Rapid Earth Fault Current Limiter (REFCL) Program

BN Zone Substation Functional Scope

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Contents

1 Project overview

This project scope covers all aspects involved in the conversion of the Benalla (**BN**) zone substation (**ZSS**) from a low impedance earthed network to a resonant earthed network that can meet the performance requirements as set out in the *Electrical Safety (Bushfire Mitigation) Regulations 2013* as amended by the *Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016* which came into effect on 1 May 2016.

Conversion to resonant earthing changes the electrical characteristics of the zone substation and the network it supplies. Resonant earthing significantly reduces single phase to ground fault currents. Phase to ground voltages on the faulted phase are reduced significantly whilst phase to phase voltages remain unaffected. The neutral voltage is raised to normal phase to ground voltage and the two healthy phases have their phase to ground voltages increase to phase to phase voltage levels.

Resonant earthing is only being applied to the 22 kV network. As such the resonant earthing does not affect (or protect) the following adjacent network, namely:

- 66 kV sub-transmission system;
- 12.7 kV Single Wire Earth Return System (**SWER**);
- High Voltage (**HV**) Customers with an Isolating Transformer installed; and
- Low Voltage (**LV**) supplies.

1.1 Background

AusNet Services' network operates in a geographical location which is exposed to extreme bushfire risk. These conditions warrant significant investment to mitigate the risk of bushfires as a result of 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 a maximum I^2t value of 0.10;

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 kOhm 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.

1.2 Selected REFCL zone substations

Schedule 2 of the Amended Bushfire Mitigation Regulations lists the selected zone substations to be REFCL enabled. For AusNet Services, 22 zone substation have been selected.

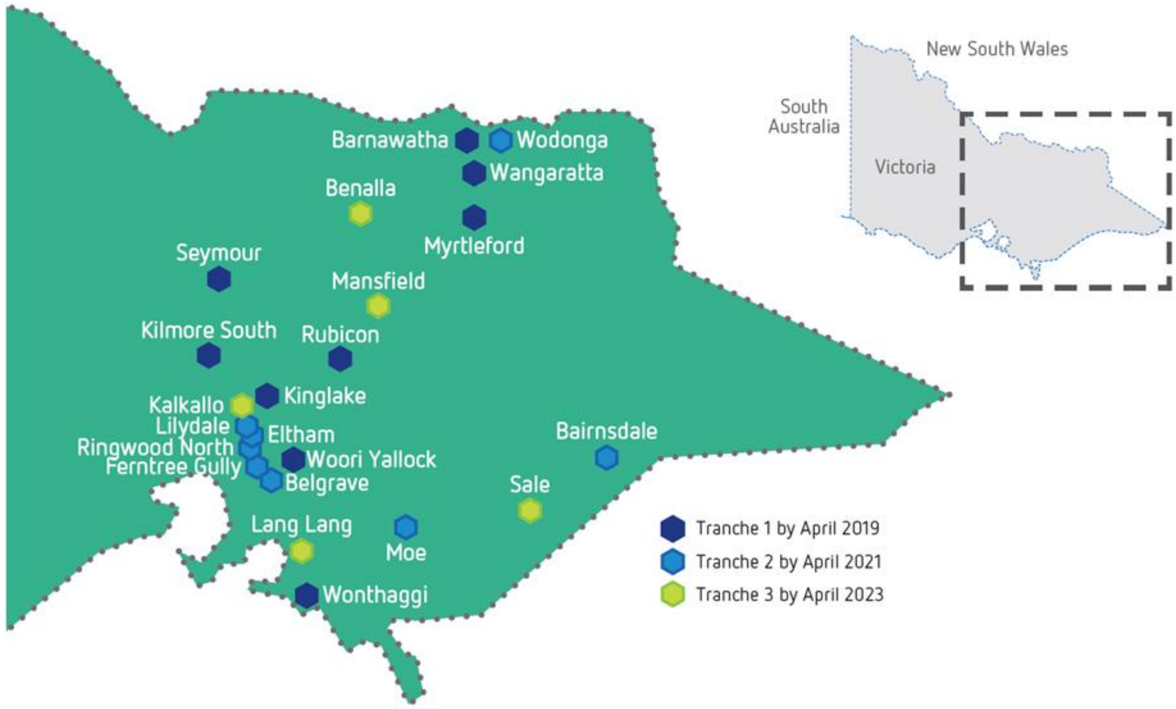
Schedule 2 assigns a number of points to each of the selected zone substations. The Amended Bushfire Mitigation Regulations require AusNet Services to ensure:

- at 1 May 2019, the points set out in Schedule 2 in relation to each zone substation upgraded, when totalled, are not less than 30;
- at 1 May 2021, the points set out in Schedule 2 in relation to each zone substation upgraded, when totalled, are not less than 55; and
- on and from 1 May 2023, each polyphase electric line originating from every AusNet Services zone substation specified in Schedule 2 has the required capacity.

AusNet Services' REFCL Program has been structured into three separate tranches in order to achieve the 'points' requirement by the mandated dates.

The following figure shows the specified zone substations by tranche.

Figure 1: AusNet Services selected REFCL Zone Substations



Source: AusNet Services

1.3 Benalla zone substation overview

The BN ZSS is included in Tranche 3 of the AusNet Services REFCL Program, situated at Mansfield Road, corner Baddaginnie-Benalla Road, Benalla which is located approximately 210 km north-east of Melbourne.

