CITIPOWER	**ELECTRICITY NETWORKS** **Asset Strategy and Performance** **Functional Scope**	Powercor AUSTRALIA

Functional Scope Created	**02-06-2017**	**By**	Danny Jutrisa		
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Related Scopes					
Project Engineer					
System Planning Engineer	Danny Jutrisa				
Protection and Control Engineer	Amy Satkunalingam				
Plant and Stations Engineer					
Asset Strategy Engineer					
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Version	Date	Changes	Responsible Officer
1.0	02/06/2017	Original	D.Jutrisa
1.1	06/06/2017	Secondary system works included	A Satkunalingam
1.2	27/07/2017	Reviewed balancing unit and auto-changeover requirements.	V.Hadya
1.3	26/10/2017	Revised the feeder rearrangement works	D.Jutrisa

1 Project overview

This project scope covers the migration of the Ballarat South zone substation (**BAS**) system to a resonant earthed network. Migration to a resonant network requires the installation and operation of a ground fault neutraliser (**GFN**). This changes the electrical operating characteristics of a zone substation and its distribution network as follows:

- full voltage displacement occurs on the system for operation of the GFN
- this significantly stresses equipment on the system and may lead to failure
- this equipment has been identified and included in this scope for replacement as part of the GFN installation
- other limitations will dictate part of the operational protocols that will be developed by Electricity Networks.

The GFN provides potential benefits to single-phase-to-ground faults on the 22kV three phase system. It provides no benefit on the following:

- the 12.7kV Single Wire Return System (**SWER**)
- the 66kV sub-transmission system
- the low voltage (**LV**) system.

1.1 Background

The Victorian Government has introduced changes to the Bushfire Mitigation Regulations that require distribution businesses with high voltage (**HV**) overhead assets in high bushfire consequence areas to meet new performance standards for detection and limiting of arc fault energy. These standards can only be achieved using rapid earth fault current limiters (**REFCLs**).

A REFCL is a network protection device, normally installed in zone substations that significantly reduce the arc fault energy generated during a phase to ground fault. The reduction in arc fault energy can be so effective that earth fault fire ignition on 22kV three phase networks is almost eliminated.

The Bushfire Mitigation Regulations mandate that REFCLs must provide the required capacity—required capacity means, in the event of a phase-to-ground fault on a polyphase electric line, the ability:

- to reduce the voltage on the faulted conductor in relation to the station earth when measured at the corresponding zone substation for high impedance faults to 250 volts within 2 seconds
- to reduce the voltage on the faulted conductor in relation to the station earth when measured at the corresponding zone substation for low impedance faults to:
  - 1900 volts within 85 milliseconds
  - 750 volts within 500 milliseconds
  - 250 volts within 2 seconds
- during diagnostic tests for high impedance faults, to limit:
  - fault current to 0.5 amps or less
  - the thermal energy on the electric line to a maximum I^2t value of 0.10

  where:

- high impedance faults means a resistance value in ohms that is equal to twice the nominal phase-to-ground network voltage in volts
- I^2t means a measure of the thermal energy associated with the current flow, where I is the current flow in amps and t is the duration of current flow in seconds

- low impedance faults means a resistance value in ohms that is equal to the nominal phase-to-ground network voltage in volts divided by 31.75
- polyphase electric line means an electric line comprised of more than one phase of electricity with a nominal voltage between 1 kV and 22 kV.

1.2 Ballarat South zone substation

The Ballarat South 66/22kV zone substation is a switched station consisting of two 20/27/33 and one 25/33 MVA transformers and a total of 15MVAr capacitor banks. It was established in 1971 and supplies nine distribution feeders which supply the southern part of Ballarat as well as area south and west of Ballarat such as Skipton and Beaufort.

Table 1 BAS: existing characteristics (zone substation)

Zone substation	Volume
Feeders	9
Zone substation transformers	3
22kV buses	3
Capacitor banks	2
Station service transformers	2
22kV circuit breakers (switching configuration)	14 (fully switched)

Table 2 BAS: existing characteristics (network)

Network	Volume
Total route length (km)	1365
Underground cable length (km)	71
Overhead line length (km)	1294
Underground network (%)	5.2
Overhead single phase	686
Estimated network capacitance (A)	280
Distribution transformers	4653
HV regulator sites	24
Fuses	3551

Network	Volume
ACRs	20
Surge arrestor sites	1,906
HV customers	4

2 ZSS requirements

This functional scope sets out the BAS zone substation requirements, including the following:

- establish ASC bunds for three (3) REFCLs
- installation of three (3) Swedish Neutral GFN Arc Suppression Coils
- modification of the 66/22kV transformer earthing arrangement
  - installation of transformer neutral isolators and direct earth switches
  - installation of 19kV surge diverters on transformer neutrals
  - installation of neutral bus systems
    - bus CB's
    - NER terminations
    - ASC terminations
    - neutral VT installation
- upgrade existing station service supply to two (2) new 750kVA kiosk transformers with changeover board
- upgrade of the station service supply cabling and installation of new AC distribution board
  - Install current limiting fuses on AC distribution boards
- replace existing three (3) 22kV VTs with three (3) new 22kV VTs
- replace ALL substation surge arrestors with new 22kV continuous voltage units for resonant network compatibility and 10hr 24kV TOV capability
- installation of neutral bus management relay
  - adoption of existing MEF function
  - neutral voltage supervision
  - neutral bus CB management functions
- installation of Station Earth Fault Management control relay
  - GFN Interface control
  - operating mode management
- install and commission three (3) GFN control and three (3) RCC inverter cubicles
- review and modify secondary systems to accommodate split bus arrangement
  - install new independent transformer and voltage control schemes
- modification of existing No.1 Capacitor Bank
  - remove HV earth from star point
  - install new Current Balance protection
- install new station HMI
- modify existing backup earth fault protection scheme
- install two (2) new Elspec Power Quality Meter
- install two (2) new ION7350 Power Quality meters

- extend station yard and earth grid as required to accommodate ASC
- install weather station

2.1 Primary plant requirements

The works associated with the installation of the BAS ASC and NER arrangement is summarised in the following single line diagram.

Figure 1 BAS single line diagram

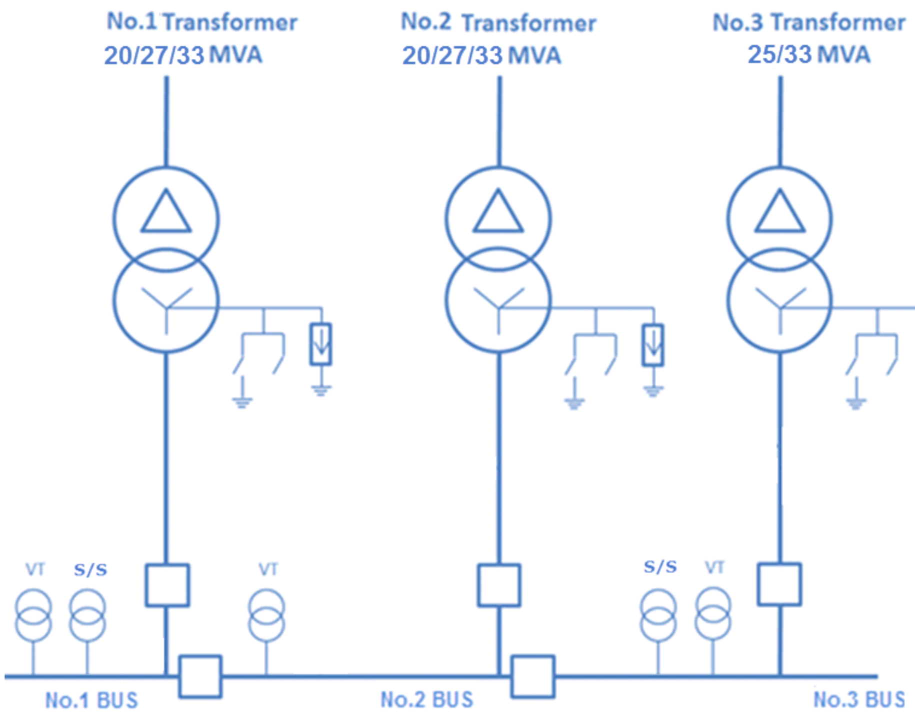
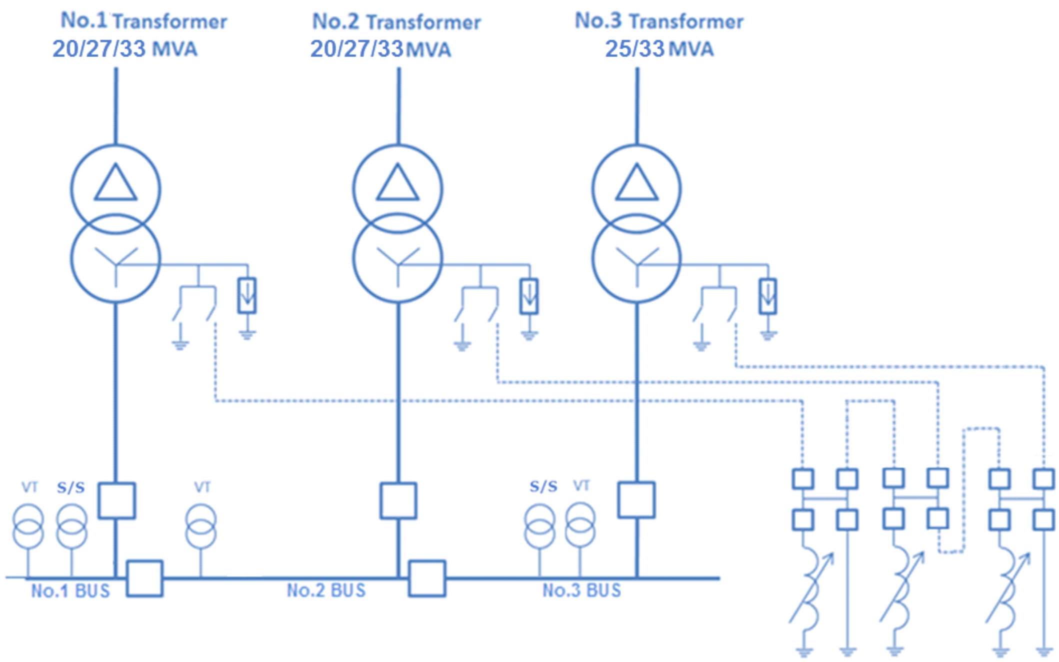


Figure 2 BAS proposed ASC Arrangement



2.1.1 Arc suppression coil

Install 3 (3x) Swedish Neutral – Ground Fault Neutraliser's Arc Suppression Coil (ASC) component. The arc suppression coil is a paper wound copper coil wrapped around a solid iron core and immersed in oil. This arc suppression coil is of fixed reluctance but contains an array of capacitors in parallel that are switch as part of the tuning process of the coil. The coil also features an LV winding for coupling of these capacitors and the Residual Current Compensator.

