REFCL Deployment Summary Report Kalkallo Terminal Station (KLO) Zone Substation

AMS – Electricity Distribution Network

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1 Project overview

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

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

Kalkallo Zone Substation (**KLO**) is included in Tranche 3 of the AusNet Services REFCL Program with compliance required to be achieved by May 1st 2023. This report investigates and seeks funding for the most prudent and efficient approach to achieve compliance with the Regulations at KLO.

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 KLO to ensure AusNet Services can maintain compliance with the Regulations.

This report reviews various options considered by AusNet Services to manage the rapid capacitance growth at KLO and summarises the work performed by WSP - *AusNet services and Jemena electricity networks economic options to maintain REFCL compliance at Kalkallo and Coolaroo zone substations joint planning report* and AusNet Services Network Planning team.

The preferred option, which is the option found to be the most economically efficient and technically feasible, recommends the installation of two remote REFCLs (including an additional Arc Suppression Coil), four 5 MVA isolation transformers, three on feeder KLO-14 and one on KLO-24.

The expected cost is $39.5 million and is the identified least cost and technically feasible solution.

2 Background

2.1 Purpose of this report

This report details the AusNet Services outcomes following joint network planning between AusNet Services and Jemena Electricity Networks. Though jointly planned this report does not detail the options required by the Jemena network, those will be provided by Jemena separately.

These plans represent further refinement and investigation of options detailed in the joint AusNet Services and Jemena report[1] and details the lowest cost options that have been considered.

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

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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[2].

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] Economic options to maintain REFCL compliance at Kalkallo and Coolaroo Zone Substations, Joint Planning Report AusNet Service and Jemena Electricity Networks, PS113850-ADV-REP-001

[2] 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 switch room. 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.

2.3.1 Remote REFCL

As conceived and implemented to date REFCL technology has been installed within the Zone Substation environment. This has been dictated by the requirement to access the neutral of the transformers supplying the network emanating from the station.

A Remote REFCL concept has been developed by AusNet Services to increase technical optionality of meeting and maintaining the Required Capacity. This concept endeavours to create a REFCL protected network within an individual distribution feeder (22 kV) when a zone substation reaches its ultimate REFCL capacity.

Remote REFCL consist of an Isolation transformer and REFCL (ASC+RCC) that creates a separate REFCL network downstream that is distinct and isolated from the supporting Zone Substation.

Through the use of the remote REFCL it is planned that expenditure to maintain the Required Capacity can be minimised.

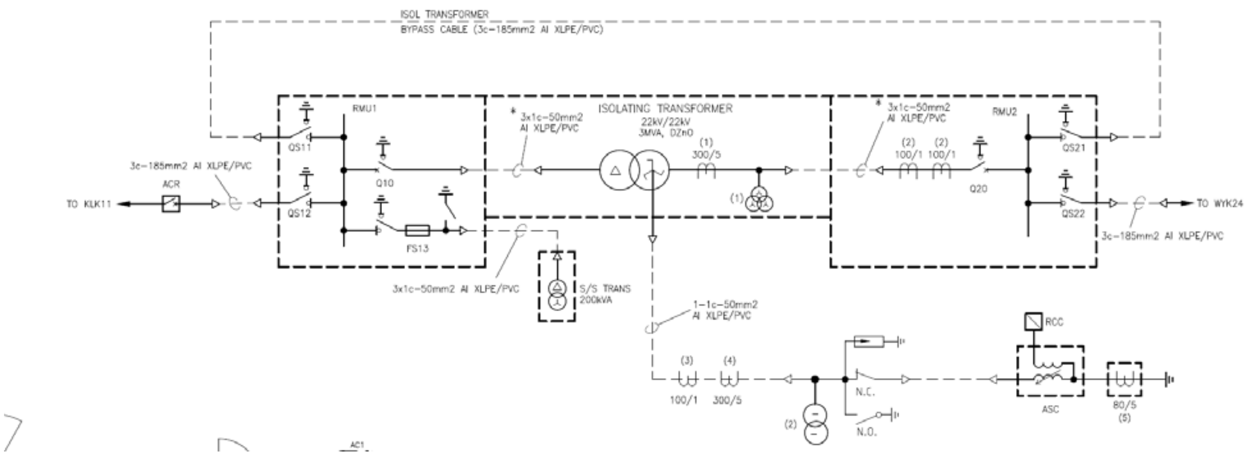


Figure 1 Remote REFC SLD

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[3] 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:

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

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 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 make options previously not credible available for re-assessment.

3 KLO zone substation overview

Kalkallo Terminal Station (**KLO**) is an outer suburb of Melbourne located on the outskirts of the city, approximately 30km north of Melbourne.

KLO 66/22kV ZSS is owned by AusNet Services. It has two 66/22kV 20/33 MVA transformers. KLO ZSS is supplied by two 66kV lines from South Morang Terminal Station (SMTS) – one directly from SMTS while the other 66kV line is via Doreen (DRN) ZSS. The 66kV overhead lines are cabled for a short distance for entry into the zone substation.