The BN ZSS was established in the 1940s and supplies approximately 12,100 customers by means of three (3) 10/13MVA transformers and five distribution feeders.

The BN electricity distribution area consists primarily of residential areas in and around the Rural City of Benalla and surrounding areas including Euroa. BN ZSS also contains long overhead rural feeders with a total network length of 1,383km.

The estimated total capacitive current of the BN 22kV network is 80.9 Amperes (**A**). As the capacitive current is below 101A, a single REFCL will be installed.

1.3.1 Key issues and challenges

The 22kV feeder, BN1, is an extremely long radial feeder that requires the installation of a tie to BN6 to maintain supply to customers during REFCL commissioning works.

Most of the outdoor switchgear (across 3 buses and 5 feeders) requires replacement to become compatible with REFCLs operations. Upgrading the outdoor switchgear is not a viable option as it would result in major outages and customer disruptions.

The existing site control room is unsuitable for the installation of the REFCL technology and the associated 22 kV protection equipment. Refer to section 2.2.4 of this functional scope document for an overview of the site control room options analysis.

1.4 BN ZSS assets

The following table provides an overview of the current assets located at the BN ZSS.

Table 1: BN Zone Substation – current assets

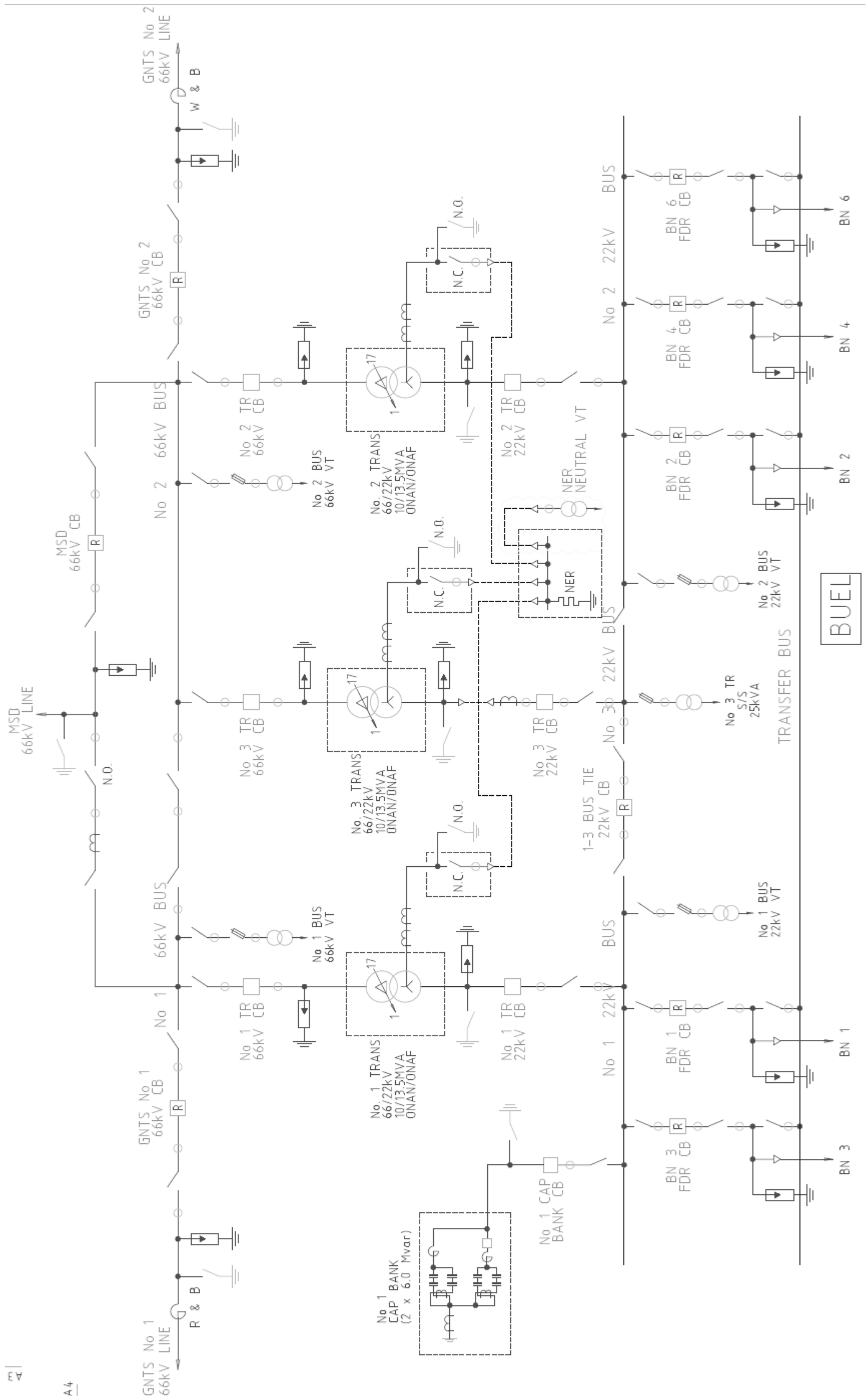
Zone Substation	Details
Location	210 km north east of Melbourne
Established	1940s
Supply Area	Rural City of Benalla and surrounding areas including Euroa
Customers	12,134
Zone Substation transformers	3 x 10/13MVA
22 kV Buses	3 (plus transfer bus)
Capacitor Banks	No.1 (2x 6Mvar)
Feeders	5
Station services transformers	1 x 25 kVA (22/0.415kV)
Schedule 2 points allocation	2

Source: AusNet Services

1.5 BN ZSS single line diagram

The following figure represents the current single line diagram of the BN ZSS.