Primary neutral and earth connections are via elbows.

As oil filled device, it shall be installed in a bunded area in accordance with current standards. The total volume of oil will be made available once the coil size has been confirmed.

The GFN ASC shall be installed in the location of the existing capacitor bank.

- install Ground Fault Neutraliser comprising of 3x 200A ASC and residual current compensation modules with maximum available tuning steps onto the provided pad mount within a newly established bunded area
- the footing of the ASC shall reside on the installed 150mm steel beams fixed to the concrete pad
- install cable connections to and from the Neutral System.

2.1.2 Zone substation surge arrestors

The operating principle of the GFN uses a tuned reactance to choke fault current in the event of a single-phase-to-ground fault. As a result, displacement of the line-to-ground voltage occurs in the healthy phases. Whilst line-to-line voltages remain at 22kV, the line-to-ground voltage rises to 22kV, phase-to-ground, on the two healthy phase's subsequently stressing substation and distribution equipment. In the case of surge diverters, this displacement cannot be tolerated and as such the diverters require replacement.

To accommodate the GFN installation:

- replace all sub-standard zone substation surge arresters with a station class 22kV continuous voltage arrestor
- install station class 19kV surge arresters across the transformer neutrals.

2.1.3 Zone substation capacitor bank

The existing No.2 22kV Capacitor Bank is connected in grounded star. The Capacitor Bank also requires modification works to take it from a grounded star connection to an ungrounded star with an insulation rating of not less than 13kV. In addition to this, neutral balance CT's required replacement to ensure that current balance protection could be installed.

To facilitate GFN installation, the earth must be removed from this Capacitor Bank:

- the neutral structure shall be modified such that the earth connection be removed and the neutral point floating with a continuous insulation rating of not less than 13kV
- install voltage protection (surge diverters) as per WND REFCL project.
- remove the Cap Bank Neutral CTs.

2.1.4 Neutral system arrangement

A new kiosk type ground mounted Neutral Bus system shall be installed for each transformer neutral connection. The neutral bus system allows for integration of the ASC, a potential NER with bypass or direct earth onto the transformer neutral. In the case of BAS, connecting the bus systems in series allows for common and split 22kV bus operation.

Neutral Bus system shall be installed in the location east of the existing Bus 1.

The purpose of this arrangement is to provide a simple switching configuration that offers the following combinations within one kit:

- Solid grounding

- ASC in service (NER CB Open) on a common bus
- ASC in service (NER CB open) on a split bus (Bus Tie Open)
- install 3 x Neutral Bus Modules – alongside the Arc Suppression Coils.

Neutral Bus

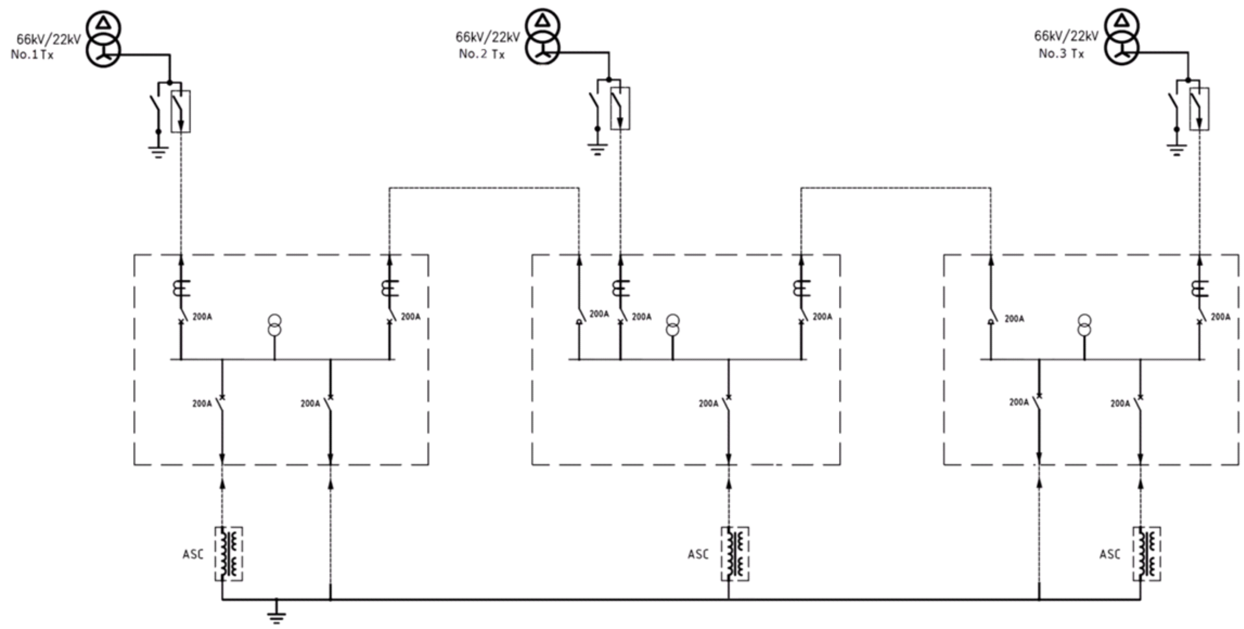
The connection to the Neutral Bus module shall be via elbow connections. Four (4) elbows are required per module for:

- transformer neutral connection
- ASC connection
- NER connection
- bus tie connection.

Neutral Voltage Transformer

A neutral VT shall be included in each of the Neutral Bus module. The neutral VT shall be 0.5M 1P at 15VA.

Figure 3 Proposed BAS neutral system single line diagram



2.1.5 Transformer earthing

The three 66/22kV transformers in service at BAS are delta/star connected with the neutral of the star windings directly earthed.

The neutral earthing arrangement shall be modified to incorporate the new NER arrangement (refer SLD) with connection to the ASC. The transformer neutral shall have a new HV insulated single phase cable installed underground from the existing NER isolator (enclosed in a lockable cage) through to HV elbow connections on the Neutral Bus modules.

External earth receptacles are required if any air cable boxes are used.

2.1.6 Neutral surge diverter

As the 22kV network is now operating as a resonant circuit, neutral surge diverters are to be installed to protect the ASC, transformer neutrals and 22kV network from overvoltages.

Install and connect a Station Class 19kV surge diverter between the transformer neutral bus and the substation earth grid. The surge diverters should be connected as close to the transformer neutrals as possible.

2.1.7 22kV Bus Arrangement

GFN Sensitivity

The BAS 22kV Network consists of an estimated 1,294km of overhead line and 71km of underground cable. This leads to a network charging current of approximately 280 amps. To meet the sensitivity requirements of the GFN, it is recommended that the network be limited to 108 amps. This is a result of a sensitivity analysis surrounding a number of unknown parameters in the BAS network. In order to achieve this, the 22kV network must be rearranged, to cater for the ability to 'split' the buses.

The following requirements are necessary to split the BAS 22kV buses:

- the existing 22kV Bus Tie Circuit Breakers between each of the 3 22kV buses to physically split the 22kV buses and provide CT measurements for bus protection zones required for the GFN fault detection schemes in a split bus arrangement
- the existing 22kV Transformer Circuit Breakers are required in order to complete the transformer and bus protection zones
- 3 x 22kV VT's are required for transformer parallel control and GFN operation with the buses split
- 2 x Station Service Transformers are required to ensure that the GFN Inverter is available following any single fault. To prevent de-sensitising the bus protection scheme, these station service transformers shall be connected beyond circuit breakers where possible or contain 22kV CT's to remove contribution from bus protection schemes. In cases where the station service transformer is connected to the bus, it is to be protected by HV fuses.

22kV works

In order to arrange the substation in such a way that the 22kV bus can be split, appropriate protection zones exist for the GFN fault detection schemes the following works are required.

<u>22 kV Feeder rearrangement</u>

To balance the charging current and load among the 3 split buses the following feeders need to be rearranged at the feeder exit:

- BAS013 moved to Bus 3
- BAS021 moved to Bus 3

To transfer BAS013 and BAS021 feeders onto Bus 3 the following works are required:

- 2 x new 630A CBs one for each feeder transferred to Bus 3
- BAS013 - install new 630mm^2 1/c. a.x.hc.h. HV cable from new 630A CB on Bus 3 to Pole 217 BATS-BAS2 lis-32167
- BAS021 - install new 300mm^2 3/c. c.epr.hc.v. HV cable from new 630A CB on Bus 3 to pole 3 Sutton St lis-24213.

New arrangement will be as follows:

- Bus 1 will have BAS011, BAS012 and BAS014
- Bus 2 will have BAS022, BAS023 and BAS024
- Bus 3 will have BAS013, BAS021 and BAS034

Note: spare conduits for feeder exits will be required for the spare CBs and spare position on Bus 3.