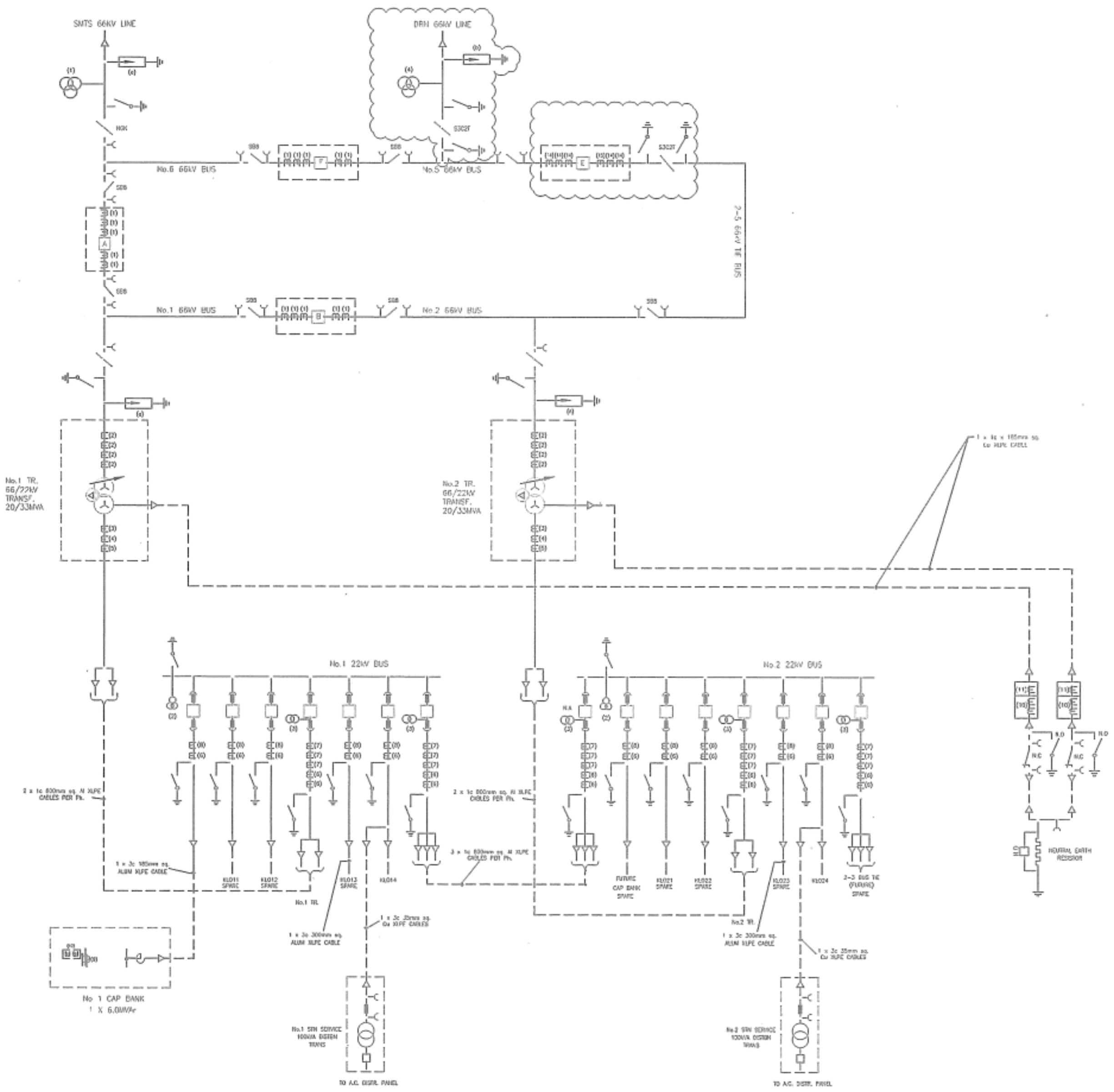
Significant residential development is driving the forecast growth in the KLO ZSS area, the development is pronounced close to the ZSS with multiple estate currently under development.

These new residential estates will have a predominately underground cable reticulation system. As underground cables typically have a higher capacitance than overhead lines by an order of approximately 100 times, the increase in underground cables will significantly increase the Co experienced at KLO ZSS in the future.

KLO has 4 AusNet Services feeders, KLO-11, KLO-12 KLO-14, KLO-24. It also provides supply to feeders supplied by Jemena to the south and west of the zone substation. Jemena feeders have been excluded from this report.

KLO-11 and KLO-12 are small, fully underground feeders. Growth on KLO-12 is not expected in the regulatory period. KLO-11 may be used in the future to transfer load from KLO14 with augmentation but this is not expected to materially change the outcomes in this report.

Figure 3.1 KLO ZSS Single Line Diagram



Source: AusNet Services

An aerial view of the 22kV feeders originating from KLO electricity distribution area is shown in Figure 2 KLO network. The distribution area includes urban areas around Kalkallo and the rural areas to the north and east of the zone substation including Wandong Regional Park.

