Protection of Embedded Generation

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Endeavour Energy

POWER together

Revision History

Nil.

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Contents

1. Introduction

This Company Standard specifies the electrical protection requirements for connecting permanent privately owned embedded generation (EG) to the Endeavour Energy low voltage (LV) distribution network. For further details regarding connection processes and associated timeframes, please contact the Endeavour Energy Customer Network Solutions team.

This document exclusively addresses protection requirements and does not cover additional technical aspects related to the connection, such as metering, power quality, inverter response modes, or communication systems. For guidance on these or any other topics not included in this document, please consult the Endeavour Energy Customer Network Solutions team.

1.1 Purpose of Document

This document specifies the protection requirements for low voltage embedded generators with a capacity of up to 1.5 MVA, which are registered as LV customers with Endeavour Energy. Proponents who are registered as high voltage (HV) customers with LV generation must adhere to Endeavour Energy's HV Embedded Generation guidelines – PDI5000 Part b. For systems with capacities beyond the scope of this document, a site-specific design must be developed in consultation with Endeavour Energy.

1.1.1 Connection Limits

The criteria for an LV Embedded Generation connection are detailed in Table 1 below:

- The system must be designed to connect to and operate in parallel with any part of the LV distribution network.
- The system must comply with all technical requirements outlined in this document.
- The system may consist of inverter-based Energy Systems (IES), rotating machines (synchronous or asynchronous LV EGs), and/or Energy Storage Systems (ESS), with a total system capacity as specified in Table 1.

Table 1: LV EG connection limits

Connection Type	Connection Voltage	Technology	Capacity
Low Voltage EG Connection	Up to 1 kV	Inverter based Energy Systems	≥ 30 kVA and <1.5 MVA three phase
		Non-Inverter based Energy Systems (rotating machine)	<1.5 MVA three phase or < the limit as per connection study for single phase

Consultation with Endeavour Energy's Secondary Systems section is only required for the following LV EG connections concerning protection requirements and review:

- Inverter-based generating systems with a capacity exceeding 500 kVA.
- Any rotating LV generating systems intending to operate in parallel with Endeavour Energy’s LV network.

1.2 Document Scope

This document is applicable to proposals for connecting LV EG systems to the Endeavour Energy network. It covers both new connections and modifications to existing LV EG systems.

The protection requirements specified in this document do not apply to the following system types:

- IES EG connections with a capacity of less than 30 kVA.
- EG units that are subject to Endeavour Energy's protection requirements for HV connected generators.
- Electric vehicles, unless the onboard battery storage system has the capability to export to the LV network, in which case the requirements outlined in this document shall apply.
- Distributed Energy Resources (DER) systems that do not generate electricity, such as demand response or demand management systems, unless they affect the ability of the LV EG system to meet the technical requirements.
- Systems that operate off-grid or in a non-parallel configuration (refer section 4.7.9 for break before make connection and section 4.7.10 for synchronise close transfer trip (SCTT) connection.

1.3 Obligations

Embedded Generation Proponents and Endeavour Energy have certain obligations for embedded generator connections.

Proponents are required to:

- Comply with the technical requirements as well as all relevant national standards, industry codes, legislation and regulations. In the event of inconsistency, legislation and regulations, followed by the technical requirements, followed by national standards and industry codes shall prevail.
- Refrain from connecting additional inverters, making modifications, or installing additional LV EG units, including ESS, without prior written consent from Endeavour Energy.
- Maintain compliance with the Endeavour Energy connection agreement.
- Ensure the requirements are met with regards to the design, installation and operation of the LV EG System.
- Meet the connection and commissioning requirements applicable to the LV distribution network.

Endeavour Energy has an obligation to ensure the safe and reliable operation of the distribution system for operating personnel, customers, and the general public.

1.4 Statement of Compliance

The protection requirements adhere to the National DER Connection Guidelines for Low Voltage EG connections. This document mainly addresses protection requirements, and any deviations from the ENA guidelines are detailed in Appendix A.

2. References

External Regulations
Electricity Supply Act 1995 (NSW)
Electricity Supply (Safety and Network Management) Regulation 2014
Work Health and Safety Act 2011 (NSW)
Work Health and Safety Regulation 2017 (NSW)
National Electricity Rules (NER)

External Standards		
Standard No.	Year	Title
AS 2067	2016	Substations and high voltage installations exceeding 1 kV a.c.
AS 3000	2018	Wiring rules
AS 5139	2019	Electrical Installations – Safety of battery systems for use with power conversion equipment
AS 5033	2021	Installation and safety requirements for photovoltaic (PV) arrays
AS 3010	2017	Electrical Installations – Generating sets
AS 4777.1	2024	Grid connection of energy systems via inverters part 1: Installation requirements.
AS 4777.2	2020	Grid connection of energy systems via inverters part 2: Inverter requirements
IEC 60255 (BS142)		Electrical relays
ENA DOC 001	2019	National Electricity Safety Code
ENA DOC 040	2022	Technical Guidelines for Low Voltage EG Connections

Company Policies and Procedures
Company Policy (Network) 9.2.2 – Network Protection

3. Definitions and Abbreviations

Definitions	
CB Fail	Circuit breaker fail
Connection Agreement	An agreement between Endeavour Energy and the proponent (Generation Company) by which the proponent is connected to the distribution network and/or receives distribution services.
Connection point	As defined in the NSW Service and Installation Rules. For this document, an agreed point of supply established between Endeavour Energy's network and the proponent's premises.
Distributed Energy Resources (DER)	Power generation or storage units that are connected directly to the distribution network.
EE Network	The Endeavour Energy network.
Embedded generator	According to the NER; a generator connected within a distribution network and not having direct access to the transmission network.

Energy storage system (ESS)	A system comprising one or more batteries or other energy storage devices that store electricity generated by distributed energy resources or directly from the grid, and that can discharge the electricity to loads.
HV	High Voltage (AC voltages greater than 1 kV nominal).
Islanding	Islanding occurs when a private generator or generating system remains connected to a portion of the network and continues to supply electricity to that portion of the network but is disconnected from the general electrical network or main source of generation.
LV	Low voltage (AC voltages less than 1 kV nominal).
MCCB	Moulded Case Circuit Breakers are protective devices used to interrupt and protect electrical circuits from overcurrent and short-circuits.
NER	National Electricity Rules.
Proponent	The party proposing the generating scheme, responsible for ownership and operation of the scheme.
Synchronism	Synchronism occurs when two (2) A.C. voltages are of the same frequency and magnitude and have zero phase difference.

Abbreviations	
AEMO	Australian Energy Market Operator
AS/NZS	A jointly developed Australian and New Zealand Standard
CEC	Clean Energy Council
DER	Distributed Energy Resources
EF	Earth fault protection (51)
EG	Embedded generation
HV	High Voltage
IEC	International Electrotechnical Commission
IES	Inverter energy system
IPSD	Inverter power sharing device
LV	Low Voltage
NER	National Electricity Rules
NVD	Neutral voltage displacement protection (59N)
OC	Overcurrent protection (51)
PU	Per unit
ROCOF	Rate of Change of Frequency
SCADA	Supervisory Control and Data Acquisition
SCTT	Synchronise, close, transfer trip operation

4. Technical requirements

4.1 Labelling and Signage

The labels and signs on the installation, including cables, shall be as per AS 4777.1, AS/NZS 3000 and AS/NZS 5033.

