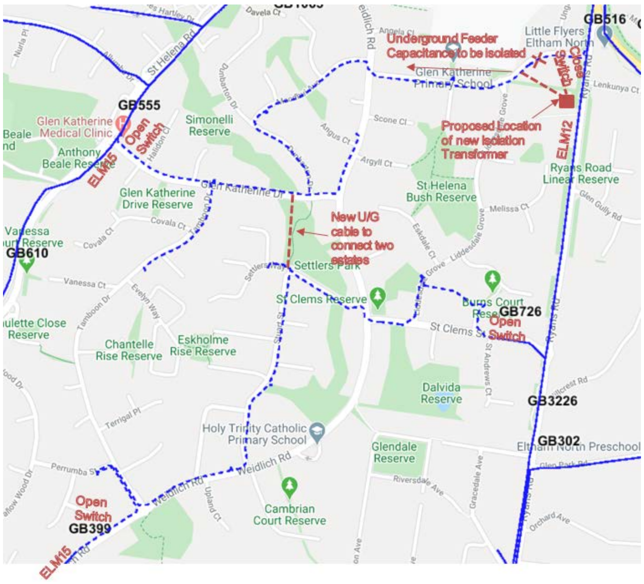
Figure 4.1 Proposed location of isolation transformer for Location 1



Location 2 (7.5MVA isolation transformer on ELM12 (now ELM24))

Installation of a 7.5MVA isolating transformer near Ryans Rd as shown in Figure 4.2 on ELM12 (now ELM24) is expected to reduce the capacitive current on ELM12 (now ELM24) by 13.5A. The majority of capacitance is contained in two underground estates between the switches GB516, GB726, GB555 and GB399. While geographically close, these are only connected via the overhead feeder backbone near the feeder exit. Isolation of this capacitance would require the installation of approximately 165m of new 22kV underground cable to link both estates and switching arrangement as illustrated in Figure 4.2. This isolation is located at the end of the feeder between ELM15 and ELM24 (backbone). It would be a similar setup to the isolation transformer installed on KLK11. This will require review from operational planning after assessing the outcomes of the KLK isolations.

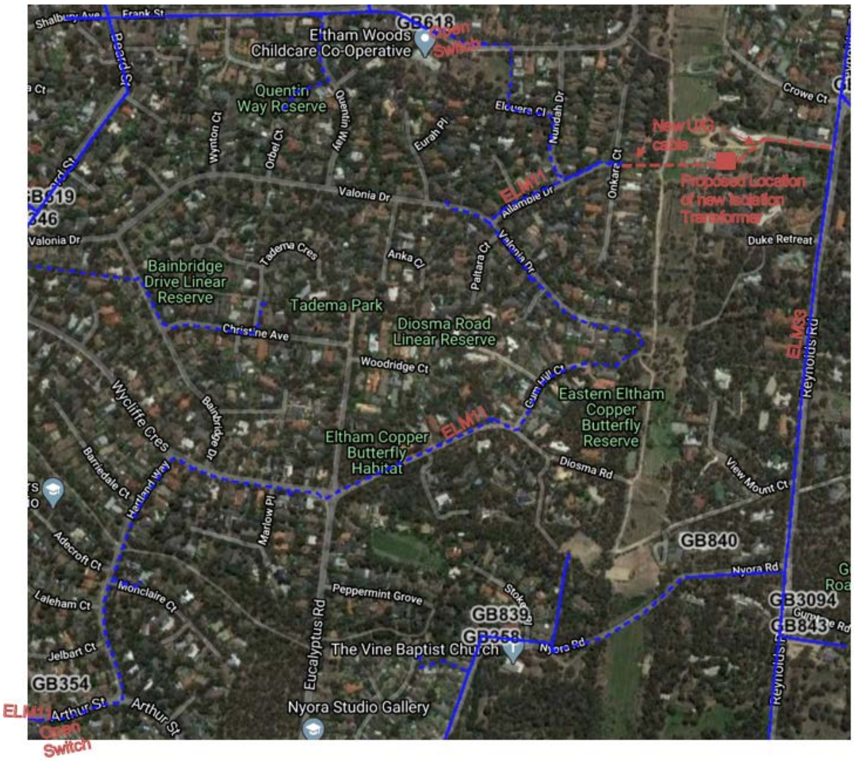
Figure 4.2 Proposed location of isolation transformer for Location 2



Location 3 (7.5MVA isolation transformer on ELM33 (now ELM32))

The majority of the capacitance in this feeder ELM11 (now ELM21) is contained in one underground section past switch GB354. While a likely candidate for isolation, land is at a premium. The only “open” space available is on a site owned by Eltham woods childcare co-op and preschool. Acquiring land on this site and installing 22kV equipment will raise community concerns and has a high risk of not being achievable. Hence, this location is not considered as viable. Another location would be the transmission corridor to the east with a network extension from ELM33 (now ELM32) to transfer and isolate the underground section of cable described above. This transfer would extend the network into the 220kV easement. Figure 4.3 illustrates this option. New underground cable is required to connect the isolation transformer to the ELM33 (now ELM32) feeder as the source of the new supply and to the underground section of the ELM11 feeder that is to be isolated.