GFN Inverter Room

- Install GFN Inverter Hut(s) east of existing Bus 3

Station Service and Capacitor Banks

- The existing No.1 and No.2 22kV Capacitor Banks are connected in grounded star. The Capacitor Bank also requires modification works to take it from a grounded star connection to an ungrounded star with an insulation rating of not less than 13kV. In addition to this, neutral balance CT's require replacement to ensure that current balance protection can be installed. Refer Technical Standards for specification.
- Replace the existing 63kVA 22kV No.1 Station Service Kiosk Transformer with new 750kVA 22kV Station Service Kiosk Transformer (Refer ZD036 Standard)
  - Station Service Kiosk to include 22kV CT's to allow for removal from 22kV bus protection zones
  - connect to AC Changeover Board within GFN Inverter Room
- Replace the existing 63kVA 22kV No.2 Station Service Kiosk Transformer with new 750kVA 22kV Station Service Kiosk Transformer (Refer ZD036 Standard)
  - Station Service Kiosk to include 22kV CT's to allow for removal from 22kV bus protection zones
  - connect to AC Changeover Board within GFN Inverter Room.

22kV Bus VT (Design to confirm the location)

- Replace existing 3 x 22kV VTs with new 22kV Voltage Transformer as the existing Voltage Transformers are not appropriately rated for 22kV phase to earth voltages:
  - Construction: 5 limb, 3-phase
  - Vector Group: YNyn0yn0
  - Ratio: 22000/110/110
  - Output: 100VA per phase per secondary
  - Accuracy: Class 0.5M1P
  - refer Technical Standards for specification, Material ID: 310661

22kV Insulators

- Replace all existing underrated HV pin insulators with 22kV station post insulators.

22kV Bus Naming

Any large scale changes to the 22kV yard require that consideration is given to the naming of plant in the substation from an operational perspective. This is critical from a healthy and safety perspective as well as from an operational

Nameplates in the 22kV yard must be reviewed and any that do not conform with the new naming of primary plant must be replaced.

- Review nameplates of all 22kV circuit breakers, buses, isolators, disconnect switches, earth points and cables.

All Primary and Secondary drawings must be reviewed and any that do not conform with the new naming of primary plant must be updated.

- Review all drawings with references to 22kV circuit breakers, buses, isolators, disconnect switches, earth points and cables.

Particular attention shall be given to the naming of primary plant items in the operational systems to ensure that any naming changes in the field are updated in the operational software such that switching instructions are correct when printed. This requires coordination between the field works, the SCADA group and network operations.

2.1.8 22kV feeder CTs

The ability to detect 25.4 kΩ faults requires a high level of accuracy in measurement to optimise network balancing. Perform diagnostic testing to confirm 25.4 kΩ faults while releasing less than 0.10 I^2T, as mandated by the Regulations, also requires very accurate current measurements.

The existing feeder CT specifications are outlined below.

Table 3 Feeder CT information

Feeder	CT Spec	Required Action
BAS011	2.5P150 300/5	Not suitable for sensitivity requirements, require new CT installation.
BAS012	5OP50 300/5	Not suitable for sensitivity requirements, require new CT installation.
BAS013	10P100 300/5	Not suitable for sensitivity requirements, require new CT installation.
BAS014	10P100 300/5	Not suitable for sensitivity requirements, require new CT installation.
BAS021	5OP50 300/5	Not suitable for sensitivity requirements, require new CT installation.
BAS022	10P100 300/5	Not suitable for sensitivity requirements, require new CT installation.
BAS023	10P100 300/5	Not suitable for sensitivity requirements, require new CT installation.
BAS024	10P100 300/5	Not suitable for sensitivity requirements, require new CT installation.
BAS034	0.2PL100R0.2 300/5	Suitable for sensitivity requirements

At BAS zone substation, 8 feeder CTs need to be installed and will require associated modifications of the 22kV bus structures and civil works to facilitate their installation. An alternative option to avoid modification to bus structures was considered, this option involved complete replacement of 22kV circuit breakers and was found to be a more expensive solution.

- Review fault levels, wiring length and relay burdens and define required specification to procure PX class CT’s
  - note: factory acceptance of CTs requires non-standard testing to confirm accuracy of zero sequence measurement through full range of load
- Relocation of existing bus structure to facilitate the installation of a new 22kV structure in each feeder bay that requires new CTs
- Installation of new 22kV CT mounting structure in each feeder bay that requires new CTs
- Install CTs and modify secondary relay settings for new CT ratios and test CT polarity.

2.1.9 Earth Grid Resistance

Experience from our REFCL trial substations and Camperdown zone substation has shown that the earth grid impedance in multiple REFCL substations negatively impacts on the ability to achieve 25.4 kΩ fault detection. In our desired range of network size (less than 108A) an earth grid impedance of 0.45 Ω will result in a neutral voltage developed in the unfaulted bus up to 1.5kV which is greater than the fault detection threshold for required capacity.

At BAS zone substation, the following works are required to reduce the earth grid impedance to below 0.2 Ω.

- Site survey, earth grid and soil resistivity testing
- Detailed analysis and modelling of earth grid and soil conditions
- Design of earth grid modification works
- Additional earth stakes and earth grid installation
- Retesting of earth grid.

2.2 Civil works requirement

The following outlines the Civil Works requirements.

For neutral systems:

- Install concrete foundation pad for neutral system modules
- Install neutral cable conduit, control cable conduit and provision for solid earth grid connections
- Install neutral cable conduits from transformers to neutral system modules
- Install conduits to ASCs and solid earth grid connection
- Install conduits for secondary circuits

For ASCs:

- Install neutral cable conduit, control cable conduits and solid earth grid connections
- Pour concrete foundation.
- Install steel beam, 150mm high at a width designed to accommodate the placement of the GFN Arc Suppression coil
- Install bunding to EPA requirements.

For station service supplies:

- Install concrete foundation for new station service transformers
- Review station service transformer foundations and enclosure for upgrade to 750kVA. Note the existing station service is 63kVA

For new 22kV No.3 bus VT review the suitability of existing footings and control cable conduits. If unsuitable:

- Install concrete footings for new structures
- Install control cable conduits for No.3 22kV VT.

2.3 Secondary works

The following outlines the Protection and Control requirements.

All secondary drawings shall be in the wiring schematic format consistent with the existing suite of drawings for the station.

2.3.1 Protection, Control and Metering Requirements

Cubicle 1 – Local Alarms, 22kV Summation Metering & Auto Volt C/O

- Install 2 x off ELSPEC Power Quality Meter and Data recorder
- Install 2 x ION7400 Power Quality Meter

The ELSPEC meter is capable of recording 16 analogue & 32 digital channels of data at a sampling rate of 1000 samples per second. 12 months of data can be captured and stored internally using a patented algorithm. One ELSPEC meter can record up to 2 transformers/buses. Hence a second ELSPEC meter is required for transformer No.3/No.3 Bus.

The ELSPEC shall be installed to capture bus voltage, neutral voltage and bus incomer currents (i.e. bus summated currents). The purpose of this recorder is to aid with GFN commissioning and long term monitoring. Connectivity to the ELSPEC meter to be fibre 100BASE-FX Ethernet to a new RS2100 switch in cubicle 16

New ION7400 PQMs are to be installed in Cubicle 1 as the No.2 and No.3 Trans/Bus Summation PQM. The CT circuits are to be wired such that each new PQM is provided currents from that bus only (i.e.No.3 PQM is provided No.3 bus current only). The new PQMs are to be connected to the ION 7650 which will provide the individual bus metering information as well as station summation via DNP.

Cubicle 2 – Transformer Controls (New Station HMI & Split bus VAR controller)

- Retire 2V164-S VRR
- Retire 2V67 OV/UV relay
- Retire transformer control switches
- Retire SCD5200 Transformer control unit
- Install rugged com RS2100 Ethernet Sub-LAN switch
- Install 1 x DC/DC Converter
- Install 1 x 21" Advantech Station HMI touch screen panel (including transformer and cap HMI)
- Install 1 x SEL3530 RTAC
- Install (N) GE F35 X MEF and Neutral Bus Management relay
- Install (N) GE C30 Neutral Bus CB Mgmt I/O extension relay

New SEL451 VRR and Transformer Parallel control relay will perform independent voltage control in split bus mode or traditional transformer control when the bus tie CBs are closed.

The HMI shall be utilised to display the VRR Controls as well as breaker controls of 66kV CBs , Transformer 22kV CBs, Bus Tie 22kV BT CB, Feeder CB's and Cap Bank CB.

A GE F35 relay shall be installed and configured as the X MEF and Neutral Bus Management relay. GE F35 X MEF and Neutral Bus Management relay together with I/O extension relay (C30) shall execute and manage the following functions:

- Master Earth Fault relay for NER/direct earth in service applications
- Neutral Voltage Supervision

- Neutral CB Management

Cubicle 3 – Spare (New VRR & Transformer Parallel control)

- Install rugged com RS2100 Ethernet Sub-LAN switch
- Install 3 x SEL2440 DPAC (Transformer Interface relays)
- Install 1 x SEL451 Programmable Automation Controller (VRR and Transformer parallel control)

SEL-2440 DPAC units shall be installed to convert signals to and from the transformers into IEC-61850 Goose Messages. This enables the SEL451 to send and receive the appropriate signalling, raise/lower tap commands, TCIP signal and tap position indication.

A SEL451 Programmable Automation Controller shall be configured to perform independent voltage control of each bus in the split bus arrangement or traditional voltage control with the 22kV Bus Tie CBs closed. It will require installation of additional relays to provide the statuses, analogues as well as a pathway for controls (feeder protection relays, CB Management relays, Station EF Management relays, Neutral Bus Management relays and Transformer I/O interface relays).