4.2 Maximum System Capacity

Refer to Table 1 for details of maximum system capacity.

4.3 Generation Control

4.3.1 Export Limit at Connection Point

The maximum export limit of LV EG connections is as per Table 1

The EG system's transfer capacity to the distribution network will depend on many factors including:

- Existing asset ratings.
- Power quality and the network connection voltage at the relevant network location
- Current and forecast DER penetration at the relevant network location

Export limits at connection point may be either static or dynamic.

- **Static Export Limits:** These are fixed limits that apply consistently at all times. For static export limits, the export limiting functionality may include both soft and hard limitation types, as defined in AS/NZS 4777.1.
- **Dynamic Export Limits:** These limits may vary based on time of day, daily fluctuations, or seasonal changes. For dynamic export limits, the connection point's net export limit should be considered a "soft" limit, which prompts the IES or rotating machine to reduce output to avoid exceeding the limit in response to network conditions. A "hard" limit is required only if the total EG rating exceeds the maximum allowed export of the system.

In all cases, if a fault or loss of operability is detected with the soft limit, hard limit control function or if an independent external device is used, the output from the LV EG must be reduced to zero or operate the automatic disconnection device within 15 seconds.

Where the soft limit is exceeded, the export limit control function shall operate to reduce the power output for the IES, multiple IES or rotating machine to the export limit of the electrical installation within 15 seconds. Similarly, if the hard export limit is exceeded, the control function shall operate to disconnect the IES , multiple IES or rotating machine within 15 seconds.

The export limit is to be interpreted by the proponent as a maximum. The ability of the proponent's LV EG system to export at the export limit is not guaranteed but rather, it will depend upon network characteristics which change over time.

For systems requiring SCADA connectivity as outlined in Section 4.7.12, a control system with appropriate metering at the connection point must be provided to ensure compliance with the site's export limit.

4.3.2 Site Generation Limit downstream of Connection Point

Endeavour Energy does not assess site generation limits downstream of the connection point.

4.4 Inverter Energy System

The IES connected to Endeavour Energy's LV network shall comprise of inverters that are:

- tested by an authorised testing laboratory and certified as compliant with AS/NZS 4777.2, including an accreditation number.
- registered with the Clean Energy Council (CEC) as approved grid-connect or multiple mode inverters.
- installed in compliance with AS/NZS 4777.1. Energy Storage System

An ESS, that is capable of supplying electricity to an electrical installation or the Distribution System is considered EE network connected, unless the inverter is installed behind a break-before-make switch compliant with AS/NZS IEC 60947.6.1.

For ESS systems deemed to be EE network connected:

- The ESS shall adhere to the requirements set forth in this Standard.
- Inverters for the ESS shall be installed in accordance with Section 4.4 of this Standard.
- The installation of the ESS shall comply with AS/NZS 5139.
- The following requirements apply to ESS inverters:
  - The inverter capacity of the ESS will be included in the aggregated nameplate rating of inverters located within the premises behind the Connection Point (as part of the Proponent's installation).
  - The export limit for the ESS inverter will be considered as part of the aggregated export limit at the Connection Point.
- If the ESS has the capability to charge from the network, the proposed system may be subject to specific limits for charging and constraints on the amount discharged back into the network. Endeavour Energy will determine these limits based on the connection study, asset ratings, and other relevant factors during the detailed design phase of the connection.

4.5 Network Connection and Isolation

The network connection and isolation requirements for IES and rotating machines must comply with AS/NZS 3000 and AS/NZS 4777.1. Although AS/NZS 4777.1 currently applies to IES systems, the same principles shall be applied to LV rotating machine embedded generation connections.

It is the proponents' responsibility to provide a connection point isolation device and all associated protection controls and ancillary equipment. The Proponent shall provide a means of isolation that is capable of disconnecting the whole of the EG System from the Distribution System.

In addition:

- **Mechanical Isolation:** As a minimum, mechanical isolation must comply with AS/NZS 3000, ensuring that the isolator is always readily accessible.
- **Lockable Isolation:** Any isolation that is lockable must only be capable of being locked in the open position.
- **Rotating Machine Isolation:** The network connection and isolation requirements for rotating machines will be determined by Endeavour Energy during the detailed design stage and may align with those required for IES.

4.6 Earthing

- For IES, earthing requirements shall be as per AS/NZS 4777.1 and AS/NZS 3000.
- For ESS, shall be earthed as per as per AS/NZS 5139 and AS 3011.
- For rotating machines, shall be earthed as per AS/NZS 3000 and AS/NZS 3010.

For LV systems, solid earthing principles must be applied.

The neutral busbar must be continuously connected to the source of supply and must also be locally earthed. Compliance with AS/NZS 3000 and the NSW Service and Installation Rules is required.

If a generating system can operate within an electrical island separated from the distribution network, the system must be equipped with an earthing system that provides adequate earthing independently of the distribution network.

4.7 Protection

To ensure the safe and reliable operation of the distribution network, embedded generating systems must be equipped with appropriate protection schemes.

Both primary and backup protection schemes, as defined in Table 2 must operate separate isolation devices. Faults occurring on the generator side may not be detected by Endeavour Energy's upstream protection systems. Consequently, all faults within the generating plant must be cleared by local protection mechanisms.

It is essential for generator circuit breakers (CBs) to include Circuit Breaker Failure (CBF) protection. CBF protection can be implemented in two ways:

- **Dedicated CBF Scheme**: This involves a dedicated CBF scheme designed to trip upstream circuit breakers, thereby disconnecting the generator from the Endeavour Energy network.
- **Independent Circuit Breakers**: Alternatively, primary and backup protection schemes may be configured to trip independent circuit breakers.

Both approaches ensure that faults within the generating plant are isolated effectively, maintaining the integrity of the distribution network.

4.7.1 Connection Point/LV Incomer Protection requirement:

Coordination with Upstream Protection: The protection scheme at the connection point must be coordinated with the existing upstream protection provided by Endeavour Energy for short circuits.

Complete Local Protection: The generation installation must have complete protection independent of Endeavour Energy's protection, unless otherwise negotiated. The protection scheme at the connection point should act as backup only and must operate if the local downstream protection or circuit breaker fails to operate, or for faults within the proponent's installation, before the downstream protection. Endeavour Energy requires that any fault within the embedded generating system be detected and isolated from the Endeavour Energy network as quickly as practical, without reliance on Endeavour Energy's network protection. The proponent is responsible for assessing and managing the risks associated with potential failure of their connection point CB.

4.7.2 LV Embedded Generator protection requirements:

The proponent must adhere to relevant Australian standards, regulations, and industry best practice for the protection of generators and associated equipment. All protection systems for the generating system must be designed with fail-safe principles, ensuring that affected generating units, or the entire generating system, are automatically disconnected from the network if any protection element (including its backup system, where applicable) fails.