Figure 2: BN Current Single Line Diagram



Source: AusNet Services

1.6 BN 22kV network

The following table provides an overview of the 22kV network originating from the BN ZSS.

Table 2: BN 22kV Network – current configuration[1]

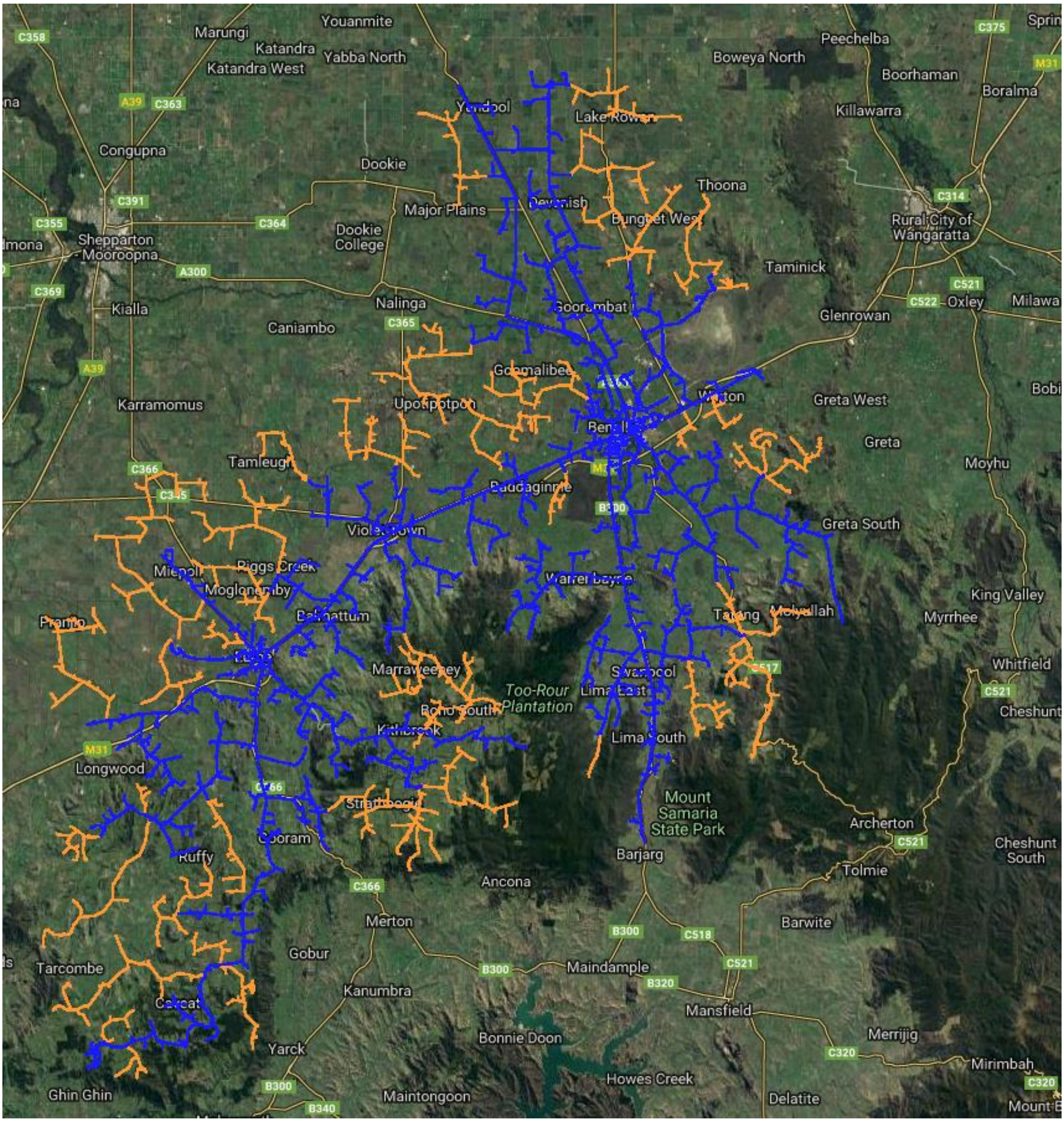
Network	Details
Total Network Length (km)	1,383.1
Aerial Bundled Cable (**ABC**) Length (km)	0.0
Underground (**U/G**) 3 phase (**ph**) Cable Length (km)	12.0
U/G 1ph Cable Length (km)	0.0
Overhead 3ph Line Length (km)	455.7
Overhead 1ph Line Length (km)	915.4
Estimated network capacitance (Amps (**A**))	80.9
HV Customer Connections	2
Automatic Circuit Reclosers (**ACRs**)	18
Sectionalisers	18
HV Regulator sites	5
Surge Arrestor Sites	2,757

Source: AusNet Services

1 Not including SWER or Transfer feeders

The following figure shows an aerial view of the 22kV feeders originating from the BN ZSS.

Figure 2: BN 22kV feeders shown in blue (SWER lines in yellow)



Source: AusNet Services

2 Zone substation requirements

The successful implementation of resonant earthing requires a number of changes at the zone substation including the installation of the resonant earthing equipment, installation of supporting infrastructure and replacement of equipment that cannot handle the elevated voltages introduced by the transition to resonant earthing.