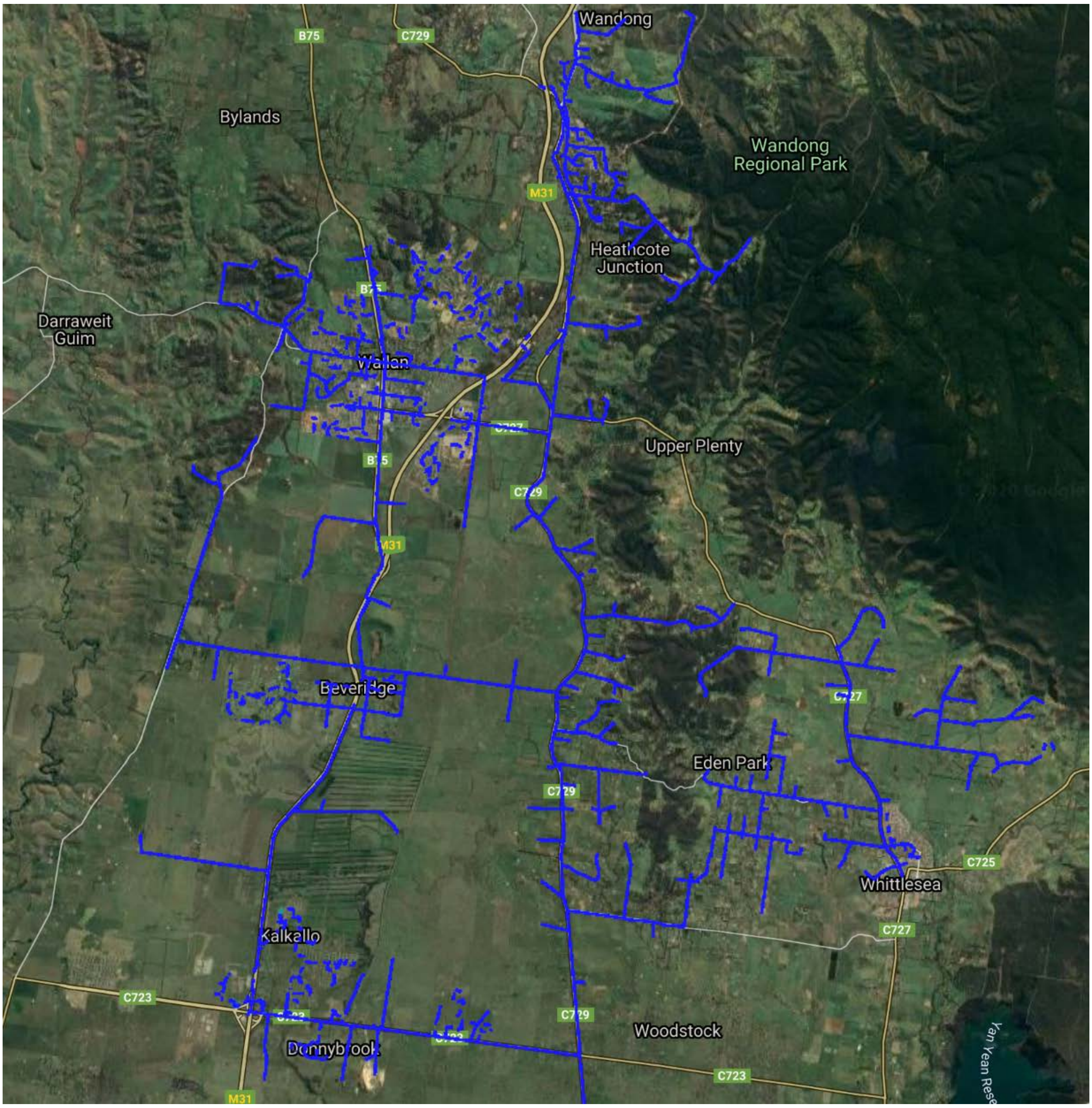


Figure 2 KLO network

The breakdown of overhead conductors and underground cables per feeder is 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

AusNet Feeders	Overhead (km)	Underground (km)	Total length (km)
KLO11	0.00	0.12	0.12
KLO12	0.00	1.74	1.74
KLO14	248.20	35.93	284.13
KLO24	75.03	37.24	112.27
Grand Total	**323.23**	**75.03**	**398.26**

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 KLO maximum demand forecast (A) between 2020 and 2029 Towards the end of the forecast period feeder loads will approach operational limits and network augmentation will be needed.

Table 3.2 Maximum Demand (MVA) Forecast for KLO – 2019 to 2029

	Capacitive Currents			MD (A)			
Feeder	Existing	Forecast		2019-2025		2019-2029	
	2020	2025	2030	P50	P10	P50	P10
KLO14	119.2	149.1	191.1	363	370	394	402
KLO24	108.4	128.2	148.0	373	381	399	407

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 URDs and other known network augmentation.

Since the growth in capacitance is strongly related to the growth of URDs, the forecast was made in five-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 and 2 installations and consideration of differences with the Tranche 3 zone substation network supply areas.

AusNet Services is acting prudently to address the network capacitive limits at each Tranche 3 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. Where 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.

The dominate growth in underground reticulation due to the land zoning will continue to drive rapid capacitance growth on on this network. KLO currently has the largest forecast capacitance growth in any REFCL network in the AusNet Services Network.