The SEL-451 VRR and Transformer Control relay shall be programmed to perform Line Drop Compensation (LDC) calculations for each bus, and the station as a whole, and apply these values based upon the status of the 22kV Bus Tie breakers.

The SEL-451 VRR and Transformer Parallel Control Relay will receive the following via IEC-61850 GOOSE Messaging:

- 22kV Transformer Volts from SEL351S Transformer CB Management Relay
- Transformer CB Statuses from SEL-351S CB Management Relay
- Bus Tie CB Statuses from SEL-351S BT CB Management Relay
- All BAS Feeder Loads from SEL-351S Feeder Management Relays
- Transformer Tap Change In Progress from new SEL-2440 Transformer Interface Controllers
- Transformer Tap Position Indication from new SEL-2440 Transformer Interface Controllers

It shall transmit the following via IEC-61850 GOOSE Messaging

- Transformer Raise/Lower Tap to the Transformer Interface Controllers
- Transformer Trip
- Close Bus Tie CBs

Cubicle 4 -6 (66kV CB MGT & CB Fail, Transformer 22kV CB MGT & CB Fail & 22kV Bus Tie CB MGT & CB Fail)

Note that all existing 66kV and 22kV CB management relays shall be firmware upgraded to provide external protection trip initiations via IEC61850 GOOSE. This is required to enable GOOSE tripping from the GFN controller for a Transformer/Bus zone tripping.

Cubicle 7 & 8 – No.1 & No.2 Bus Feeder Protection Relays

Note that relays shall be reconfigured to provide external protection trip initiations via IEC61850 GOOSE. These GOOSE initiations shall drive auto reclose functionality direct to lockout through the internal 79DTL function.

The CB fail functionality of the feeder CBs will be provided by the GFN controller. In this case the 22kV CB management relays will be tripped by GOOSE trip initiations from the GFN controller.

22kV feeder CT contributions are required by the GFN zero sequence bus admittance calculations. To facilitate the GFN connection, install an extra set of neutral links on feeder link rack to permit the installation of the I0 connection off to the GFN controller.

Cubicle 9 – No.3 Bus Feeder Protection Relays

- Install rugged com RS2100 Ethernet Sub-LAN switch
- Install Tekron TCG-01 GPS Clock
- Install 1 x SEL351S Feeder Management relay

The new Tekron TCG-01 GPS clock, antenna, is to be used for time stamping on all equipment.

Cubicle 10 – No.1 Cap Bank Protection & Control

- Remove the existing No.1 Capacitor Bank earth connection from the neutral star point
- Remove the cap bank No.1 neutral current contribution from the MEF and BUEF protection circuit to accommodate the removal of the No.1 Cap bank earth connection from the neutral star point
- The existing capacitor bank Neutral Balance protection shall be used as current balance protection to accommodate the removal of the No.1 Capacitor bank earth connection from the neutral star point
- Install new 25/1 Class 1 MCTs upon the modified neutral structure. Secondaries to be terminated on a new link rack on the bottom of cubicle.
- Local control of Cap bank step switches to remain off the manual switches on Panels.
- The existing SEL351S relay (Z101 firmware version) shall be firmware upgraded to provide external protection trip initiations via IEC61850 GOOSE
- SEL351S Cap Bank protection relay to be connected to the Sub LAN Ethernet switches in a point to point arrangement and not in “loops” for SCADA, engineering access and GFN tripping via IEC 61850

Cubicle 11 – No.3 Cap Bank Protection & Control

- Note the existing SEL351S relay (Z105 firmware version) shall be firmware upgraded to provide external protection trip initiations via IEC61850 GOOSE.

Cubicle 13 – VAR control

Note to maintain the existing VAR controller

Cubicle 16 – Ethernet

- Install a second firewall unit – Fortigate 60C
- Install a rugged com RS2100 Ethernet Sub-LAN switch

Cubicle 19 –Spare (New Station EF Mgmt and VAR controller)

- Install rugged com RS2100 Ethernet Sub-LAN switch
- Install 3 x SEL451 Station Earth Fault Management relays

Note the Station Earth Fault Management relays are require to perform the automated control of the GFN installed at the substation. This relay will manage the following functions:

- Operating mode selection
- GFN remote controls
- Automate fault detection handling
- Request fault confirmations consistent with operating mode
- Trip faulted zones consistent with operating mode

- Bypass ASC
- Provide local controls and indications

Cubicle 25 – X & Y MEF & BUEF (New X MEF, Neut Volt & Neut Bus Mgmt and Y MEF & BUEF)

- Retire (E) RMS 2C137 X MEF Relay

The existing RMS 2C137 relay currently performing X MEF shall be replaced with GE F35 relay to allow flexible control of feeder earth protection and GFN integration. A GE F35 relay shall be installed and configured as the X MEF and Neutral Bus Management relay.

2.1.10 Ground Fault Neutraliser

Cubicles 20-22 – New GFN Control Cubicles

The GFN control unit is a single cubicle comprising of;

- GFN Master Control module
- GFN Slave Control Module
- Windows Based PC utilising proprietary NM Term software
- All VT & feeder I_0 CT terminations
- All trip link outputs
- RCC Inverter and ASC Interface
- Panel Meters

BAS Zone substation will require three (3) GFN controllers as such it will require a split bus operation.

Powercor will request through their specification process that the control unit be constructed within a standard cubicle. The cubicle will contain an interface controller in the form of a SEL-2440 DPAC control unit in the top 2U of this cabinet. This control unit will be used to interface controls to the Station Earth Fault Management relay.

2.1.11 VT supplies

VT supplies from the new No.1, No.2 and No.3 22kV Bus VTs are required to the GFN control units. For earth fault detection, an open delta (U_N) input is required from the 22kV bus VT at 110V secondary. To achieve this, Swedish Neutral has provided an open delta connected auxiliary transformer within their GFN control cubicle. As such no works beyond normal star connected VT supplies are required.

- Connect No.1 Bus VT to No.1 GFN
- Connect No.2 Bus VT to No.2 GFN
- Connect No.3 Bus VT to No.3 GFN

2.1.12 Protection settings

A protection review shall be undertaken by Network Protection & Control of all schemes within BAS zone substation with particular reference to earth fault schemes on the 22kV network.

- SEL-351S relays will have configuration changes to introduce:
  - GOOSE (via GFN) tripping capability
  - Auto Reclose integration of GFN initiated trips
  - GOOSE message isolation function

- No.1 and No.3 22kV high impedance bus protection scheme will need a CT contribution from the station service supply circuit.

2.1.13 Protection relay configurations

Powercor Network Protection and Control will make standard relay configuration files available to the Service Provider where appropriate. Given the nature of this project, the service provider must expect that this project will have non-standard requirements.

2.1.14 Control and monitoring requirements

Remote Control and monitoring of new:

- Modified SEL-351S Feeder Protection Relay Configurations
- Modified SEL-351S Cap Bank Feeder Protection Relay Configurations
- X MEF, Neutral Voltage & Neutral System CB Management Relay UR F35
- SEL-451 Station Earth Fault Management relays
- GFN Controller
- ELSPEC Power Quality recorder
- ION7400 Power quality meters
- Modified 66kV and 22kV CB Management Relay configuration
- SEL451 VRR and Transformer Control Relay
- SEL2440 Transformer Interface Control Relays (3 off)
- SEL 451 VAR Controller
- SEL-2411 Step Switch Management
- F35 Current Balance and Step Switch Management

Relay communication shall be via DNP 3.0 with DNP Maps provided to the SCADA group and produced by the service provider in conjunction with Network Protection & Control.

Powercor SCADA group are responsible for developing a suite of ENMAC control pages in conjunction with the Network Operations group and Network Protection & Control.

2.1.15 Communications Requirements

Ethernet Connectivity

All communications shall be over 100 BASE-FX (optic fibre) Ethernet back to the zone substation Sub-LAN RSG-2100 Ethernet switches.

Tripping from the GFN to the feeder CB's will be over IEC 61850 via an interface module built into the GFN control cubicle. For this reason, the architecture for Ethernet communications shall change to eliminate "loops" that emanate from the sub-LAN switch.

Given the proximity of the devices to be connected, five (5) new RuggedCom RSG-2100 switches (location specified in the panel layout drawing attached in Appendix) are adequate at BAS.

- Install Gigabit backbone connection between the 6 Ethernet switches
- Install fibre Ethernet links from the SEL-351S Feeder Protection relays, Cap Bank protection relay, 66kV CB management relays, 22kV CB Management relays, Station EF management relay, Trans parallel control relay, Split

bus VAR controller relay, X MEF Neutral Voltage & Neutral system CB Management relay, ELSPEC PQM and GFN DPACs to each Ethernet switch (refer to SCADA connectivity diagram)

- Install fibre connections from GFN Interface controller (SEL-2440)
- Ensure relay configurations modified to Port Failover configuration
- Ensure Sub-LAN switch architecture configured to support fail over scenario's

A suggested Ethernet connection diagram is included in Appendix.

Engineering Access

Powercor SCADA shall ensure remote engineering access is available to select members of the Network Protection & Control group. Remote access is required to all sub-LAN connected devices including protection relays, data recorders and GFN controller.

Time Stamping

The existing Tekron TCG-01 GPS Clock is to be used for time stamping all equipment. All NTP capable equipment shall synchronise with the BAS GPS NTP server. All non NTP capable equipment is to be connected to the BAS GPS IRIG-b loop.

2.1.16 415/240 AC Supplies

The existing station service supply transformer is located in the switchyard and is supplied off the 22kV bus. The size of this station service transformer will not be adequate for the RCC inverter used to drive faulted phase voltage to zero via the Arc Suppression Coil.