The scope of works for the installation of REFCL equipment, supporting infrastructure and asset hardening at the BN ZSS is summarised in the following sections of this functional scope document.

2.1 Primary systems

2.1.1 REFCL Equipment

Taking into account the network size, dissymmetry and damping originating from the BN ZSS, only one (1) Arc Suppression Coil (**ASC**) is required to be installed at BN ZSS. [2]

- Installation of one (1) Ground Fault Neutraliser (**GFN**) primary equipment, including:
  - One (1) ASC;
  - One (1) Residual Current Compensator Inverter (**RCC**); and
  - One (1) Grid Balancing Unit.

2.1.2 Neutral Bus

A neutral bus system must be installed to control the neutral earthing arrangements allowing change of operational mode during fault management. [3]

- Installation of two (2) Neutral Bus kiosks.

2.1.3 Primary Cables

- Replacement of the existing five (5) 22kV exit feeder cables (1228m) with 3C 300 mm^2, AL XLPE. The existing cables are condition C5 with install dates prior to 1986, therefore these cables cannot withstand the elevated voltages imposed by the operation of REFCL.
  - Replacement of 143m of existing C5 exit feeder cable supplying BN6;
  - Replacement of 200.3m of existing C5 exit feeder cable supplying BN4;
  - Replacement of 338.6m of existing C5 exit feeder cable supplying BN2;
  - Replacement of 66.2m of existing C5 exit feeder cable supplying BN1;
  - Installation of 200m of 3C, 300mm^2, Al XLPE for BN1 to BN6 feeder tie to maintain supply to BN1 during commissioning (no back-feed currently);
  - Replacement of 280m of existing C5 exit feeder cable supplying BN3; and
  - Replacement of five (5) terminations on the feeder exit cables.
- Replacement of 22kV cable (6 x 500mm^2 IC CU) from:
  - No.2 Transformer to No.2 22kV Switchboard (300m);
  - No.3 Transformer to No.2 22kV Switchboard (300m).

[2] For further information on the ARC sizing refer to REF 30-04 REFCL Program Arc Suppression Coil Sizing Policy

[3] For further information refer to REF 30-16 REFCL Program Operating Modes Policy

    - No.1 Transformer to No.1 22kV Switchboard (300m); and
    - No.3 Transformer to No.1 22kV Switchboard (300m).
- Installation of the following 22kV 3C 185 mm^2, AL XLPE, from:
    - No.1 Station Service Transformer to Switchboard (50m); and
    - No.2 Station Service Transformer to Switchboard (80m).
- Installation of the following single core 185 mm^2, AL XLPE 22 kV neutral cables, from:
    - No. 1 Transformer neutral isolator to No. 1 Neutral Bus kiosk (50m);
    - No. 2 Transformer neutral isolator to No. 1 Neutral Bus kiosk (70m);
    - No. 3 Transformer neutral isolator to No. 2 Neutral Bus kiosk (80m);
    - No. 1 GFN to No. 1 Neutral Bus kiosk (20m);
    - No. 1 NER to No. 1 Neutral Bus kiosk (60m);
    - No. 1 Neutral Bus kiosk to No.2 Neutral Bus Kiosk (20m); and
    - Replacement of Cap Bank cable 185mm2 Al XLPE (150m).

2.1.4 Circuit Breakers and isolators

- Replacement of the existing outdoor insulated 22kV switchgear and all associated equipment with two (2) new 22kV indoor switchboards. Refer to section 2.2.4 of this document for an overview of the options analysis.

2.1.5 Station Service Transformers

The existing 25 kVA Station Service 22/0.415 kV transformer does not have adequate rating to supply the RCC during fault compensation and must be replaced with a suitably rated transformer.

- Installation of two (2) 750 kVA (22/0.415V) transformers; and
- Removal of the existing Station Service Transformer.

2.1.6 AC Supplies

The existing AC supply boards cannot supply the current required by the RCC and handle the fault level introduced by the new station service transformer.

- Installation of one (1) AC 415V REFCL change over board rated for 750 kVA and suitable for the REFCL equipment.
- Installation of one (1) AC 415V station services change over board rated for 750kVA and suitable to supply the station AC supplies.

2.1.7 Surge Arrestors

The existing surge arrestor units are not suitable for operation with the voltages imposed by REFCL operations.

- Replacement of twelve (12) 22kV surge arrestors within the zone substation for the following:
    - Nine (9) 22kV transformers surge arrestors (3 for each Transformer); and
    - Three (3) single phase surge arrestors for the neutral structures for the transformers due to various scenarios leading to excessive overvoltage at the neutral point.

2.1.8 Instrument Transformers

Current Transformers (CTs)

- Replace six (6) Supply transformer CTs (2 per Transformer) due to the condition and the incompatibility with REFCL operations.

Zero Sequence CTs

Zero Sequence (Core Balance) CTs are required to measure the individual imbalance on each feeder and any change in balance due to network modification or switching.

- Installation of a zero sequence CT on each feeder exit; five (5) feeder exits, plus one on the Cap Bank and one for each station service transformer, totalling eight (8) in number.

2.1.9 22 kV Cabling Tests

22 kV transformers, capacitors and feeder exit cables are critical assets within the zone substation, failures in service may result in significant customer outages. To minimise this likelihood of failure, offline cable testing is to be undertaken and any issues identified will be addressed.