Endeavour Energy does not assume responsibility for the proponents internal generation protection requirements unless these affect the network and potentially impact other customers. However, the following level of protection must be provided as part of the embedded generation connection:

Table 2: LV EG Protection Requirements

Protection	EG System	Protection Location
Primary	IES	Inverter integrated protection according to AS/NZS 4777.2:2020
Primary	Rotating machine	LV rotating machine EG integrated protection

Interface Protection	IES, rotating machine	As per section 4.7.5

4.7.3 Inverter Integrated Protection

The inverter integrated protection requirements for inverters connected to the Distribution System shall comply with AS/NZS 4777.2 for active anti-islanding requirements. Active anti-islanding protection shall be enabled.

Other inverter settings including passive anti-islanding settings shall be set according to the settings below, corresponding to the 'Australia Region A' settings of AS 4777.2:2020 standard.

Table 3: LV EG IES Inverter Integrated Protection

Protection Function	Protection Setting	Trip Delay Time	Maximum Disconnection Time
Undervoltage 2 (V<<)	70V	1s	2s
Undervoltage 1 (V<)	180V	10s	11s
Overvoltage 1 (V>)	265V	1s	2s
Overvoltage 2 (V>>)	275V	-	0.2s
Sustained Over Voltage (V>) (10min Average)	258V	-	3s
Under Frequency 1 (F<)	47Hz	1s	2s
Over Frequency 1 (F>)	52Hz	-	0.2s
Active Anti-Islanding	ON, Method: Frequency shift / Frequency Instability / Power Variations / Current injection		2s
Reconnection	No sooner than 60 seconds after the EE network supply is restored as per AS 4777.2:2020.		

Rate of change of frequency (ROCOF) and Vector shift shall comply with the withstand requirements of AS4777.2:2020 section 4.5.5 and section 4.5.6 i.e.:

a) Vector Shift – Inverters shall remain in continuous operation for a single-phase vector shift of 60 degrees and three phase vector shift of 20 degrees.
b) ROCOF – inverters shall maintain continuous operation for ROCOF that do not exceed 4HZ/s for a duration of 0.25s.

4.7.4 LV rotating machine EG integrated protection

LV rotating machine EG integrated protection refers to protection mechanisms configured directly on the rotating machine EG, incorporating passive anti-islanding elements. For example, for a diesel generator, this involves protection programmed directly into the diesel generator controller.

In some schemes, the connection point may include duplicate passive anti-islanding and short circuit protection, while the generator itself will only have generator-specific protection functions. Both approaches are acceptable. If duplicate central protection is provided at the connection point, the fail-safe arrangements are not required.

The settings for LV rotating machine EG protection shall be calculated by proponents based on the generator characteristics and shall be submitted to Endeavour Energy for review and approval during the detailed design phase of the project.

Table 4: LV rotating machine EG Integrated Protection

Protection Function	Requirements: Protection setting, trip delay time, maximum disconnection time
Undervoltage 2 (V<<)	The outer limits that will be considered acceptable for LV EG rotating machine integrated protection or LV EG rotating machine interface protection are defined in Table 8 – passive anti islanding setting - LV EG rotation machine part. Set points may be chosen as required to suit the proponent's generator/installation within these limits. LV EG rotating machine integrated protection are to be at least as sensitive and at least as fast as the backup protection setting.
Undervoltage 1 (V<)	
Overvoltage 1 (V>)	
Overvoltage 2 (V>>)	
Under Frequency 1 (F<)	
Over Frequency 1 (F>)	
ROCOF Note1	
Vector Shift Note1	
Synch Check	To be proposed by proponent as per manufacturer's specifications and synchronising method
Generator Pole Slip	To be proposed by proponent as per manufacturer's specifications
Current/Voltage Unbalance	To be proposed by proponent as per manufacturer's specifications
Reconnection	No sooner than 60 second after the EE network supply is restored and correctly synchronised

Note 1: The proponent must accept that ROCOF and Vector Shift protection may trip for system disturbances and fault events within and external to the local network that the generator is connected to. Experience has shown that it is difficult to set these schemes to avoid nuisance tripping whilst providing adequate protection.

4.7.5 Interface Protection

Although AS/NZS 4777.1 currently only applies to IES EG systems, the interface protection requirements will be as per AS/NZS 4777.1 for all LV EG connections including:

- LV EG IES connections greater than 200 kVA

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- LV EG rotating machine connections

Operation of any interface protection element must result in disconnection of the generator from the Endeavour Energy network via a suitably rated CB / CBs or disconnection devices as required, preferably an embedded generation common coupling breaker or disconnection device to avoid site load interruption.

The interface protection for parallel generators shall be designed as a minimum to:

a) Coordinate multiple IES or rotating machine EG installation for one point of supply from Endeavour Energy's network. Where there are both IES and rotating machine EG Systems connected at a single point of supply, two Interface protections are allowed to be installed where one Interface protection relay shall coordinate all IES, and one Interface protection relay shall coordinate all rotating machine EGs.
b) Provide protection for all inverters or IES EG using one device and rotating machine EG using one device within one point of supply from the Endeavour Energy's network.
c) Provide backup islanding protection to the Endeavour Energy's network.
d) Be integrated in a way that it is fail safe, and the EG system do not generate while the interface protection is out of service.
e) Preserve safety of EE network personnel and general public.
f) Reference a single point that is located on the electrical installation between main switch (EE network supply) and all IES or rotating machines EG within the electrical installation.

Exception: Where a residential electrical installation has an IES or multiple IES with aggregated rated apparent power greater than 200 kVA that is part of a multiple electrical installation that is connected to a single point of supply from the grid, with separate consumers and separate IES at different electrical installations, each of the separate IES connected to the same single point of supply from the grid may not be subject to Clause 4.7.5(a) and (b) of this standard.

AS4777.1:2024 specifies additional requirements for inverter power sharing device (IPSD). These devices are typically used where it is not practical to install an individual IES to each electrical installation within a multiple electrical installation. The interface protection shall be installed for IPSD with a connected aggregated inverter rated apparent power greater than 30kVA. IPSD systems shall fulfill the installation, compliance, control and protection requirements specified in AS4777.1:2024.

The following table shows interface protection requirements for exporting and non-exporting LV EG IES and rotating machine EG systems.

Table 5: Interface Protection Requirements

Protection Requirements	LV EG IES		LV EG rotating machine	
	>200[Note 3] kVA			
	Exporting	Non-Exporting	Exporting	Non-Exporting
Grid Reverse power (32R)	-	✓	-	✓
Generator Circuit phase balance protection (46/47)	-	-	-	-
Overcurrent facility fault, EE network fault and earth fault protection (50/51) (Note 1)	-	-	✓	✓
Passive anti-islanding protection (27U/O, 59 U/O, 81U/O, 81R)	✓	✓	✓	✓

Intertripping	×	×	×	×
Power Limit Protection (Note 2)	-	-	-	✓
Grid Low Forward Power	×	×	×	-
Neutral Voltage Displacement (NVD)	-	-	✓	-

Symbols are used to denote protection requirements where:

✓ Represents protection shall be required.

- Represents protection may be required.

× Represents protection shall not be required.