As the size of BAS network requires a split bus arrangement and 3 Arc Suppression Coils, one for each transformer, the AC Supplies must ensure capacity and reliability requirements are fulfilled for a three ARC Suppression Coil:

- Install two (2) new 750 KVA kiosk type station service transformers, location shown on proposed GA
- Upgrade existing station AC board, incoming mains and change over schemes such that they are compliant with existing standards
- Configure new auto-changeover board to only restore to Supply 1 for loss of Supply 2, i.e. not changing over immediately after Supply 1 is restored, interrupting the REFCL supply unnecessarily
- Install AC supplies for the GFN inverter to meet its specifications.

2.1.17 DC Supplies

The battery capacities shall be verified as being of adequate capacity to supply the station standing load and any CB operations that could occur within a 10 hour period following loss of AC Station Service supplies.

Documentation must be provided that demonstrates the battery amp-hour rating chosen has been sized for the load and the duty of the load. Calculations and appropriate documentation must be provided to demonstrate compliance with IEEE – 485 "IEEE Recommended Practices for Sizing Lead Acid Batteries for Stationary Applications".

2.1.18 Station Design

As a minimum the secondary design documentation shall include:

- 22kV Station Schematic Diagram
- Protection, Control, Instrumentation and Alarm data schedules
- Control room layout and elevation of cubicles
- Cubicle Layouts

- Wiring schematics/diagrams for individual protection, control and metering schemes
- DC supply schematics
- Remote control equipment and associated data schedules
- Labelling for cubicles and all slide link terminals
- Manufacturer and interface drawings for the Ground Fault Neutraliser equipment

The latest modular design concepts shall be used as far as practical for this project.

2.1.19 Powercor control centre SCADA works

A new series of Control System Pages shall be created for the GFN interface. Consultation between SCADA, Operations and Network Protection and Control is required to establish these pages.

2.1.20 Fibre Optic Cable

Fibre optic patch leads are required for Zone Substation Sub-LAN Ethernet communications.

These optic fibres shall be of OM1 62.5/125um type.

2.1.21 Radio

No radio communications are required.

2.1.22 Weather Station

A weather station is to be installed in order to provide monitoring of temperature, solar radiation, wind speed and humidity in the area. This provides an indication of REFCL sensitivity as it will fluctuate as the network damping (resistive leakage to earth) will vary with weather conditions. Care is to be taken when earthing the weather station to ensure there is no risk of damage to the control room from lightning strikes.

2.1.23 Building and Property Considerations

Yard lighting

Switch yard lighting shall be reviewed to ensure adequate coverage of the ASC, Neutral System.

Fire suppression

The ASC winding is immersed in oil. A review of its design and the amount of contained oil is required to determine if any fire suppression assets are required.

3 22 kV distribution feeder requirements

3.1 Surge diverters and insulation limitations

The operating principle of the GFN uses a tuned reactance to choke fault current in the event of a single-phase-to-ground fault. As a result, displacement of the line-to-ground voltage occurs in the healthy phases. Whilst line-to-line voltages remain at 22kV, the line-to-ground voltage rises to 22kV, phase-to-ground, on the two healthy phase's subsequently stressing substation and distribution equipment. In the case of surge diverters, this displacement cannot be tolerated and as such the diverters require replacement.

To accommodate the GFN installation, replace approximately 4,669 surge diverters across the 22kV three phase and single phase system.

This covers all feeders ex BAS ZSS as well as surge arrestors beyond inter-station open points shall also be upgraded to permit transfer of loads with the GFN in service.

The replacement diverters should be of 22kV continuous rating with a 10 hour 24kV TOV rating such as the ABB POLIM D 22kV arresters.

CitiPower and Powercor previous standard surge diverters were the ABB MWK 20 and POLIM D 20 arresters.

These, and all previous types except Bowthorpe ‘Type A’ arresters do not meet the overvoltage requirement needed for use with a GFN and therefore the higher rated arresters are required.

These surge diverters will be a new standard, applicable to distribution systems with a GFN installed.

3.2 Distribution transformers

Operation of the GFN displaces the neutral voltage of the entire 22kV system from the bus to the outer extremities of the feeders. This is different from an NER arrangement, when displacement is at its highest for a fault on the 22kV bus, and decreases for faults occurring down the feeders.

During GFN commissioning, voltage offset testing will simulate the voltage displacement that will occur for a single-phase-to-ground fault (22kV phase-to-ground).

1. Some distribution transformers may not be in a condition to withstand the overvoltage and will subsequently fail during the voltage offset testing
2. Some distribution transformers may fail following repeated subjection to sustained over-voltages caused post commissioning due to normal operation of the GFN

At this time, experience from network resilience (voltage stress) testing at GSB and WND does not support a proactive replacement of any distribution transformers.

3.3 Line insulators

As is the case above for distribution transformers, line insulators are also susceptible to premature failure caused by the repetitive over-voltage stresses.

At this time, experience from the network resilience testing does not support a proactive replacement of any line insulators.

3.4 Line regulators

Single phase open-delta-connected Cooper regulators displace the system neutral voltage by regulating line-line voltages on two phases as opposed to three.

Closed-delta independent regulator control schemes tap each regulator independently, a similar displacement to the neutral voltage occurs, as per the open-delta mode.

All regulator works shall be compliant with current CitiPower and Powercor standards for 22kV regulators.

The BAS distribution network contains twenty four (24) 22kV regulating systems:

Table 4 BAS regulating systems

Feeder	Name	Manufacturer	Phasing	Issue
BAS011	BEAUFORT P454 REG	Cooper – 3 x 200A	RWB	New control box required to tap all phases together
BAS011	CARNGHAM P150 REG	Cooper – 3 x 200A	RWB	New control box required to tap all phases together
BAS011	STONELEIGH P154 REG	Cooper – 2 x 50A	RB	Require a 3rd unit or rebuild of regulating site to operate in 'closed delta'
BAS011	WINDERMERE P200 REG	Cooper – 3 x 200A	RWB	New control box required to tap all phases together
BAS021	SKIPTON P302 REG	Cooper – 3 x 200A	RWB	New control box required to tap all phases together
BAS022	BUNINYONG P211A REG	Cooper – 1 x 50A	RW	Single phase line with single phase regulator – this must be addressed as part of balancing works
BAS022	DEREEL P26 REG	Cooper – 1 x 50A	BR	Single phase line with single phase regulator – this must be addressed as part of balancing works
BAS022	ELAINE P232A REG	Cooper – 1 x 50A	RW	Single phase line with single phase regulator – this must be addressed as part of balancing works
BAS022	MERCER P186 REG	Cooper – 2 x 50A	RW	Require a 3rd unit or rebuild of regulating site to operate in 'closed delta'
BAS022	MERCER P226 REG	Cooper – 1 x 50A	BR	Single phase line with single phase regulator – this must be addressed as part of balancing works
BAS022	NAPOLEONS P74 REG	Cooper – 1 x 50A	WB	Single phase line with single phase regulator – this must be addressed as part of balancing works
BAS023	NAVIGATORS P39 REG	Cooper – 3 x 200A	RWB	New control box required to tap all phases together

The following regulators require modification in order to meet the requirements for installing the GFN.

3.4.1 Beaufort P454 Regulator

Beaufort P454 regulator has 3 single phase regulators. They will need to tap in step with each other, which will require a new CL7 control box as a minimum. If it is not possible for this to be fitted, a new 3 phase regulator may be required.

3.4.2 Carngham P150 Regulator

Carngham P150 regulator has 3 single phase regulators. They will need to tap in step with each other, which will require a new CL7 control box as a minimum. If it is not possible for this to be fitted, a new 3 phase regulator may be required.

3.4.3 Stoneleigh P154 Regulator

Stoneleigh P154 regulator is an open delta connected regulator; this artificially moves the neutral point of the line beyond it. This must be either replaced with a 3-phase ground type regulator, or a third single phase regulator installed on a neighbouring pole and a control scheme installed to ensure that all 3 phases tap in unison.

3.4.4 Windermere P200 Regulator

Windermere P200 regulator has 3 single phase regulators. They will need to tap in step with each other, which will require a new CL7 control box as a minimum. If it is not possible for this to be fitted, a new 3 phase regulator may be required.

3.4.5 Skipton P302 Regulator

Skipton P302 regulator has 3 single phase regulators. They will need to tap in step with each other, which will require a new CL7 control box as a minimum. If it is not possible for this to be fitted, a new 3 phase regulator may be required.

3.4.6 Mercer P186 Regulator

Mercer P186 regulator is an open delta connected regulator; this artificially moves the neutral point of the line beyond it. This must be either replaced with a 3-phase ground type regulator, or a third single phase regulator installed on a neighbouring pole and a control scheme installed to ensure that all 3 phases tap in unison.

3.4.7 Navigators P39 Regulator

Navigators P39 regulator has 3 single phase regulators. They will need to tap in step with each other, which will require a new CL7 control box as a minimum. If it is not possible for this to be fitted, a new 3 phase regulator may be required.

3.5 Admittance balancing

The ground fault neutraliser uses a tuned inductance (Petersen Coil / Arc Suppression Coil) matched to the capacitance of the distribution system. The 3 phase 22kV distribution system ex BAS zone substations contains approximately 1,294 km of overhead conductor length (excluding SWER). Of this 1,294 km, 686km (53%) is single phase or unknown. Whilst planning philosophies have always attempted to balance the single phase system, inevitably this is difficult to achieve. In order to balance the capacitance of the three phase system such that the ASC can be correctly tuned, balancing substations will be placed at nodes on the system that utilise low voltage capacitors to inject the missing capacitance onto the system.

Note: Balance does not refer to the balancing of load. System balance is required from a capacitance-to-ground perspective and affected by route length and single phase connected distribution equipment.

A reconciliation (survey) of all 22kV overhead and underground lines routes shall be conducted to assess the scope of the network balancing requirements.