Transformer tests including partial discharge (**PD**) testing, power transformer condition monitoring test and REFCL operational test on each transformer (there are 3 x power transformers) and one (1) Circuit Breaker test on the existing Sumitomo 1-3 Bus tie.

If testing identifies any issues, it is likely to result in full cable replacements due to the short lengths of these cables.

Offline partial discharge and high potential tests are required to be performed on the following cables:

- BN1 Feeder exit cable once replaced;
- BN2 Feeder exit cable once replaced;
- BN3 Feeder exit cable once replaced;
- BN4 Feeder exit cable once replaced;
- BN6 Feeder exit cable once replaced;
- No. 1 Transformer 22 kV cables;
- No. 2 Transformer 22 kV cables;
- No. 3 Transformer 22 kV cables; and
- No. 1 Capacitor Bank cable;

2.1.10 Capacitor Banks

The existing Capacitor Bank is 2 x 6.0 MVAr stepped grounded star arrangement. The existing Capacitor Bank will be modified to achieve an ungrounded star arrangement.

- Replacement of two (2) 6MVAr capacitor bank reactors; and
- Replacement of five (5) insulators at the base of the Capacitor Bank Reactors.

2.1.11 Neutral Earthing Resistor (NER)

- Replacement of one (1) NER.

2.1.12 Earth Grid Design

- The existing earth grid design shall be reviewed to ensure the earthing system will continue to adequately protect personnel, plant and the public post the introduction of resonant earthing.

2.2 Civil infrastructure

A number of civil infrastructure installations and modifications are required to support the REFCL installation.

2.2.1 ASC

- Installation of one (1) footing, neutral cable conduit and oil bunds.

2.2.2 Station Service Transformer

- Installation of two (2) footings, cable conduits.

2.2.3 Neutral Bus

- Installation of two (2) footings, cable conduits.

2.2.4 REFCL control room

- The existing site control room at the BN ZSS is very compact and does not have the physical space for the required installation of REFCL technology, namely the RCC unit, REFCL control panels, protection and communications updates and modifications and network monitoring and switchgear interface relays.
- Options considered included:
  - Do nothing
  - Installation of two new modular urban type rooms in addition to one (1) REFCL room and one (1) Control Room.
  - Installation of one (1) tilt slab building to house the new switchboard and all other REFCL equipment. (Note: No REFCL or control room is needed for this option)

The do nothing option does not allow the installation of REFCL technology at BN and therefore does not meet the requirements of the regulations.

The installation of two modular urban buildings, along with a REFCL room and a new control room meets the one GFN requirement for the BN ZSS, however this presents challenges with space. Therefore, the preferred option is to install one tilt slab building which can house the REFCL equipment and the new 22kV switchboard.

The following civil items are required to deliver this option.

- Design, construction, delivery and installation of one (1) tilt slab building for the REFCL equipment and the new 22kV switchboard.
- Temporary security during delivery and installation.
- Provision for chipping to be laid throughout the yard to prevent dust on the outdoor equipment.

2.2.5 Cable trench

- Installation of additional cable trenches for connection from the existing cable trench system to the following locations (allowance of 50m):
  - REFCL control room;
  - ASCs;
  - Neutral Buses;
  - New Station Service Transformers; and
  - Feeder exit cables.

2.2.6 Earth Grid

- Extension of the earth grid to protect the REFCL control room, ASCs, Neutral Buses, Station Service Transformers and other installed equipment as required.

2.2.7 Switchyard Surfacing

- Restoration of the disturbed switchyard surfaces.

2.2.8 NER

- Install one (1) footing for new NER

2.2.9 Lighting

- Produce lighting design and establish outdoor switchyard lighting to relevant standard.

2.3 Secondary systems

A number of secondary systems need to be added or modified to support the installation of REFCL equipment at the station.

2.3.1 GFN Control System

The GFN vendor will install a free issued GE C30 relay RUGGEDCOM Ethernet switch and C-VT410 Voltage transformer (110V/63.5V 25VA Class1enclosed multi tapped with ratios 36V, 48V, 63.5V and 110V for the Auxiliary VT push button test circuit) to allow AusNet Services control the operational mode of the GFN system.

- Installation of one (1) GFN control system panel as part of the GFN product; and
- GE C30 relays, RUGGEDCOM RSG2488 Ethernet Switches and Auxiliary VT push button test circuit transformers (1 per GFN) shall be free issued for installation in their GFN control system panels.

2.3.2 Neutral Control System

- Installation of two (2) neutral bus interface control system panel including:
  - No. 1 Neutral Bus X ABB REF630 controller relay; and
  - No. 1 Neutral Bus Y GE30 controller relay.

2.3.3 Fault Recording and Switchgear Interface Panels

Fault location and diagnosis can be significantly more difficult with resonant earthed networks.

To assist with GFN commissioning, annual compliance testing and fault investigation activities, additional network monitoring relays must be installed to capture bus voltage, neutral voltage and bus current waveforms.

To interface status and control signal wiring between the switchgear and the GFN system, one (1) control relays is required per 22 kV bus.

- Installation of two (2) network monitoring and switchgear interface panels. Each panel includes:
  - 2 x ELSPEC Network Monitoring relays; and
  - 1 x GE C30 control relay.

2.3.4 Protection Systems

Protection review required for transformers, feeders, Master Earth Fault (**MEF**) & Back Up Earth Fault (**BUEF**), Bus and 66/22 supply transformers addressing protection sensitivity, settings and time grading between stages when NER is in service;

- 66kV CB failure protection is required if the distance protection settings review comes up short;

Standard protection and control schemes may require modifications to suit specific site conditions. Any such modification should be carried out in consultation with Technical Standards and Services.