3.1.3 Transfer capacity

Review of the network has identified that while there are adjacent zone substations with interconnections, capacity and voltage constraints limit permanent transfers viability.

3.2 Identified need

As shown in section 3.1, due to expected network growth in AusNet Services' network, AusNet Services needs an innovative solution to achieve and maintain compliance with the Required Capacity in the Regulations.

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

- The zone substation is forecasted to exceed its overall planning limit of 200A (two REFCLs installed).
- Both buses, considered individually, are forecasted to exceed the 100A planning limit.

The asset condition and capacity at KLO do not present a risk to supply and therefore do not warrant any augmentation or replacement capital expenditure.

AusNet Services needs to identify the most economic option to address the capacitive current constraints affecting the ability to achieve REFCL compliance.

4 Options analysis

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

AusNet Services has highlighted 4 options that could maintain compliance with the Regulations. These are summarised in Table 4.1.

Seventeen further options considered can be found in the AusNet Services Jemena Joint Planning report prepared by WSP.

Two of the options (options 2 and 3) were found to be credible and are discussed in further detail in sections 5 and 6.

Table 4.1 Options Reviewed

Option	Discussion	Credible
Option 1 - Business as Usual	The Business as Usual option maintains the status quo at KLO which will entail a standard 2 REFCL installation. With an increasing capacitive current forecast, KLO may be impossible to be made compliant with the Regulations, the community served by the KLO 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 – Remote REFCL, Feeder Augmentation	Install isolation transformers on both KLO-14 and KLO-24 to isolate housing estates reducing capacitance. Replace feeder backbone with covered conductor and underground cable from KLO to identified remote REFCL sites. Install remote REFCL solution for KLO-24 and KLO-14 away from the zone substation. A supporting Arc Suppression Coil will also be purchased to support this equipment in case of failure. Seek exemption for covered conductor between ZSS and remote REFCL site. UG cable covered by general exemption.	Y
Option 3 - New ZSS	Build a new REFCL BEV ZSS with two transformers and offload KLO to BEV ZSS. Install 2 REFCLs at KLO and BEV ZSS	Y
Option 4 – 3rd GFN	Install a third REFCL on a new bus to achieve compliance with the higher capacitive current found at KLO. Growth is expected to continue and individual feeder capacitance exceeds limits required to meet the Required Capacity. This option does not resolve this issue. On this basis, Option 4 is not a credible option.	N

5 Remote REFCL – Option 2

This option seeks to avoid installation of REFCL technology within the Zone Substation environment of Kalkallo Zone Substation. Through the application of Remote REFCL concept as outlined in section 2.3.1 and covered conductor[4] the Required Capacity for bare AusNet Services conductors emanating from KLO can be achieved.

A key benefit of this option is Remote REFCL and covered conductor option can protect the overhead network of KLO whilst enabling the continued growth of high capacitance underground developments.

A PSS® Sincal model of KLO14 and KLO24 in conjunction with the forecast capacitance by switch zone and known future URD development areas was used to determine the ideal location for the Remote REFCL's. The best location for the Remote REFCL on KLO14 is adjacent to an existing ACR SM15013. Alternatively the Remote REFCL can be located anywhere along the network highlighted yellow in the photo below. The Remote REFCL network has been modelled from SM15013 on KLO14.