The following steps shall be outworked prior to GFN installation;

1. Consolidate all “Single Phase” and “unknown” conductor into the “BR”, “RW” or “WB” categories
   (i) validate “Single Phase” and “unknown” conductor where required
   (ii) spot check the validity of current phasing information
2. Consolidate all single phase transformers on the 22kV system and assign to one of the “BR”, “RW” or “WB” categories

3. Ascertain the construction types for all sections
   (i) Indicate whether LV subsidiary exists
4. Consolidate all "1 Phase" and "unknown phase" 22kV cable and assign phase information
5. If single phase circuits are used underground, ascertain the design principles behind the single phase underground sections
   (i) Conductor type, two or three core?
   (ii) Treatment of the unused core (earthed or phase bonded)—if bonded, to what phase?

The course balance shall look at sections of the system in 'switchable blocks' and for any re-phasing and finite admittance balancing opportunities in order to balance out the single phase route lengths and large single phase spurs where the capacitance is fairly easy to approximate.

A tuneable balancing approach shall then look at the system again in switchable blocks for the application of 3-phase admittance balancing substations.

The use of 3-phase admittance balancing substations will provide accurate capacitive balancing in each section. Admittance balancing substations shall be placed at the following locations to enable switching of balanced blocks of the system. The blended approach to admittance balancing is designed to cater for the historical use of single phase spur lines, single phase cable and the variability in capacitive balancing. The number of re-phasing sites, single phase balancing units and 3 phase balancing units are also informed by experience of GSB and WND and scaled to the relative network parameter of this substation.

Table 5 Balancing requirements summary

Balancing concept	Number of sites
Re-phasing Sites	45
Single Phase Balancing Units	31
3 Phase Balancing Units	61

3.6 Automatic Circuit Reclosers (ACRs) and remotely controlled gas switches

Each RVE or VWVE ACR on the BAS network should be replaced with the current standard Schneider N27 ACR which has inbuilt voltage measurement.

Table 6 ACR replacements

Name	Operating voltage	Phase code	ACR model
BEAUFORT P175 ACR	22kV	RWB	VWVE27
BEAUFORT P375 ACR	22kV	RWB	VWVE27
BEAUFORT P528 ACR	22kV	RWB	VWVE27
ILLABAROOK P1 ACR	22kV	RWB	VWVE27
MT MERCER P25A ACR	22kV	RWB	unknown

Name	Operating voltage	Phase code	ACR model
NAPOLEONS P1 ACR	22kV	RWB	RVE
SKIPTON P219 ACR	22kV	RWB	unknown

Each ACR or remote controlled gas switch requires a modern control box which has required programmable functions and up to date firmware. ACR and gas switch control box replacements are required (for CAPM5 or GCR300 control boxes) in order to:

- automatically detect REFCL operation and prevent incorrect operations de-energising customers
- provide advanced fault locating algorithms capable of detecting REFCL fault confirmation tests
- continue to operate in the traditional manner automatically when REFCL is not in operation.

Table 7 Control box replacements

Name	Control box model
BEAUFORT P492A CTRL	GCR-300
BEAUSOUTH P28 ACR CTRL	PTCC (CAPM5)
SKIPTON P126A ACR CTRL	PTCC (CAPM5)
SKIPTON P219 ACR CTRL	PTCC (CAPM5)
SKIPTON P373 ACR CTRL	PTCC (CAPM5)
BUNINYONG P145 ACR CTRL	PTCC (CAPM5)
MAGPIE P93 ACR CTRL	PTCC (CAPM5)
WARRENHEIP E TITREE CTRL	GSC-600 (CAPM3)
EUREKA P97A ACR CTRL	PTCC (CAPM5)
YORK ST P127 ACR CTRL	PTCC (CAPM5)

Table 8 ACR and control box requirements summary

Units	Number of sites
ACR replacements	7
Control box replacements	10

3.7 Fuse savers

HV Fuses pose a difficulty in operating a network with a REFCL. Maintaining capacitive balance is critical in the network, and scenarios that result in 1 or 2 out of 3 fuses blowing in a 3 phase section, such as phase-phase faults can result in large capacitive imbalances. These imbalances can result in loss of REFCL sensitivity, REFCL maloperations resulting in widespread outages or REFCL backup schemes operating to remove the REFCL from service.

Fuse Savers are to be installed as a 3 phase ganged unit such that when any individual phase operates for a fault, all 3 phases open in unison de-energising a balanced section of the network regardless of the fault type.

Fuse Savers are required to operate for any fused section with a downstream network capacitive charging current of 540 mA or greater.

In some locations where the network fault levels are high, Fuse Savers cannot be used as they do not have the appropriate fault breaking capacity. In these situations, an ACR is required to clear faults as a three phase device else the feeder will be tripped on days of high sensitivity.

Table 9 Fuse saver requirements

Units	Number of sites
Fuse savers	57
ACRs	4

3.8 HV underground cable

Experience from REFCL testing has shown that a percentage of HV underground cable is likely to experience failure due to elevated phase to earth voltages experienced in a resonant network. An allowance for cable failure is to be made for the transition to resonant earthing.

Table 10 HV underground cable requirements

Location	Length (m)
Cable failure length	6,496

3.9 Distribution switchgear

Overhead distribution switchgear has been shown to be largely resilient to the phase to earth over-voltages experienced in a resonant network. There is no planned replacement of these assets.

Resilience testing has shown that Felten and Guilleaume ground mounted kiosk switchgear is not capable of withstanding 24.2kV phase to earth voltages. The inherent design and construction of these units preclude them from any repair works and as such must be replaced.

Table 11 Felten and Guilleaume switchgear replacements

Location	Kiosk Size (kVA)
ALBERT-DANA	500
ARMSTRONG STURT	500

Location	Kiosk Size (kVA)
ENTERPRISE-UNIVERSITY	500
GRENVILLE-LAW COURT	750
PARK OAKBANK	300
THE RIDGE-HANOVER	315

3.10 HV customer isolation substations

The Electricity Distribution Code stipulates that at the point of connection to a customer on the 22kV network, the phase to earth voltage must be no greater than 80 per cent for up to 10 seconds.

In order to maintain compliance with the code, the installation of HV isolation substations is required.

The service provider is to ensure that the detailed design of these installations considers:

- a delta zig-zag (Dzn0) vector group transformer is required to provide the isolation
- isolation substation to be sized appropriate for the total size of the customer's load, taking into account any generation
- voltage control requirements for the customer is likely to require tap changing capability for larger customers
- station service supply via the tertiary winding to provide supply to protection, metering and control circuitry
- appropriate HV source side protection to protect for faults in the substation transformer
- appropriate HV load side protection to protect for faults between the substation and customer protective devices
- note that customer protection is in some cases not at the point of connection and there is a risk of sensitive earth faults
- bunding and other environmental considerations for substations
- undergrounding of any electrical conductor between the isolation substation and customer connection

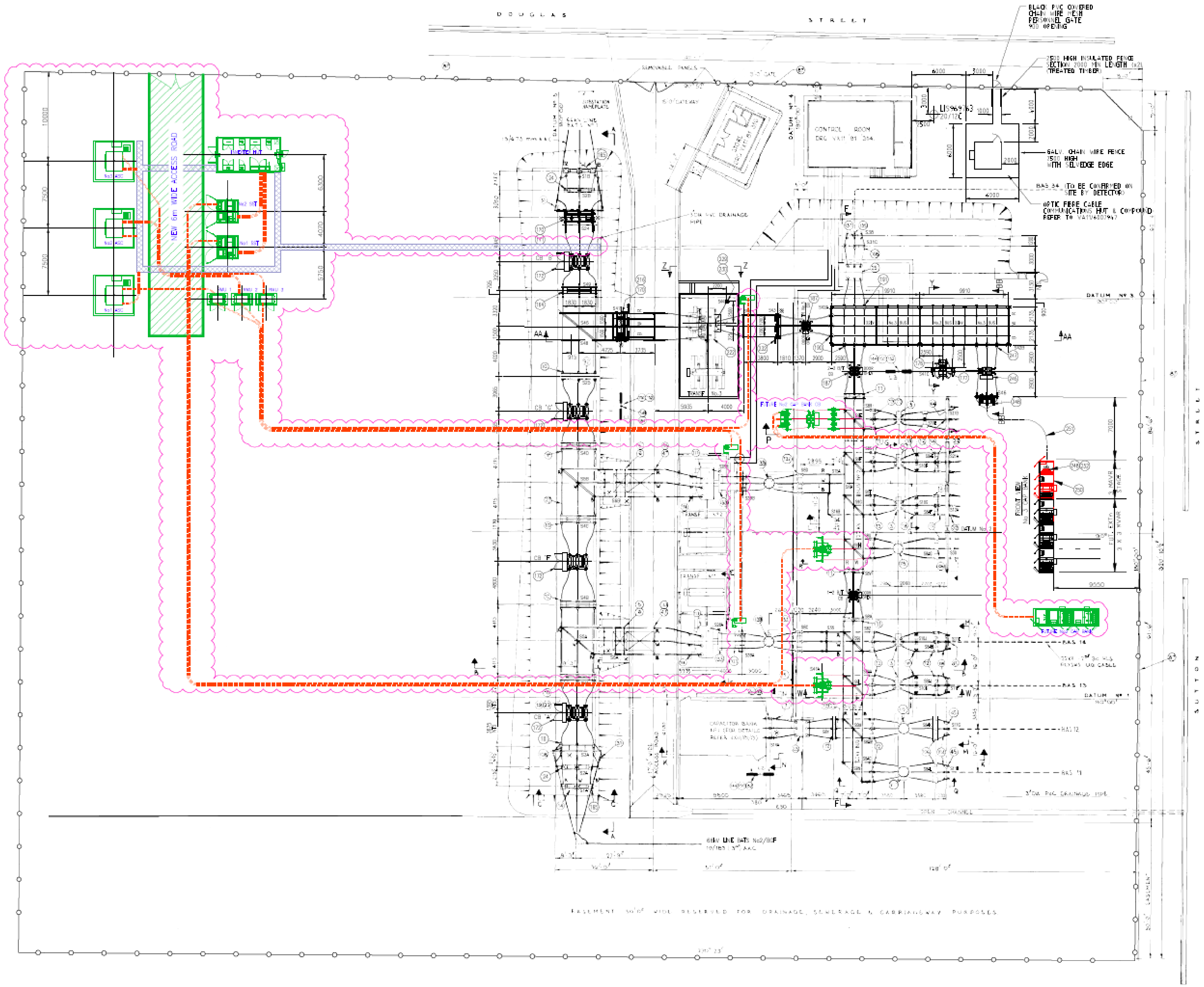
HV customer connection sizes are set out in table 12.