Transformer Protection

- Replacement of three (3) Transformer X and Y protection relays due to incompatibility with REFCL operations.
- Replacement of two (2) VRR controls due to incompatibility with REFCL operations.

Feeder Protection

The existing feeder protection is not compatible with the GFN system.

- Install five (5) feeder protection relays with ABB REF630 relays.

Station Master Earth Fault (MEF), Backup Earth Fault (BUEF) and PQM

- The existing REF630 Master Earth Fault relay is not suitable and will require a firmware upgrade and wiring changes; and
- Replacement of one (1) Back Up Earth Fault relay and one (1) Power Quality Meter (**PQM**) as the existing are not compatible with the GFN operations.

Bus Protection

The existing bus protection is not compatible with the GFN system.

- Replacement of four (4) X and Y bus protection relays.

Battery Systems

- Installation of additional batteries to allow for the REFCL equipment operations.

Capacitor bank protection and control

- Replace one (1) capacitor bank Relay (F650) with a standard REF (630) for REFCL compatibility.

2.3.5 Communications

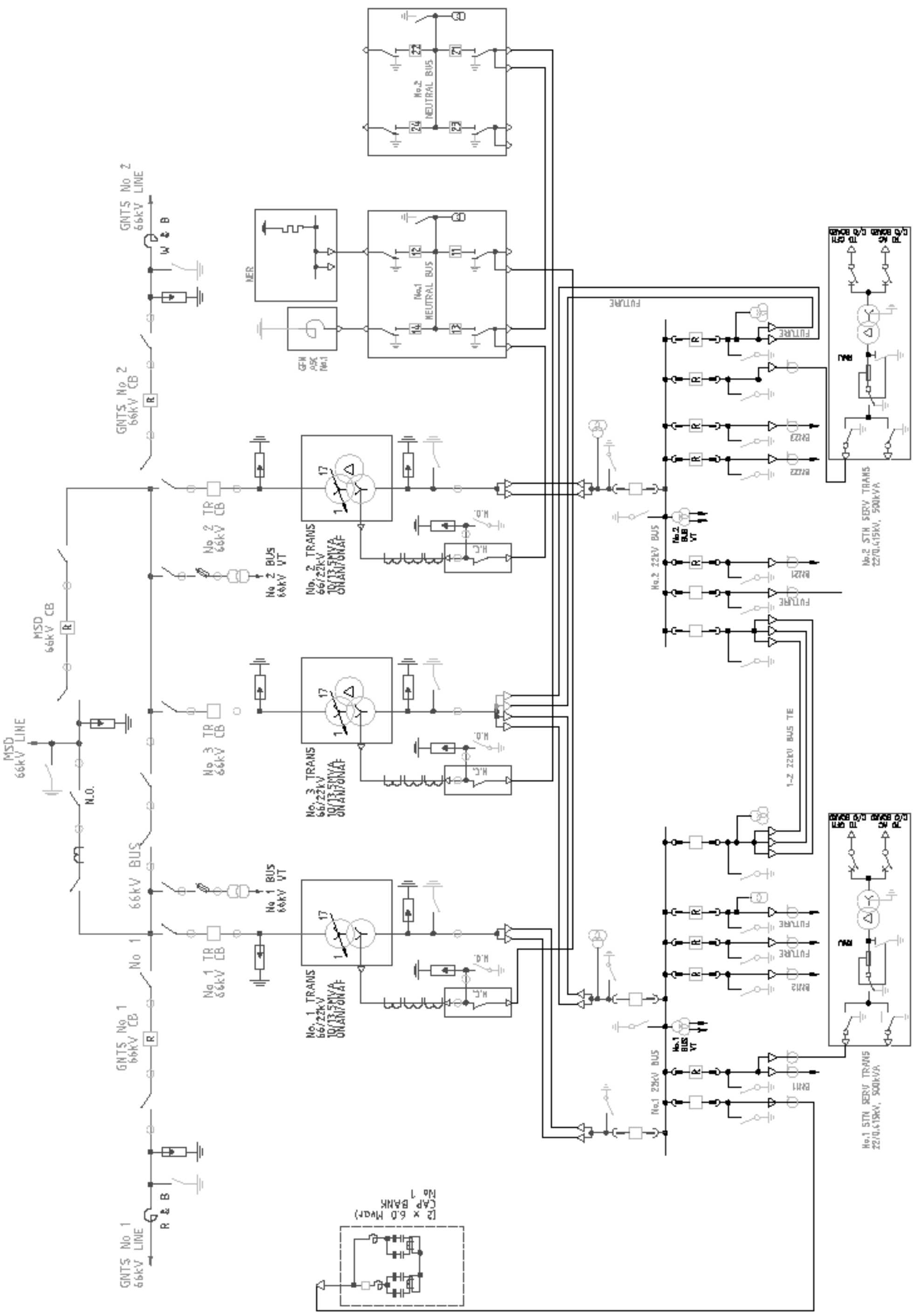
The new equipment in the REFCL control room requires connection to the existing Digital Interface Cubicle (**DIC**).

- Upgrade tele-protection equipment and communications:
- Install 1x RS2488 switch;
- Install 1x 2488 clock;
- Install one (1) HMI; and
- SCADA modifications.