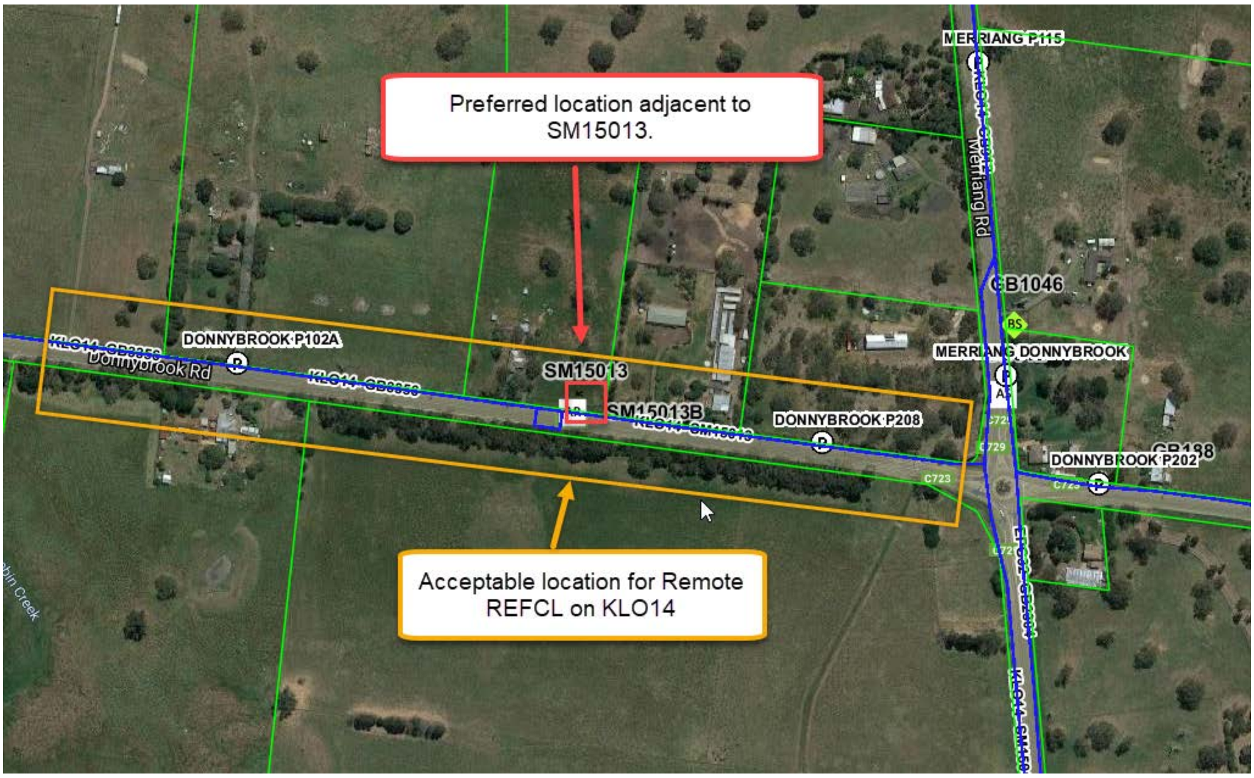


Fig 1. Proposed location for Remote REFCL on KLO14.

The best location for the Remote REFCL on KLO24 is the corner of Spring St and Kelly St Beveridge. Alternatively, the Remote REFCL can be located anywhere along the network highlighted yellow in the photo below. The Remote REFCL network has been modelled based on the preferred location.

[4] AusNet Services is currently progressing with an exemption application to Energy Safe Victoria for the use of covered conductor.

Fig 2. Proposed location for Remote REFCL on KLO24.

Assuming the locations marked above as ideal are able to be obtained the post reconfiguration network data is as follows:

	Capacitive Currents		MD	
Feeder	**Pre-Remote REFCL**	**Post Remote REFCL**	**Pre-Remote REFCL**	**Post Remote REFCL**
	2030	**2030**	**P10 2029**	**P10 2029**
KLO14 (less Cloverton)	136.5	36.5	352	352
KLO14 Remote REFCL	N/A	100.0	352	322
KLO14 with Remote REFCL and isolations	N/A	65.0	325	322
KLO24	148.0	46.9	407	407
KLO24 Remote REFCL	N/A	99.5	407	314
KLO24 with Remote REFCL and isolations	N/A	80	407	314

5.1 KLO14 Remote REFCL

The Remote REFCL is forecast to be loaded to 322A under P10 conditions by 2029, or 12.3MVA. Voltage studies were carried out with a 10MVA isolation transformer (15MVA cyclic rating) configured Dzn0, and on neutral tap. Impedance was assumed to be 8%. There is a 1% reduction in voltage after the Remote REFCL under maximum demand conditions, but the proximity to the Merriang Janna Regulator means this is not significant. Under minimum demand conditions there is a 1% increase in voltage after the Remote REFCL. Once again the Merriang Janna Regulator reduces the impact. There will not be a requirement for OLTC under system normal conditions.

Three phase fault current is significantly affected in the vicinity of the Remote REFCL and along the main feeder backbone, but there is less impact at the end of the steel spurs on the feeder. The reduced fault levels in the backbone will make it difficult to suitably protect the network as the load grows without the addition of ACRs. A protection review will be required.

5.2 KLO24 Remote REFCL

The Remote REFCL is forecast to be loaded to 314A under P10 conditions by 2029, or 12MVA. Voltage studies were carried out with a 10MVA isolation transformer (15MVA cyclic rating) configured Dzn0, and on neutral tap. Impedance was assumed to be 8%. Under max demand conditions today, and into the future, the Remote REFCL will cause the voltage around the Wallan area to breach the Electricity Distribution Code. An OLTC or Cooper LVR will be required at this location.

Three phase fault current is significantly affected in the vicinity of the Remote REFCL and along the main feeder backbone, but there is less impact at the end of the steel spurs on the feeder. The reduced fault levels in the backbone will make it difficult to suitably protect the network as the load grows without the addition of ACRs. A protection review will be required.

There will be reconductoring of the O/H line from KLO to Beveridge in order to satisfy the requirements for an exemption to the regulations. As we are approaching an overload situation on KLO24 in the next few years it would be beneficial to reconductor this section as a double circuit line, enabling the estates west of the Hume Freeway at Beveridge to be supplied from a new feeder.

5.3 Isolations required for ongoing compliance

The following network isolations have been identified as being required to capacitively reduce the network size to an acceptable size allowing compliance to be achieved. All network proposed to be isolated will be fully underground and hence covered by the general exemption to REFCL protection.