Note 1: For LV EG IES or LV EG rotating machine, Overcurrent & Earth fault protection can be a part of Interface protection or a separate relay. OCEF functionality within Interface protection is not mandatory for LV EG IES.

Note 2: Non-export or Partial- export system must meet the requirements specified in section 4.7.5.6 of this standard.

Note 3: >30kVA for IPSD.

4.7.5.1 Reverse Power Protection

Reverse power protection must be configured to monitor power flow towards the network, where required. This protection should be set as low as practicable, considering the accuracy of the protection relay, current transformers (CTs), and the generating system's synchronisation characteristics. The design of control systems should aim to minimise reverse power flow immediately following synchronisation.

The specific settings for grid reverse power protection shall be determined through a connection-specific technical assessment conducted by the proponent and approved by Endeavour Energy.

Table 6: Grid Reverse Power Protection

System	Protection	Pickup Setting	Trip Delay
No Export EG	Grid Reverse Power (32R)	To be finalised during connection technical assessment	

4.7.5.2 Phase Balance Protection

If required for LV EG rotating machine, specific settings for current unbalance or voltage unbalance will be determined by a connection specific technical study.

For LV IES EG system, the inverters shall comply with the current imbalance requirements specified in AS4777.2:2020.

4.7.5.3 Overcurrent Facility Fault, Overcurrent EE Network Fault and Earth Fault Protection

LV incomer/Connection point earth fault (EF) protection is not required for LV applications as it is unlikely that the upstream protection (the LVCB or fuse of the Endeavour Energy Distribution Substation) will provide EF protection. The OC protection provided by the Moulded case circuit breakers (MCCBs) can be considered sufficient.

For IES EG systems, the requirement for overcurrent & earth fault protection within Interface protection is not mandatory and may not need to be in a fail safe arrangement. Overcurrent and earth fault protection is only required to detect the fault within the proponent's installation and grade with upstream protection. There is no requirement for overcurrent and earth fault to detect faults external to generating system for IES EGs.

For rotating machine EG systems, the overcurrent & earth fault protection is required to detect faults within proponent's site and for faults on the LV network. Directional protection may be advised by Endeavour Energy based on the connection study. This shall be part of Interface protection or separate relay but shall be in fail-safe arrangement. The setting shall grade with existing protection systems.

4.7.5.4 Passive anti-islanding Protection

Passive anti-islanding protection shall be implemented for LV EG systems as per Table 7 and Table 8.

Table 7: LV EG Passive Islanding Setting - IES

Protection Function	Protection Setting	Trip Time Delay	Maximum Disconnection Time
Over voltage (V>)	267 V	2.5 s	3 s
Under voltage (V<<)	69 V	2.5 s	3 s
Under voltage (V<)	179 V	11.5 s	12 s
Over frequency (F>)	52Hz	1 s	1.5 s
Under frequency (F<)	47Hz	2.5 s	3 s
ROCOF Note1	4Hz/s	0.5 s	1 s
Reconnection	Interface protection shall reconnect the disconnection device only after meeting the conditions in accordance with AS4777.2:2020.		

Table 8: LV EG Passive Islanding Setting - Rotating Machine

Protection Function	Protection Setting	Trip Time Delay
Over voltage (V>)	265 V	2 s
Under voltage (V<)	180 V	2 s
Over frequency (F>)	52Hz	2 s
Under frequency (F<)	47Hz	2 s
ROCOF Note1	1Hz/s	1 s
Vector Shift Note1	8 degrees	-
NVD (Neutral Voltage displacement)	20% (of nominal phase to earth voltage)	<2 s
Reconnection	No sooner than 60 seconds after the EE network supply is restored and correctly synchronised	

Note 1: The proponent must accept that ROCOF and Vector Shift protection may trip for system disturbances and fault events within and external to the local network that the generator is connected to. Experience has shown that it is difficult to set these schemes to avoid nuisance tripping whilst providing adequate protection

4.7.5.5 Intertripping

The Endeavour Energy network is not equipped to facilitate intertripping for generators connected at LV.

4.7.5.6 Power Limit Protection

Power limit protection shall be installed at the connection point or upstream of all embedded generator units within the Connection point for systems where:

- The embedded generation system has been approved by Endeavour Energy as either a Non-export or Partial export system and does not employ a soft or hard control as described in section 4.3.1.
- Proponent's load and charging of ESS exceeds the upstream asset rating.
- It is deemed necessary during the connection specific technical study.

4.7.5.7 Network Low Forward Power

Non-export generating systems are designed to ensure that all generated electricity is consumed within the Proponent's premises and are not intended to export power to Endeavour Energy's distribution network.

Grid low forward power protection shall be used as an alternative to intertrip protection to detect islanding events. In cases where a non-export generation system is designed to operate in island mode, this protection can trip the connection point CB in the event of a loss of network supply, while still allowing the generation system to supply power to the proponent's premises. The specific CB to be tripped should be nominated by the proponent.

The low forward power function must also be configured to operate in conjunction with reverse power protection.

This protection must be installed in a fail-safe arrangement, unless duplicated protection is provided.

4.7.5.8 Low DC Volts / Control Volts protection

The CB associated with generator central protection must be tripped immediately if the protection and control voltage (DC or AC) drops below a level that cannot guarantee the reliable operation of protective devices and CB tripping. This may necessitate the installation of undervoltage coils or capacitor tripping units to ensure the relevant CB trips as required.

4.7.5.9 Fail-Safe Tripping

The generating system is to automatically disconnect from the network in the event of the failure of any supplies and relay failure that would inhibit the correct operation of the protection equipment.

The protection and control circuits must be a fail-safe design to ensure that the EG system is completely isolated upon loss of supply from the network.

The disconnection device shall operate within 5 s when the interface protection is interrupted by either of any power supply operation failure, loss of control signal to disconnection device, internal fault of the protection device, protection relay watchdog contact. Where a wireless communication channel or device is used the communication link shall be supervised. The delay to operation of the disconnection device due to wireless link should not exceed 0.5s.

4.7.6 Interlocking

The interaction, interlocking, and safe operation of different types of generation downstream of the point of connection shall be the responsibility of the Proponent.

4.7.7 Synchronisation

Synchronising check before closing is required for rotating machine LV synchronous generators. The generator must parallel with the EE network without causing a voltage fluctuation at the network connection point greater than +/5% of the prevailing voltage level at the network connection point.

Requirements:

a) **Automatic Reconnection**: Synchronous generators connected at LV may use synchronising facilities to automatically reconnect the generation plant following a system disturbance no sooner than 60s after the main supply is restored.
b) **Protection Against Dead Bus**: For LV connected synchronous generators, protection must be provided to prevent the generator circuit breaker from closing onto a de-energised (dead) bus. The Generator circuit breaker may be closed onto a dead bus provided that mechanical interlocks are used to prevent the generator output energising the Endeavour Energy network without the correct synchronisation process occurring.
c) **Correct Synchronisation**: Under no circumstances is the generator circuit breaker allowed to be closed without being correctly synchronised.
d) **Supervision of Synchronising VTs**: Synchronising VTs must be supervised to prevent the generator circuit breaker from being closed during VT failure. Monitoring of VT supply fuses is considered adequate.