2.4 BN proposed single line diagram

The following figure represents the proposed single line diagram of the BN ZSS following the installation of the GFN and associated compatible equipment.

Figure 3: BN proposed single line diagram



Source: AusNet Services

3 22 kV distribution feeder requirements

The suitability of the assets on the feeders supplied by a REFCL equipped zone substation is critical to ensure successful operation of the technology without undue reliability or safety consequences.

These assets must be able to sustain the additional phase to ground voltage stress introduced by the REFCL technology, be balanced with regards to capacitance to ensure the REFCL technology works at the regulated performance levels and operate normally during REFCL fault compensation.

To achieve these outcomes, three programs address equipment that does not meet the above criteria, namely:

- Network hardening;
- Capacitive balancing; and
- Compatible equipment.

Additionally, customers connected directly to the 22 kV supply network need to ensure their electricity assets can withstand REFCL voltages. If the HV customer assets are not hardened to withstand REFCL voltages, they must be isolated from the REFCL protected network.

3.1 Network hardening

Operation of resonant earthing, on which the REFCL technology is based, introduces periods of increased phase to ground voltages.

This increased voltage can cause issues for existing assets specified for a solidly grounded operational profile.

AusNet Services has assessed its assets and determined that network assets most impacted by the increased voltages are:

- Surge arrestors; and
- High Voltage (**HV**) cables.

3.1.1 Surge arrestors

Surge arrestors are a voltage dependent resistor designed to begin to conduct as the voltage increases to supress very short duration overvoltage such as those associated with lightning strikes. In doing this, they absorb energy whilst the voltage is higher. If not rated suitably, surge arrestors may overheat and fail during REFCL operation, potentially obstructing the effectiveness of the REFCL in limiting the fault current.

AusNet Services has tested each type of surge arrester installed on its networks to determine the suitability of each type for REFCL protected networks.[4] To determine the volumes for the BN network each surge arrestor site was inspected and the surge arrestor types installed confirmed to determine replacement requirements.

At BN, the following surge arrestors need to be addressed.

[4] For further information, refer to REF 20-07 REFCL Program Line Hardening Strategy.

Table 3: BN surge arrestor replacement volumes

Sites	Units
682	1559

Source: AusNet Services

3.1.2 HV Cables

Insulated HV cables are susceptible to failure resulting from damage that can occur during operation at higher voltages. Periods of operation at higher voltage can cause immediate failure or initiate partial discharge that can continue to damage the cable after voltages have returned to normal. Premature cable failure can occur in the subsequent hours or days after the initiating overvoltage occurred.[5]

AusNet Services i utilises offline testing for critical backbone portions of the feeder to identify cables requiring repair or replacement. A review of the cables database has been undertaken and cable failures and test results from REFCL tranche 1 and 2 investigations have been utilised to forecast the likely proportion of cables that will need to be tested and replaced for Tranche 3.

Due to the construction and expansion of the Hume Highway during the 1980s, AusNet Services undergrounded long segments of 22kV overhead power lines that crossed over the Hume Highway to make way for an oversized vehicle route. These works resulted in a large portion of HV cables (steamed cured XLPE) on the BN network with manufacture dates prior to 1986 (approximately 20%). Experience gained in Tranche 1 and 2 showed these cables are likely to fail when exposed to elevated voltages and therefore will be proactively replaced.

Table 4: BN HV cable testing, repair and replacement volumes

Online tests	Offline tests	Repair Cable	Replace Cable
8	8	6	2,774m

Source: AusNet Services

3.1.3 Other Assets

Other asset classes may exhibit issues with the voltages introduced by operation of REFCL technology and will be replaced when they fail as it is impractical to proactively identify which ones may fail. The most common items are:

- Distribution transformers; and
- Line insulators – especially in areas on the coast where salt contamination can cause current tracking to ground failures at REFCL voltages

From previous stress testing, AusNet Services has not experienced extensive failures of other distribution assets excluding cables and HV Aerial Bundled Cable (**ABC**) addressed in section 3.1.2. AusNet Services does not anticipate failures of other assets.

[5] For further information, refer to REF 20-07 REFCL Program Line Hardening Strategy

3.2 Capacitive balancing

Capacitive balance is a key enabler of achieving the performance requirements of the Amended Bushfire Mitigation Regulations. Neutral voltage caused by capacitive imbalance decreases the sensitivity of the REFCL technology.[6]

A number of balancing activities are required to achieve the necessary capacitive balance level including:

- Installation of a 3rd conductor on single phase spurs where only a few spans are required;
- Conversion of single phase cable spurs to three (3) phase by connecting the 3rd phase;
- Phase rotations of single phase spurs;
- Installation of single phase capacitor banks at the beginning of single phase spurs;
- Installation of 3 phase capacitor banks for each automatically switchable section; and
- Removal of fuses on network segments with excessive capacitive current as single phase fuse operation will cause excessive imbalance causing the GFN to trip the feeder. Therefore, to solve the excessive imbalance, it is essential AusNet Services remove the existing fuses and replace the fuse elements with solid links and to install fuse savers where required for network protection.

The BN network is a long network and it has a number of automatic switching sections to provide reliability in the areas it serves.

This necessitates an increased quantum of balancing activities. Network data has been analysed to identify the material sources of imbalance and the optimal mixture of balancing works to achieve the necessary level of capacitive balance for the BN network.