- KLO-14 Location A – Wallan industrial area S Station road 2 x 5 MVA, 18A reduction
- KLO-14 Location B – William St Wallan 1 x 5 MVA, 16A reduction
- KLO-21 Location C – Hidden Valley Blvd 1x 5 MVA, 19 A reduction

5.4 Operational Considerations

To ensure the Remote REFCL can be bypassed without off-load transfers the isolation transformer should have a Dzn0 vector group to ensure there is no phase shift between the supply and load side of the transformer. This will also assist transfers between KLO14 and KMS12, EPG13, EPG32 and DRN22 at times when the REFCL is not required to be in service.

5.5 Summary of Requirements

5.5.1 The requirements to install a Remote REFCL on KLO14 are as follows:

1. Reconductor existing O/H up to Remote REFCL location with covered conductor that is suitable for ESV exemption and can achieve a summer rating of 360A for the backbone.
2. Retire spurs or reconductor with covered conductor that is suitable for ESV exemption. It is expected that spurs on the section of KLO14 between the zone substation and the remote REFCL will be retired by landowners over time as development extends along Donnybrook Rd.
3. Install a Remote REFCL adjacent to SM15013. The transformer to have with Dzn0 vector group and be rated 10MVA continuous, 15MVA cyclic.
4. There will be no impact on capacitive balance if the Remote REFCL can be installed adjacent to SM15013.
5. A protection review will be necessary to determine if additional ACR's are required as a result of the reduction in fault level.
6. Install isolation transformers on existing fully underground network segments to ensure on going compliance

Refer to 8.4 Remote REFCL Proposal for a marked up plan of the work required for the KLO14 Remote REFCL.

5.5.2 The requirements to install a Remote REFCL on KLO24 are as follows:

1. Reconductor existing O/H up to Remote REFCL location with covered conductor that is suitable for ESV exemption and can achieve a summer rating of 360A for the backbone.
2. While carrying out the above add an additional circuit to enable the Beveridge West area to be transferred to a new feeder.
3. Retire spurs or reconductor with covered conductor that is suitable for ESV exemption. It is expected that spurs on the section of KLO24 between the zone substation and the remote REFCL will be retired by landowners over time as development extends north towards Beveridge.
4. Install a Remote REFCL near GOVT HUME substation. The transformer to have with Dzn0 vector group and be rated 10MVA continuous, 15MVA cyclic. An OLTC will be required for this transformer, or the installation of a 300A Cooper LVR.
5. The location of the Remote REFCL will create a new automated switch section. As a result the capacitive balance will need to be reviewed.
6. A protection review will be necessary to determine if additional ACR's are required as a result of the reduction in fault level.
7. Install isolation transformers on existing fully underground network segments to ensure on going compliance

Refer to 8.4 Remote REFCL Proposal for a marked up plan of the work required for the KLO24 Remote REFCL.

5.6 Remote REFCL Outcome

At the completion of work to install the Remote REFCL units on KLO14 and KLO24, and following Jemena's work to become REFCL compliant on the Jemena feeders, KLO feeders will either be underground or covered up until the Remote REFCL units. All future augmentation in this zone will be required to be by underground cable, or other ESV approved method.

In order to limit capacitance growth on the Remote REFCL units all future underground networks should be connected to KLO in the exempted region of the feeders, or isolated from the Remote REFCL supplied sections of the network.

6 New Zone Substation: - Option 3

Based on the current forecast the Remote REFCL solution is expected to be viable for the next 10 years, after which time we will be approaching load and capacitance limits. At this point a new zone substation will likely be considered to supply Wallan, Wandong and Beveridge. As an alternative to installing the Remote REFCL sites a new REFCL protected zone substation could be installed in Beveridge. The same exemption works for KLO would be required, but we would no longer be installing two Remote REFCL's at separate locations.