Synchronising facilities are not required for Asynchronous generators and/or inverter systems which are not configured for Islanding operation.

For IES EG systems designed for islanding operation such as Battery ESS, synchronising check is required before closing to the Endeavour Energy network when transitioning from islanded operation to EE network connection.

4.7.8 Additional Requirements for LV-EG rotating machine

Main and backup anti-islanding protection shall be provided for rotating machine systems to ensure the generating system is disconnected from the network when the distribution network is de-energised.

One option is by duplicating the anti-islanding relays as close as practicable to connection point. These relays can use the same VT provided that the circuits are separately fused, duplicate DC system and trip separate trip coils.

The other option is to apply the anti-islanding protection on generating units as main protection similar to inverter integrated protection and operate individual generator circuit breakers. Backup islanding protection shall be applied in Interface protection and operate the generator common coupling breaker without disturbing the site load.

NVD protection is required at the HV side of the upstream distribution transformer where practicable. This shall use a protection class 3 phase, 5 limb broken delta VT or three single phase VTs. NVD may be exempted for non-export generation with grid low forward power protection scheme implemented.

NVD, primary & backup protection shall be integrated in a way that it is fail safe and disconnect the generating system in case of relay failure or AC or DC Supply failure or tripping circuit failure.

4.7.9 Requirements for non-parallel operation generators

Operating aspects for non-parallel (alternative) operation include:

- inadvertent parallel connection cannot be made under any circumstances.
- mechanical interlocks and suitable deliberate time delays are required between the opening and closing of the change-over circuit breakers;
- provision of a fail-safe design so that one circuit breaker cannot possibly be closed if the other circuit breaker in the change-over sequence is closed;
- connection must be made on the load side of metering equipment;
- switchgear to allow manual or automatic changeover must be located on or adjacent to the switchboard supplying the electrical load; and
- where automatic switch-on and connection of the generator system is possible, suitable warning hazard notices must be openly displayed at appropriate locations.

4.7.10 Requirements for Synchronise Close Transfer Trip (SCTT) generators

Usually, the conditions that apply to this arrangement are:

- a written assurance that the generator will be used for standby supply only.
- the generator will run only in parallel with Endeavour Energy's network when switching the generator on and off for generator testing for changeover purposes.
- the period for operation in parallel with the network for any circumstance must be no longer than 1 second as per the NSW Service and Installation Rules.
- a blocking scheme must be provided to prevent the generator circuit breaker closing onto a de-energised network while the main switch (or another suitable switch) is closed.
- manual synchronisation, where employed, must be supervised by a check synchronisation relay; and
- a 60 second timer must be included to prevent the installation load from being transferred back to the network following loss of network voltage and to confirm the network is stable before load is returned to the network from the generation system.

The 1 second period must include: synchronising with the electrical network; increasing the generator load to the desired test level; and isolation from the network.

The period for reconnection includes synchronising the generator with the network; removing the generator load; and disconnecting the generator.

4.7.11 Operating Voltage and frequency

Operating and sustained Voltage and frequency range requirements can be found in Table 3 and Table 4.

Endeavour Energy's Customer Network Solutions team shall be consulted by proponent for voltage rise, frequency withstand and frequency response limits applicable to the connection.

4.7.12 Remote monitoring and control systems

Remote monitoring and control requirements, where applicable, must comply with Endeavour Energy's ADI 0002 Customer Connection SCADA standards.

4.7.13 Technical Studies

Endeavour Energy Secondary Systems team shall only be consulted for LV EG IES having capacity greater than 500 kVA or LV EG rotating machine of any size for detail review and assessment.

Generators in parallel with the network may raise fault levels beyond the fault rating of existing installed equipment. Calculations of the contribution of the generation plant to fault levels on the network may be required to determine:

- fault level contribution by the generator.
- the impact on neighbouring installations and customers; and
- the level of protection required because of changed fault levels.

The proponent will be responsible for all costs associated with:

- the required system studies.
- upgrading of Endeavour Energy protection facilities where required primarily because of the connection of generation; and
- changes to their protection settings where required.

The proponent must ensure that the LV EG system, regardless of type, coordinates with Endeavour Energy's upstream protection.

The proponent should consult with Endeavour Energy's Customer Network Solutions team to determine the studies requirements for power quality, power flow, or other related aspects.

5. Exclusion from Scope

The following items are excluded from the scope of this standard. For guidance or inquiries regarding these matters, please consult Endeavour Energy's Customer Network Solutions team:

- Power factor control
- Metering
- Power quality
- Data and information
- Fee and charges
- Model connection agreement

6. Testing and Commissioning

Endeavour Energy's Customer Network Solutions team shall be consulted for advice regarding the testing and commissioning requirement for connection.

All protection equipment associated with the generator must be tested and verified on site prior to connection to the network. The commissioning test results must be forwarded to Endeavour Energy's Customer Network Solution team five working days before the connection of supply is required.

7. Operation and Maintenance

All protection equipment associated with the generator must be tested at least once every three (3) years, or as specified by the Generator Connection Agreement.

Settings of the protection relays and control equipment or associated wiring must not be altered unless written authorisation is received from Endeavour Energy.

Protection equipment must comply with the relevant parts of IEC 60255 or equivalent.

8. Responsibilities

Head of System Operations has the authority and responsibility for:

- Approving this standard.

Secondary Systems Manager has the authority and responsibility for:

- Endorsing this Standard

Delivery Manager Secondary Systems has the authority and responsibility for:

- Keeping this Standard up to date in accordance with Company Procedure GAM 0001 – Network Standards Framework: Preparation and Amendment of Network Standards.
- Overseeing the implementation of this standard within the Secondary Systems Delivery section.
- Approving exceptions to this standard, provided that the exceptions are compliant with Company Policy 9.2.2 – Network Protection.

Senior Protection Engineer

- As is applicable for a Protection Engineer (listed below).
- Approving designs which are compliant with this standard.

Protection Engineer/Specialist and Secondary Systems Development Specialist/Engineer

- Maintaining familiarity with and for complying with the requirements of this Standard with respect to Protection work.

Customer Network Solutions Employees

- Maintaining familiarity with and complying with the requirements of this standard.