Table 12 Isolation substation requirements

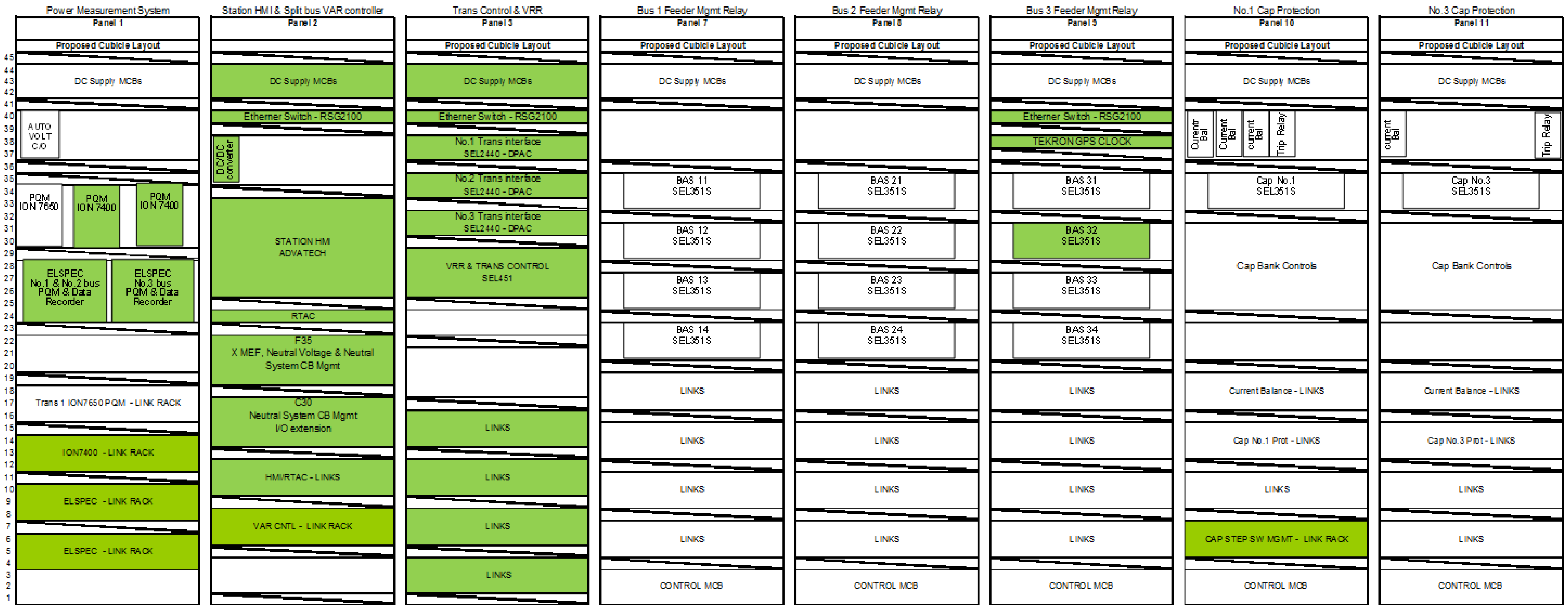
Size	Quantity
3 MVA	3
6 MVA	2

4 Appendix

4.1 Proposed Site General Arrangement

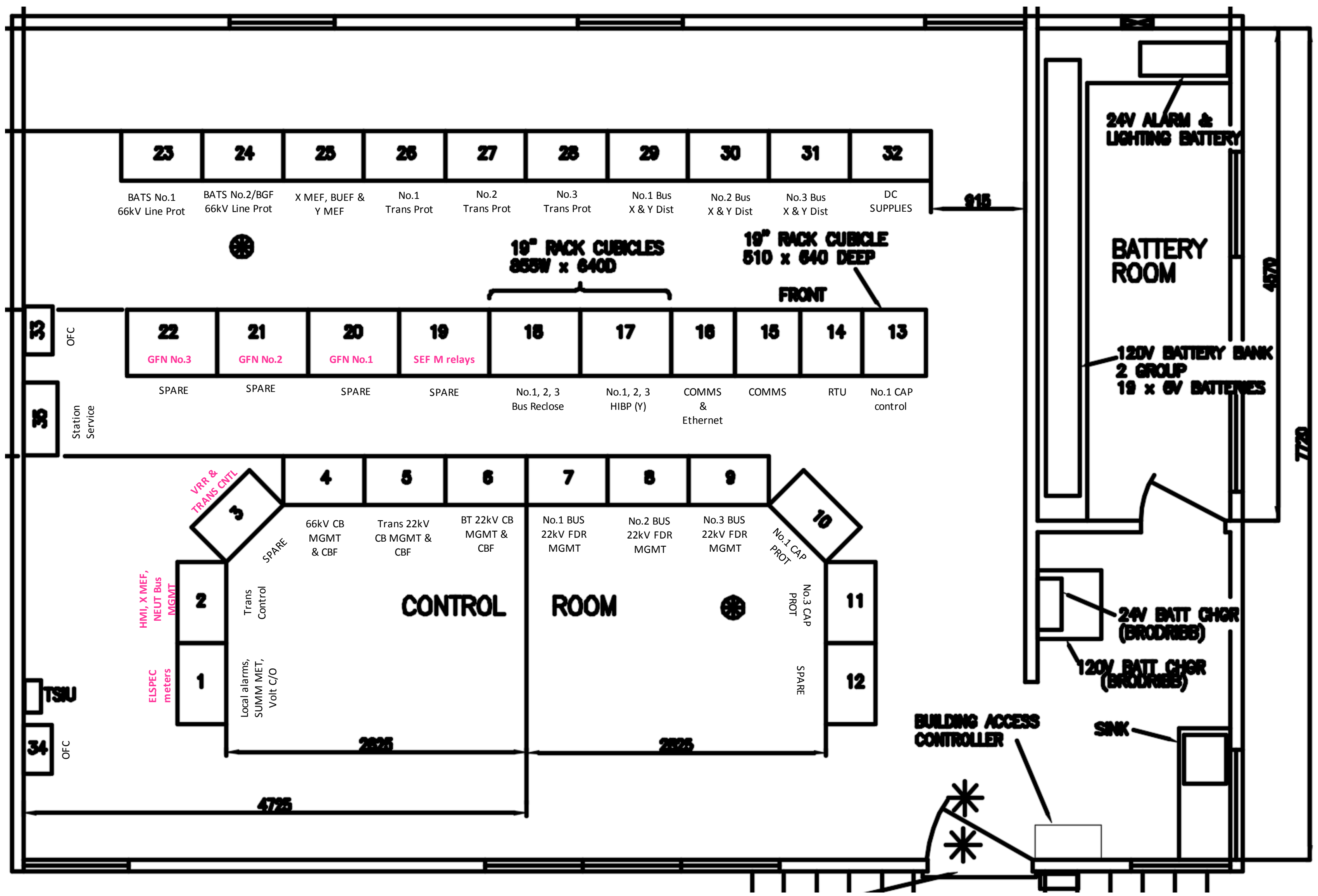


4.2 Suggested Cubicle Layout

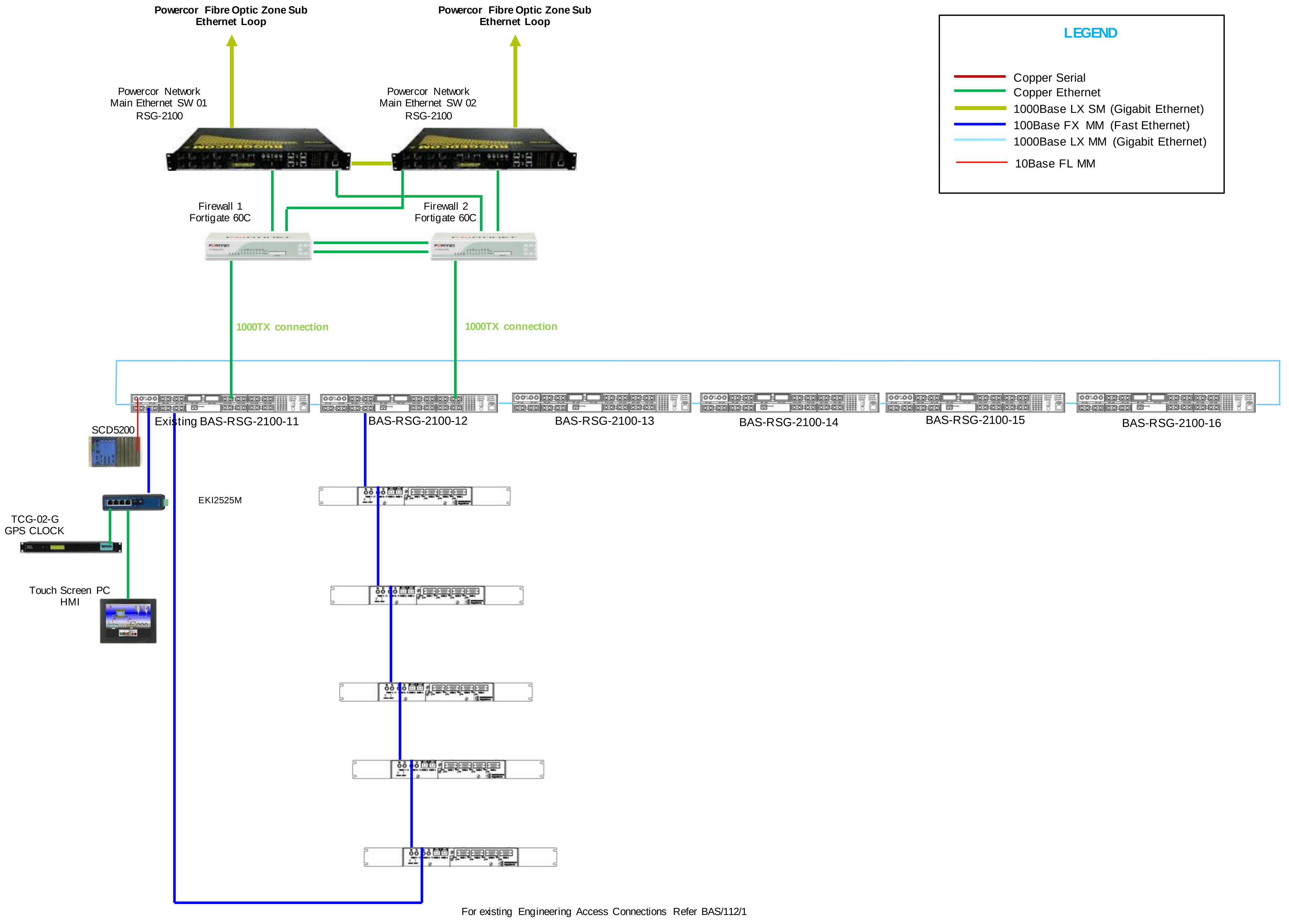


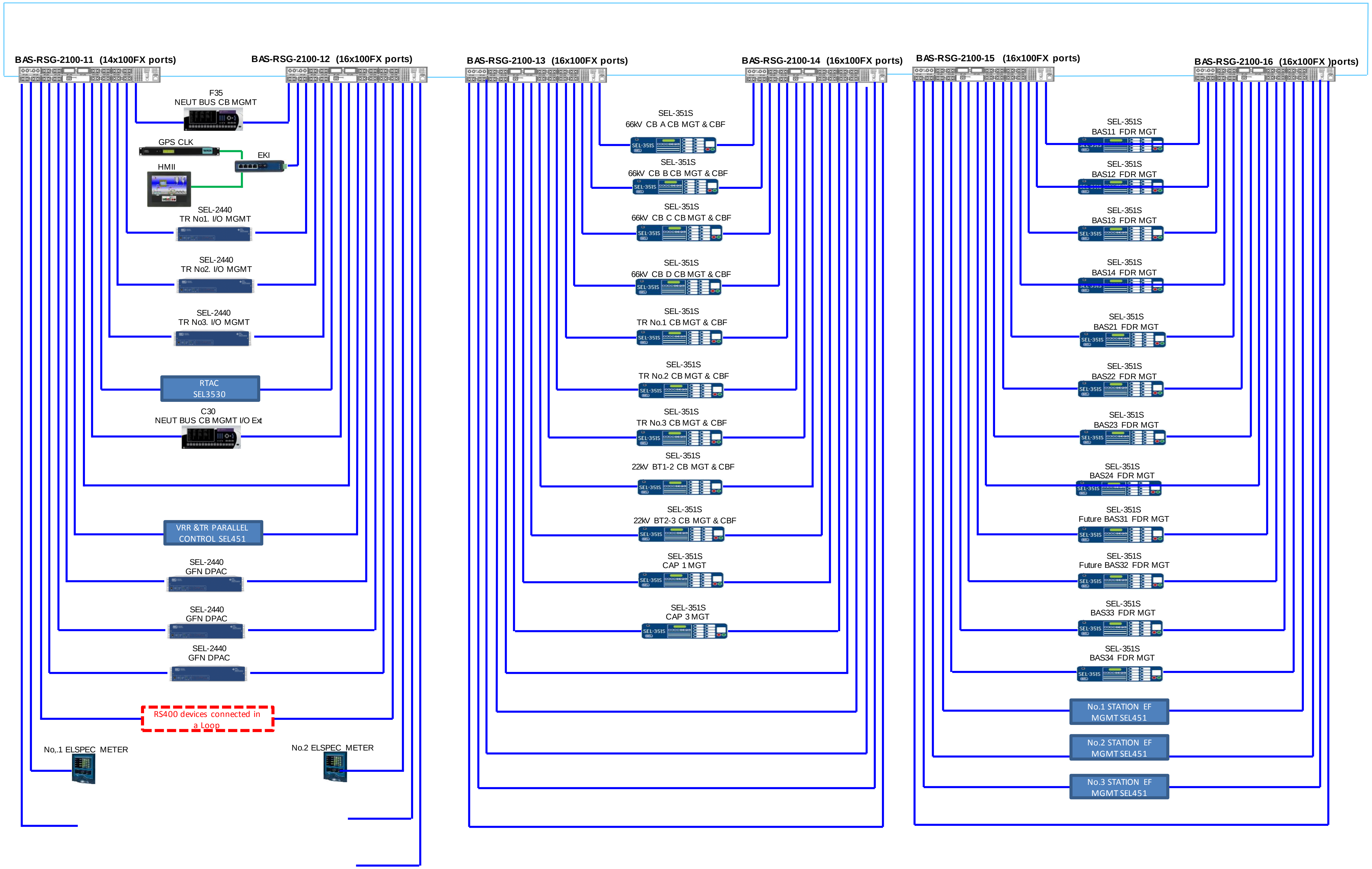

Station EF Management Relay
Panel 19
DC Supply MCBs
Etherner Switch - RSG2100
STATION EF MGMT RLY No.1
SEL451
STATION EF MGMT RLY No.2
SEL451
STATION EF MGMT RLY No.3
SEL451
LINKS
LINKS
GFN No.1 Cubicle
Panel 20
Proposed Cubicle Layout
Etherner Switch - RSG2100
INSTRUMENT PANEL
PC/HMI
MASTER CONTROLLER
SLAVE CONTROLLER
DPAC
LINKS
LINKS
LINKS
LINKS
DC Supply MCBs
GFN No.2 Cubicle
Panel 21
Proposed Cubicle Layout
Etherner Switch - RSG2100
INSTRUMENT PANEL
PC/HMI
MASTER CONTROLLER
SLAVE CONTROLLER
DPAC
LINKS
LINKS
LINKS
LINKS
DC Supply MCBs
GFN No.3 Cubicle
Panel 22
Proposed Cubicle Layout
Etherner Switch - RSG2100
INSTRUMENT PANEL
PC/HMI
MASTER CONTROLLER
SLAVE CONTROLLER
DPAC
LINKS
LINKS
LINKS
LINKS
DC Supply MCBs
22kV X & Y MEF & BUEF
Panel 25
Proposed Cubicle Layout
DC Supply MCBs
X MEF
TR1 BUEF
TR2 BUEF
TR3 BUEF
Common BUEF & 'Y' MEF
SEL351A
X MEF - LINK RACK
Y MEF AND Y BUEF - LINK RACK
Y BUEF STAGE 2/3- LINK RACK
11kV FDR CB's CONTROL MCBs
EXISITNG
RELOCATE
NEW