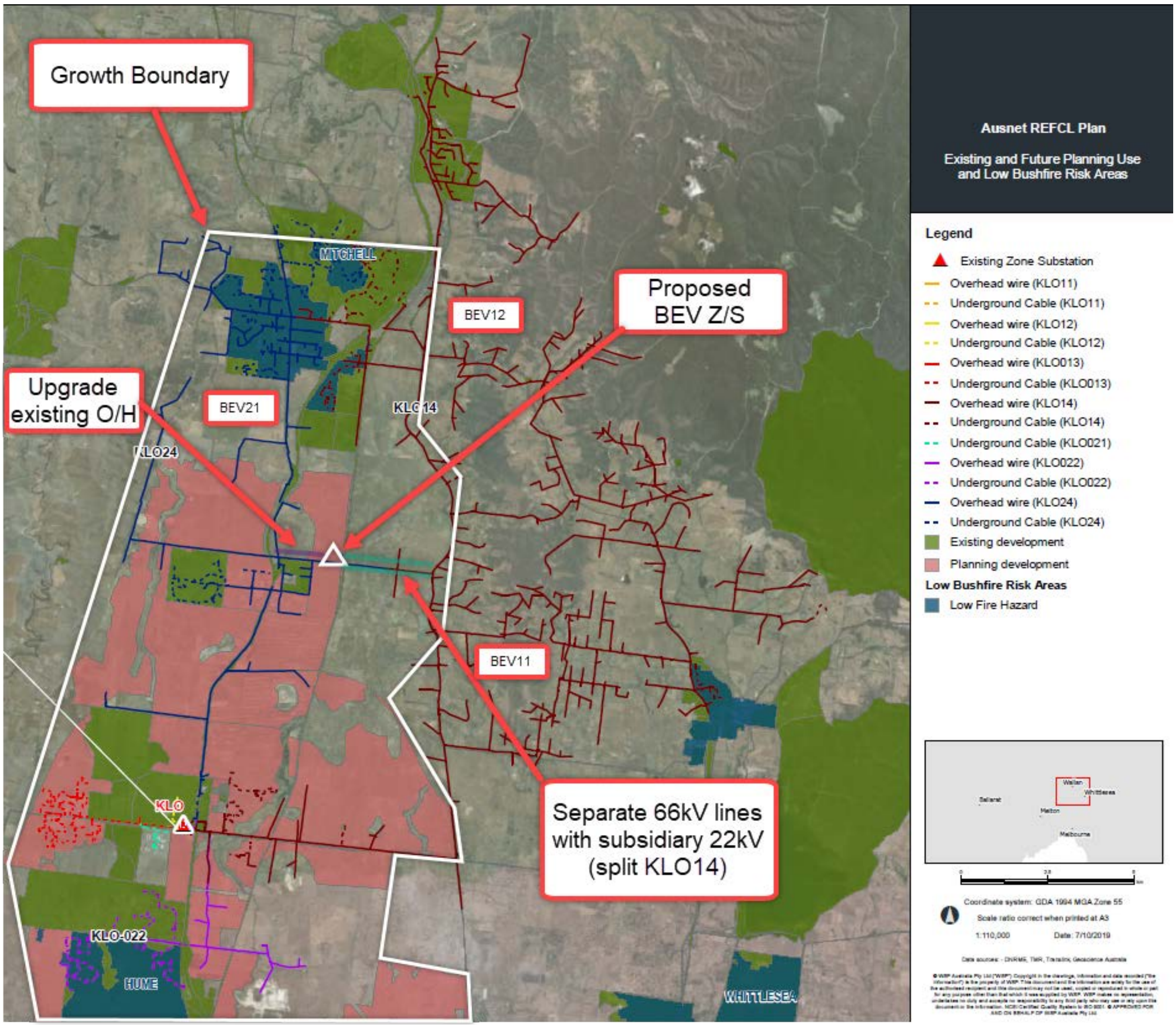


Figure 3 Proposed location of BEV Z/S

The results for BEV Zone Substation are as follows:

	Capacitive Currents		MD	
Feeder	Pre BEV	Post BEV	Pre-BEV	Post BEV
	2030	2030	P10 2029	P10 2029
KLO14 (less Cloverton)	136.5	36.5	352	102
KLO24	148.0	46.9	407	100
BEV11	N/A	19.9	N/A	125
BEV12	N/A	80.1	N/A	175
BEV21	N/A	99.5	N/A	307

6.1 Summary of Requirements

6.1.1 Stage 1 Work

1. All KLO feeder work previously proposed for KLO in option 2, including connecting Beveridge West to KLO24. However, the double circuit section between KLO and Beveridge would no longer be required, single circuit only required.
2. Establish a two transformer, two switchboard, two GFN zone substation in Beveridge Rd near the rail line on a site suitable for three transformers.
3. Cut into SMTS-KLO/KMS line with two new 66kV lines for approx. 2.6km in Beveridge Rd. Lines to include 22kV subsidiary with covered conductor to allow for creation of BEV11 and BEV12 feeders above.
4. Upgrade BEV21 conductor from BEV to Hume Freeway with covered conductor rated at 360A.

Refer to 8.5 New Zone Substation Proposal for a marked up plan of the work required for the BEV REFCL protected zone substation.

6.1.2 Future Work

The timing of future work would be as follows:

1. Target BEV21 (see above) over the next 10 years for conductor replacement with covered options to progress towards an exemption for BEV21 in the future.
2. Connect new underground estates to KLO feeders where possible, or temporarily isolate from BEV feeders.
3. When load on underground network suits add a third transformer and bus 3 to BEV but no GFN. The bus tie would be open and would not be impacted by the GFN. Connect underground feeders to this bus.
4. When BEV21 is ready for exemption remove bus 2 GFN and keep only BEV11 and BEV12 as REFCL feeders on bus 1.
5. Continue connecting all underground estates to non-GFN feeders from BEV.

Note: Steps 3, 4 and 5 are contingent on developing a solution for having GFN and non-GFN busses in the same station. If this cannot be achieved then it must be mandated that all estates be connected via isolation transformers.

6.2 New Zone Substation Outcome

At the completion of work to install the Beveridge (BEV) Zone Substation, and following Jemena's work to become REFCL compliant on the Jemena feeders, KLO feeders will either be underground or covered up until the new open points with BEV feeders BEV11 and BEV21. All future augmentation in this zone will be required to be by underground cable, or other ESV approved method.

In order to limit capacitance growth on BEV all future underground networks should be connected to KLO, or isolated from BEV feeders.

6.3 Option comparison

The two viable options studied in this report are summarised below. The comparison of the options shows that option 6 is the preferred option as it is the least cost and technically feasible solution.