Figure 4.3 Proposed location of isolation transformer for Location 3



For this option, it is recommended to open the GB354 switch to allow the feeder to be supplied by ELM33 as shown in Figure 4.3. This solution is expected to reduce the capacitive current of ELM11 (now ELM21) by 11A.

With these in place, the total capacitance is likely to reduce by 40A. The updated capacitive current per feeder in 2026 is summarised in the following table. The approximate cost for this three 7.5MVA isolation transformer solution is approximately $5 million including land and additional underground cable for connections.

Table 4.3 Estimated Capacitance Reduction

Old Feeder Name	New Feeder Name	Forecast I_{CO} (A) 2026	Capacitance Reduction	Revised Forecast I_{CO} (A) 2026
ELM11	ELM21	21	-11	10
ELM12	ELM24	29	-14	15
ELM34	ELM22	9	0	9
ELM15E	ELM23	37	0	37
ELM15E	ELM26	28	0	28
ELM13	ELM25	9	0	9
Total Bus 2		**133**	**-25**	**108**
ELM31	ELM34	26	-15	11
ELM32	ELM33	23	0	23
ELM33	ELM32	62	0	62
Total Bus 3		**111**	**-15**	**96**
Grand Total		**244**	**-40**	**204**

As per Table 4.3, Bus 3 is marginally below the 100A planning limit and Bus 2 is still above the 100A planning limit. For Bus 2 feeders, no other isolation transformer options can be readily found. The following practical challenges and risks also exist:

- For installation, each 7.5MVA isolation transformer requires approximately 13m x 19m land parcel. Preliminary desktop investigation has found the risk to acquire or lease land from the council at the three locations to be high;
- Land cost maybe higher than assumed in this report given the urban nature of Eltham;
- 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.

Therefore, this option is not recommended as a permanent solution.

4.3 Option 8 – New Zone Substation

This option proposes to construct a new zone substation at Diamond Creek (**DCK**) and transfer load and capacitive current (>40A) to enable ELM to maintain compliance with the Regulations.

Installing a new zone substation is a technically viable option. The cost of a new single transformer ZSS (with one REFCL) is $21.5 million. Since Diamond Creek is still undeveloped and has semi-rural areas, locating a new zone substation in the Diamond Creek area is more likely then locating a zone substation in the Eltham area due to land availability. Furthermore, extending feeders from Diamond Creek to pick up Eltham feeders can be achieved via overhead construction methodology, thereby reducing cost and additional capacitance associated with underground construction. This solution gives more flexibility then the remote REFCL option as all capacitive growth from new developments to the north of Eltham will be captured by the new zone substation and won't be subject to feeder limitations.

The scope of this option is:

- Installation of the Diamond Creek (DCK) Zone Substation.
  - Land and easements
  - Single 20/33 MVA 66kV/22kV transformer
  - REFCL and associated equipment
  - Protection and control equipment
- Construct 5.5 km of two new 66 kV sub transmission lines to supply DCK
- network reconfiguration to transfer load and capacitive current from ELM to DCK
- network reconfiguration to balance load across the busses at ELM

Key advantage of this option is that it provides the real option for additional demand and capacitive current capacity if required in the future

This option has the following key disadvantages:

- Additional capacity (demand MW) is not required in the 2022-2026 regulatory control period based on current load forecast
- Ability to acquire land in an appropriate location and to obtain the necessary easements for the new 66kV line and distribution feeder exits. AusNet Services will attempt to utilise the existing overhead network within the road reserves to minimise this risk.
- High cost – approximately $23 million.
- Long lead time.

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 3 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 3 - Install a third REFCL	Yes, but solution has not been deployed and tested elsewhere	$9.1 M	Yes	No	Yes
Option 5 – Install isolation transformer and undergrounding work	Partly feasible. Bus 2 capacitance is still above 100A planning limit	$ 5 M	Yes	Yes	No
Option 8 – New Zone Substation	Yes	$23 M	Yes	Yes	No

5 Recommendation

It is recommended that option 3, installation of a third REFCL, is approved. In addition, 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, it may be necessary to install isolation transformers as a temporary measure, pending results from commissioning.

The expected cost for this option is $9.1 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 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.