Table 5: BN network capacitive balancing volumes

Spans of 3rd phase	Unbonded 3rd phase (cable)	Single phase spur phase rotations	Single phase balancing capacitors	Three phase balancing capacitors	Solid links	Fuse Saver Sites
18	0	57	17	20	29	27

Source: AusNet Services

3.3 Compatible equipment

Some existing network equipment is incompatible with the operation of REFCL technology. This equipment includes:

- Automatic Circuit Reclosers (**ACRs**);
- Sectionalisers;
- HV voltage regulators.

3.3.1 ACRs

Existing ACRs have non-directional fault detection and may 'mal' operate during REFCL operation due to the capacitive charge flowing back through healthy parts of the network to the fault.

[6] For further information, refer to REF 20-06 REFCL Program Network Balancing Strategy

Replacement ACRs have VTs installed to determine when the REFCL is displacing the neutral voltage and supress tripping for reverse fault current direction. [7]

Existing ACRs require upgrades or replacement to operate successfully with REFCL technology.

Each ACR on the BN network has been identified from network data and its type confirmed through protection setting data to determine whether it can be upgraded or must be replaced.

The general Distribution Feeder Automation (**DFA**) and sectionaliser algorithm will require an ACR or equivalent to be present at key points on each feeder to allow the DFA/Sectionalisers to locate a fault with the GFN in service. Without these additional devices the DFA/Sectionaliser algorithm will not be able to identify which feeder is faulted. As a result, one (1) additional ACR is required to be installed on the BN network.

Furthermore, as part of the fuse review detailed above in section 3.2, additional ACRs are required as a least cost alternative to the replacement of many fuse sites within a network segment and utilising the much larger protection coverage of the ACR. There is also considerable labour cost savings to be gained from adapting this method. As a result, two (2) additional ACRs are required to be installed on the BN network.

Table 6: BN ACR upgrade, installation and replacement volumes

Additional	Upgrade	Replacement
3	5	9

Source: AusNet Services

3.3.2 Sectionalisers

Existing sectionalisers, that are a key part of AusNet Service's DFA Scheme to provide customer reliability benefits, do not have high accuracy CTs that are compatible with the low fault currents that the REFCL introduces.[8]

Existing sectionalisers require replacement to operate successfully with REFCL technology.

On the BN network, there are a number of automatic switchable sections involving sectionalisers to ensure a reliable service for the customers served. Each sectionaliser on the BN network has been identified from network data and individually confirmed as non-compliant with REFCL requirements.

Table 7: BN Sectionaliser update and replacement volumes

Upgrade	Replacement
0	18

Source: AusNet Services

3.3.3 HV voltage regulators

Some HV voltage regulators have individual phase voltage tap controls. These controllers are not compatible with REFCL operation as they may try to tap voltages whilst the REFCL is compensating and introduce further imbalance reducing the effectiveness of the REFCL. [9]

The BN network has no HV voltage regulators requiring works to be compatible with REFCL operations.

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7 For further information, refer to REF 20-08 REFCL Program Automatic Circuit Recloser Strategy

8 For further information, refer to REF 20-13 REFCL Program Distribution Feeder Automation (DFA) Strategy

9 For further information, refer to REF 20-09 REFCL Program Line Voltage Regulator Strategy

3.4 HV customers

HV customers are connected directly to the 22 kV network rather than the Low Voltage (**LV**) networks and are therefore impacted by the increased voltages introduced by the REFCL technology. This can cause issues for customers including:

- requirements to harden their equipment to withstand the increased voltages;
- updates to protection equipment and settings; and
- interruption to the customer's business operation.

In some cases, it may be more economical to isolate the customer from the REFCL voltage profiles rather than address each of the issues listed above.

The dedicated REFCL Program HV Customer Lead has proactively engaged with impacted HV customers to share the learnings from Tranche 1 and to provide guidance on the most appropriate solution for the HV electrical assets to either be harden to withstand, or isolated from, REFCL operations.

3.4.1 HV customers serviced by the BN network

There are two HV customers on the BN network:

- one (1) HV customer supplied by BN2; and
- One (1) HV customer supplied by BN3.

The HV Customers have been requested to be ready for REFCL operations by 30 June 2022.

AusNet Services will install an ACR at each HV Customers connection point. An ACR is necessary because it will enable AusNet Services to operate our network safely:

- The ACR can help reduce the impact cross-country faults have on the 22kV network;
- The ACR provides an isolation point that stops supply into the customer site. This is a safe guard in the event that a HV customer's site fails under REFCL conditions;
- ACRs assist AusNet Services to identify fault locations promptly so that we can take the appropriate safety action; and
- Reliability – the ACR will allow the network to quickly isolate a faulted HV customer and restore power quickly to unaffected customers once the fault is resolved.

4 Proposed Site Plan

The following figures provide an aerial view of the current BN ZSS with the proposed sites of the new REFCL-related assets and control room.

Figure 5: Aerial view of the BN ZSS

Source: AusNet Services

5 Referenced Documents

Supporting documents referenced in this document:

- REF 20-06 REFCL Program Network Balancing Strategy
- REF 20-07 REFCL Program Line Hardening Strategy
- REF 20-08 REFCL Program Automatic Circuit Recloser Strategy
- REF 20-09 REFCL Program Voltage Regulator Strategy
- REF 20-13 REFCL Program Distribution Feeder Automation Strategy
- REF 30-04 REFCL Program Arc Suppression Coil Sizing Policy
- REF 30-16 REFCL Program Operating Modes Policy