Appendix A: Deviations from National DER Connection Guidelines

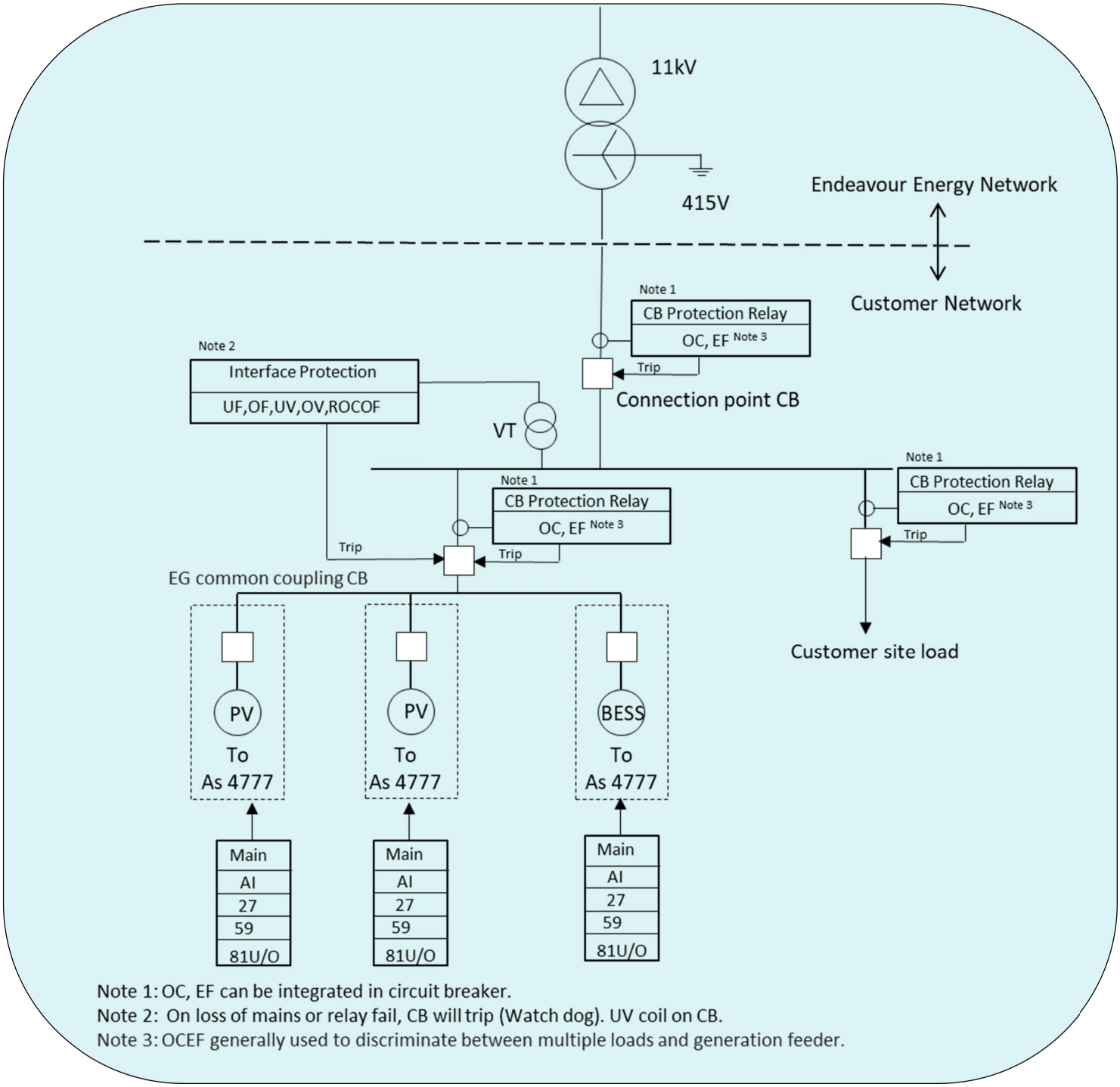
Table 9: Table of Deviations from National DER Connections Guidelines

Section	Description of deviation	Type of deviation	Justification
1.2,2.3.1,4.2,4.4	Removed exclusion for ESS in both total system capacity and export limits for IES. Included a new sub-section 4.4.1 for additional information regarding ESS.	Improvement	Endeavour Energy requirement
2.3	Subcategories section not included	Administrative	To improve readability
3	Endeavour Energy documents included	Administrative	Identification of documents applicable to Endeavor Energy
4.4.1	Addition of section 'Energy Storage Systems'	Improvement	Endeavour Energy requirement
4.7.1	Inverter settings included	Improvement	To improve readability
4.7.1a	Requirements for LV EG integrated protection added	Improvement	Endeavour Energy requirement
4.7.2.4	Settings included for IES EG	Improvement	To improve readability
4.7.2, 4.7.2.2	Synchronous generator phase balance is not required at a Central Protection level.	Improvement	Duplication of generating unit level protection for central protection is not required for Grid Protection. A Proponent can avoid additional costs by only having to design and locate this protection at the generating unit level.
4.7.2.6	Power limit protection is added	Improvement	Provides another design option for certain scenarios
4.7.6	Included NVD protection requirement for rotating machines in a new subsection.	Improvement	Ensures best practice safety compliance for HV faults.
4.7.7	Addition of section for non-parallel generators	Improvement	Endeavour Energy requirement
4.7.8	Addition of section for SCTT generators	Improvement	Endeavour Energy requirement

Appendix B: Connection Arrangement Requirements

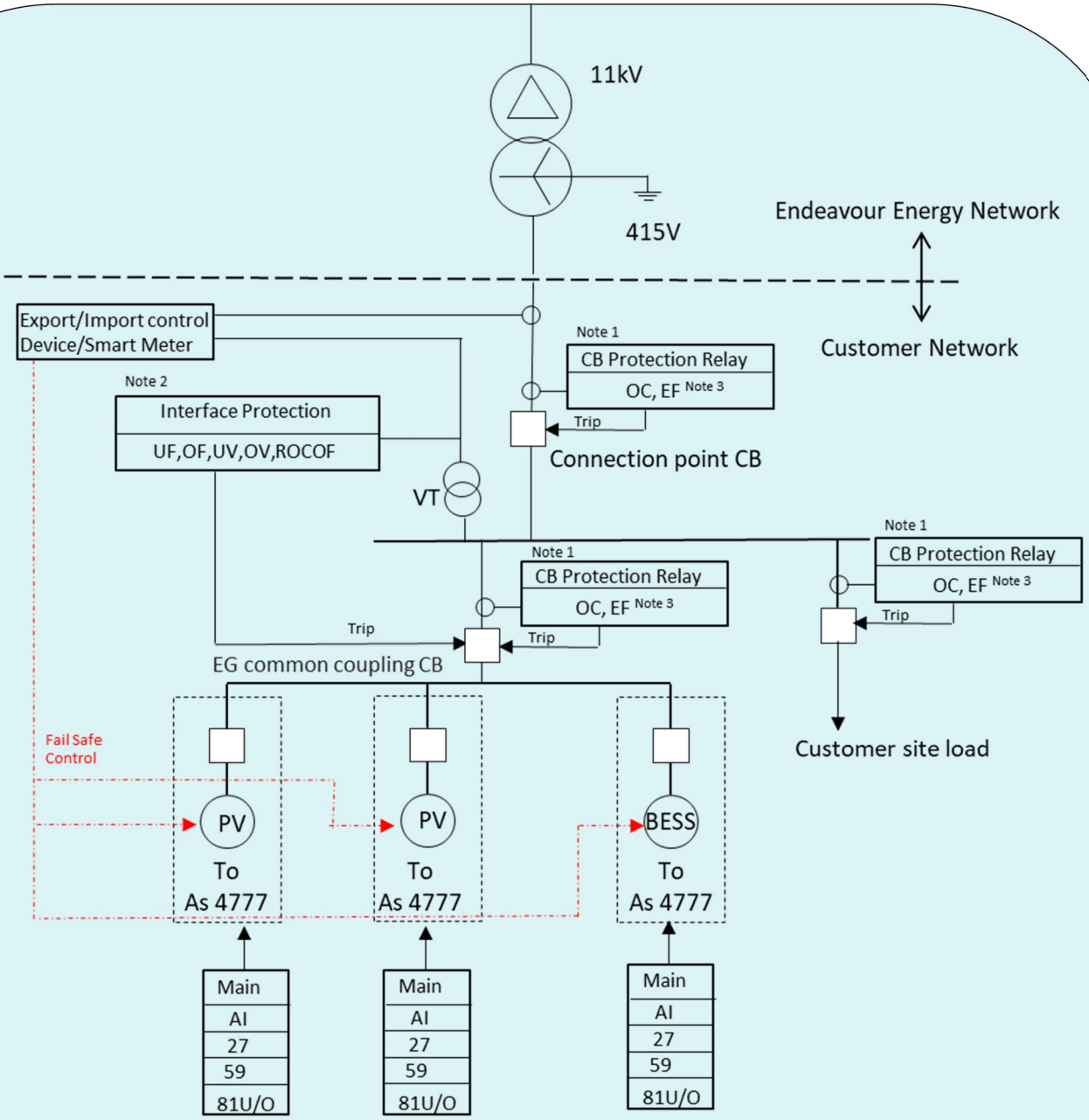
The following are examples of typical connections which meet the requirements of this standard. These are examples only. The specific design will be a function of the proponent's network and may require different arrangements.