4.3 Suggested Control Room Layout



4.4 Ethernet and Sub LAN connections




BAS-RSG-2100-11 (14x100FX ports)
BAS-RSG-2100-12 (16x100FX ports)
BAS-RSG-2100-13 (16x100FX ports)
BAS-RSG-2100-14 (16x100FX ports)
BAS-RSG-2100-15 (16x100FX ports)
BAS-RSG-2100-16 (16x100FX)ports)
F35
NEUT BUS CB MGMT
GPS CLK
EKI
HMII
SEL-2440
TR No1. I/O MGMT
SEL-2440
TR No2. I/O MGMT
SEL-2440
TR No3. I/O MGMT
RTAC
SEL3530
C30
NEUT BUS CB MGMT I/O Ext
VRR &TR PARALLEL
CONTROL SEL451
SEL-2440
GFN DPAC
SEL-2440
GFN DPAC
SEL-2440
GFN DPAC
RS400 devices connected in a Loop
No,.1 ELSPEC METER
No.2 ELSPEC METER
SEL-351S
66kV CB A CB MGT & CBF
SEL-351S
66kV CB B CB MGT & CBF
SEL-351S
66kV CB C CB MGT & CBF
SEL-351S
66kV CB D CB MGT & CBF
SEL-351S
TR No.1 CB MGT & CBF
SEL-351S
TR No.2 CB MGT & CBF
SEL-351S
TR No.3 CB MGT & CBF
SEL-351S
22kV BT1-2 CB MGT & CBF
SEL-351S
22kV BT2-3 CB MGT & CBF
SEL-351S
CAP 1 MGT
SEL-351S
CAP 3 MGT
SEL-351S
BAS11 FDR MGT
SEL-351S
BAS12 FDR MGT
SEL-351S
BAS13 FDR MGT
SEL-351S
BAS14 FDR MGT
SEL-351S
BAS21 FDR MGT
SEL-351S
BAS22 FDR MGT
SEL-351S
BAS23 FDR MGT
SEL-351S
BAS24 FDR MGT
SEL-351S
Future BAS31 FDR MGT
SEL-351S
Future BAS32 FDR MGT
SEL-351S
BAS33 FDR MGT
SEL-351S
BAS34 FDR MGT
No.1 STATION EF
MGMT SEL451
No.2 STATION EF
MGMT SEL451
No.3 STATION EF
MGMT SEL451

4.5 Proposed Protection Schematic