Table 4.1 Feasible Options Comparison

Option	Technical feasibility	Estimated Cost (real $ 2020)	Regulatory feasibility	Social impact	Preferred
Option 6 - Remote REFCLs and isolation transformers	Yes, however, it will be difficult to find suitable land	$39.5 M	Yes	Yes	Yes
Option 8 - New ZSS	Yes, however, it will be difficult to find suitable land	$53.0 M	Yes	Yes	No

7 Recommendation

It is recommended that option 3, two remote REFCLs (including an additional supporting Arc Suppression Coil in case of failure), partial feeder reconductor with covered conductor and 4 isolation transformers, is approved.

Following approval, AusNet Services will be required to acquire or lease land near KLO to install the two remote REFCLs and isolation transformers on KLO14 and KLO24.

This option will also require AusNet Services to apply for a specific exemption for the parts of the net work to be excluded from REFCL protection not covered by a general exemption.

The expected cost is $39.5 million and is the least cost and technically feasible solution identified.

8 Appendix A

8.1 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.

8.2 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.*

8.3 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).

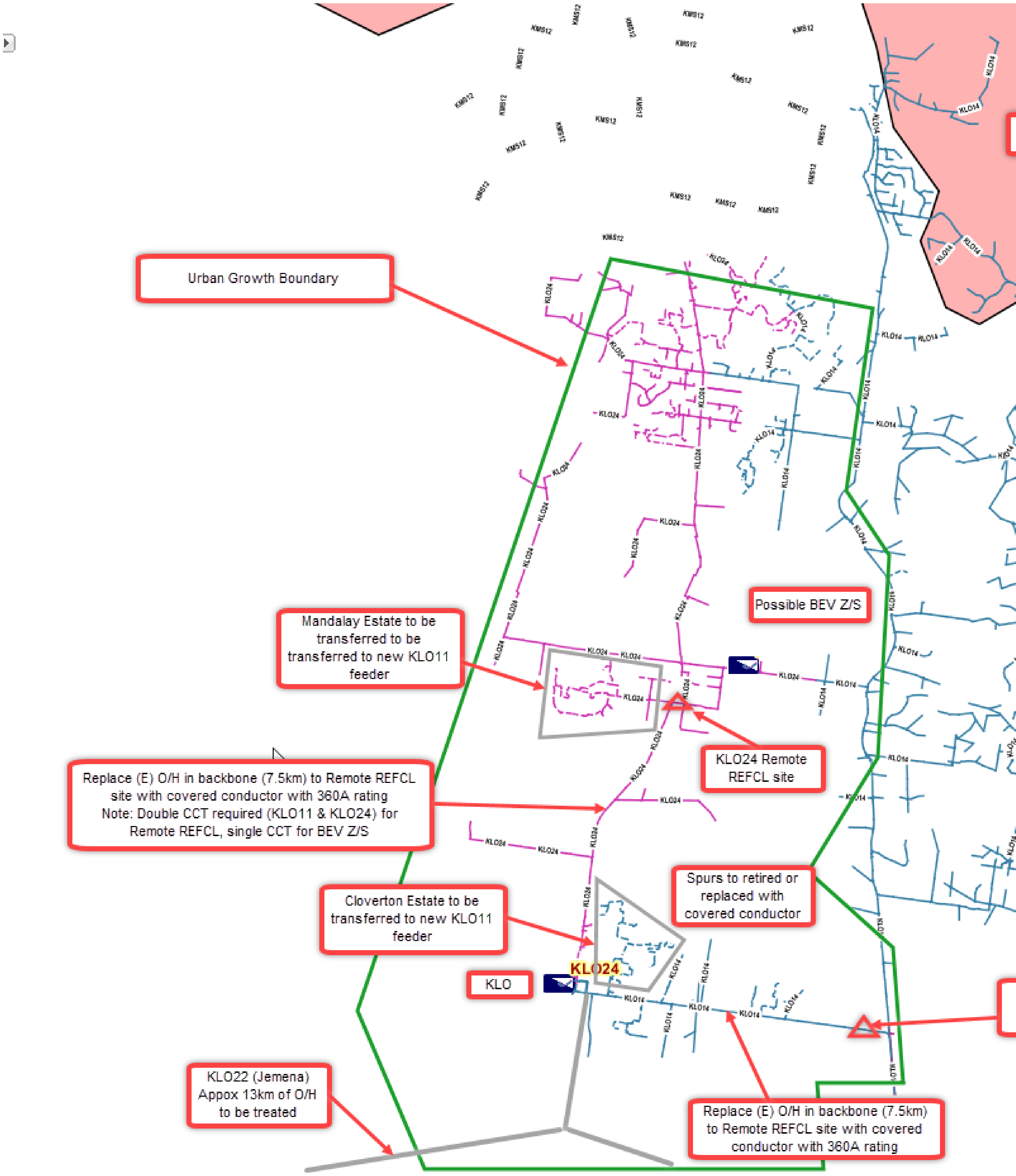
13 Exemptions

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.

8.4 Remote REFCL Proposal



8.5 New Zone Substation Proposal