Example 1: >200kW export inverter connected at 415V



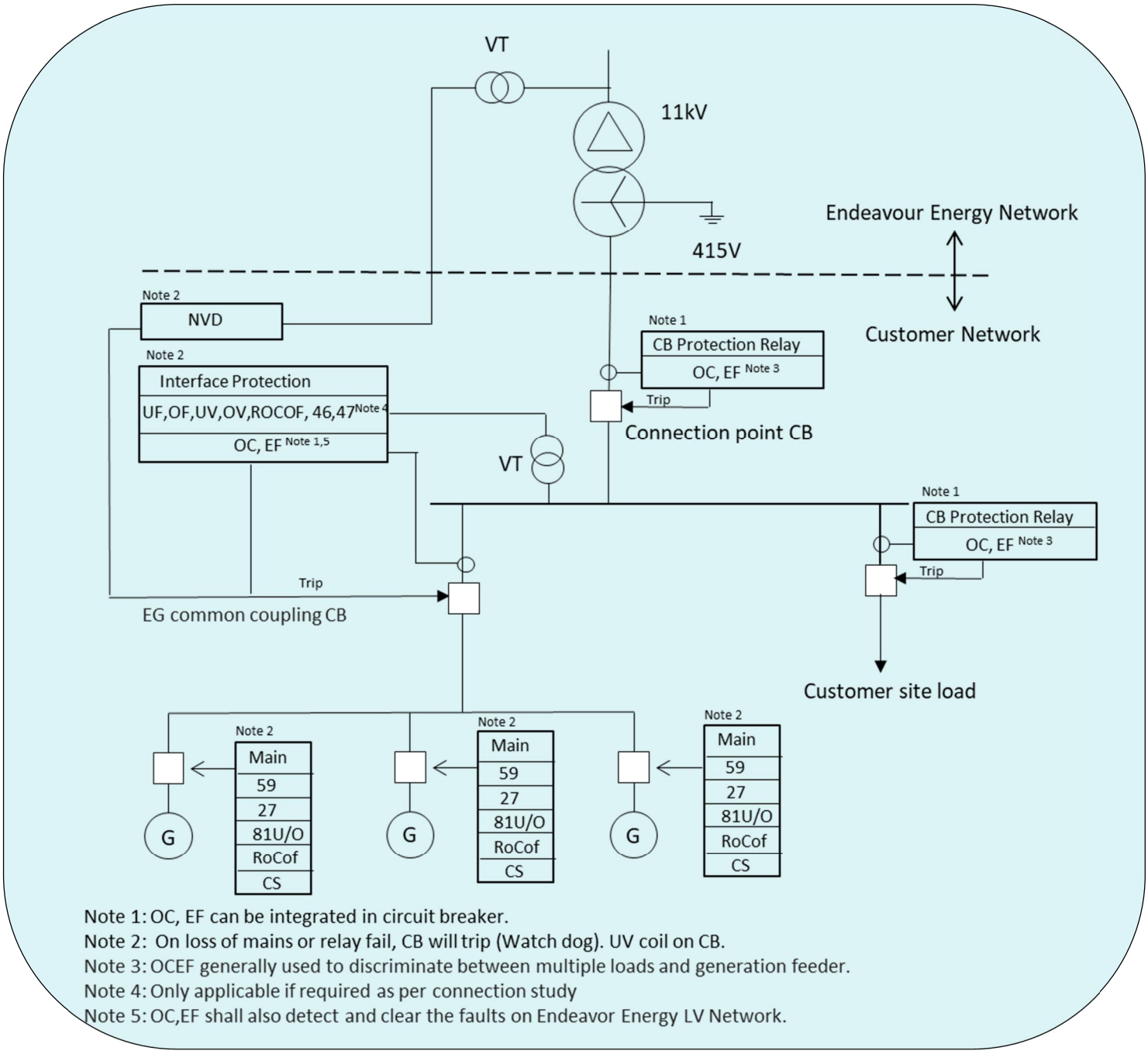
Note 1: OC, EF can be integrated in circuit breaker.
Note 2: On loss of mains or relay fail, CB will trip (Watch dog). UV coil on CB.
Note 3: OCEF generally used to discriminate between multiple loads and generation feeder.

Example 2: >200kW export inverter connected at 415V with export/import limit



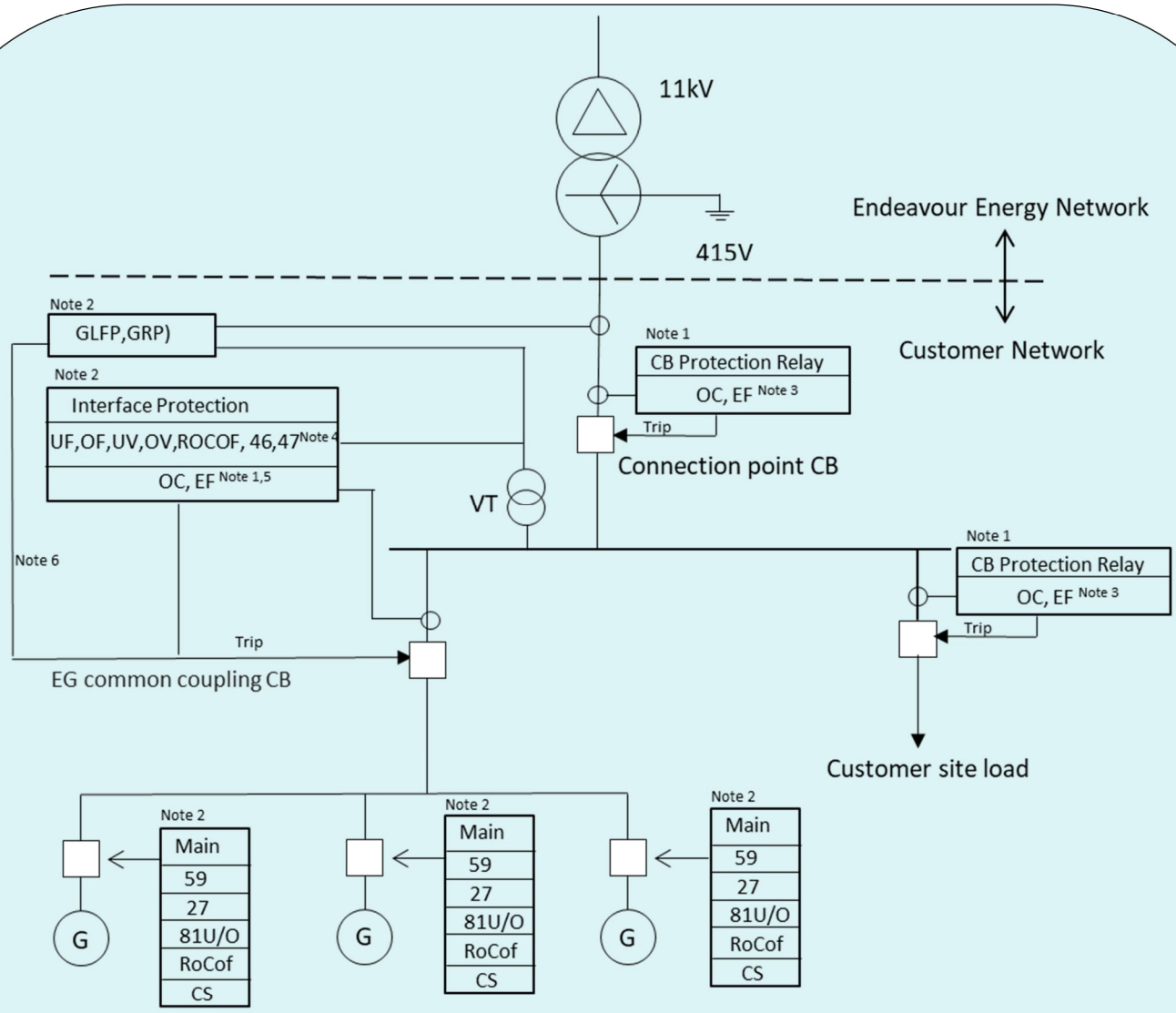
Note 1: OC, EF can be integrated in circuit breaker.
Note 2: On loss of mains or relay fail, CB will trip (Watch dog). UV coil on CB.
Note 3: OCEF generally used to discriminate between multiple loads and generation feeder.

Example 3: Export rotating generator connected at LV



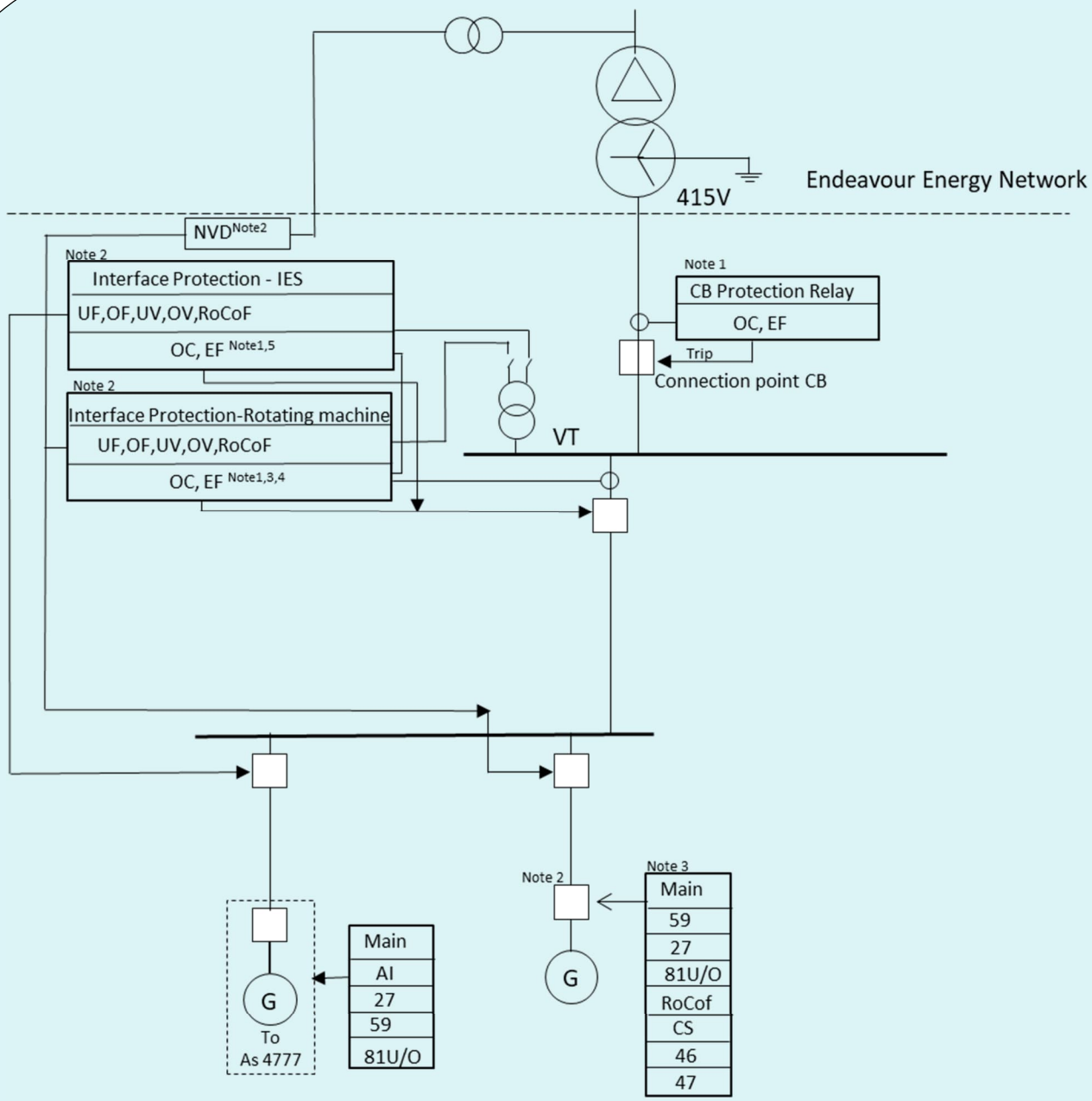
Note 1: OC, EF can be integrated in circuit breaker.
Note 2: On loss of mains or relay fail, CB will trip (Watch dog). UV coil on CB.
Note 3: OCEF generally used to discriminate between multiple loads and generation feeder.
Note 4: Only applicable if required as per connection study
Note 5: OC,EF shall also detect and clear the faults on Endeavor Energy LV Network.

Example 4: No export rotating generator connected at LV



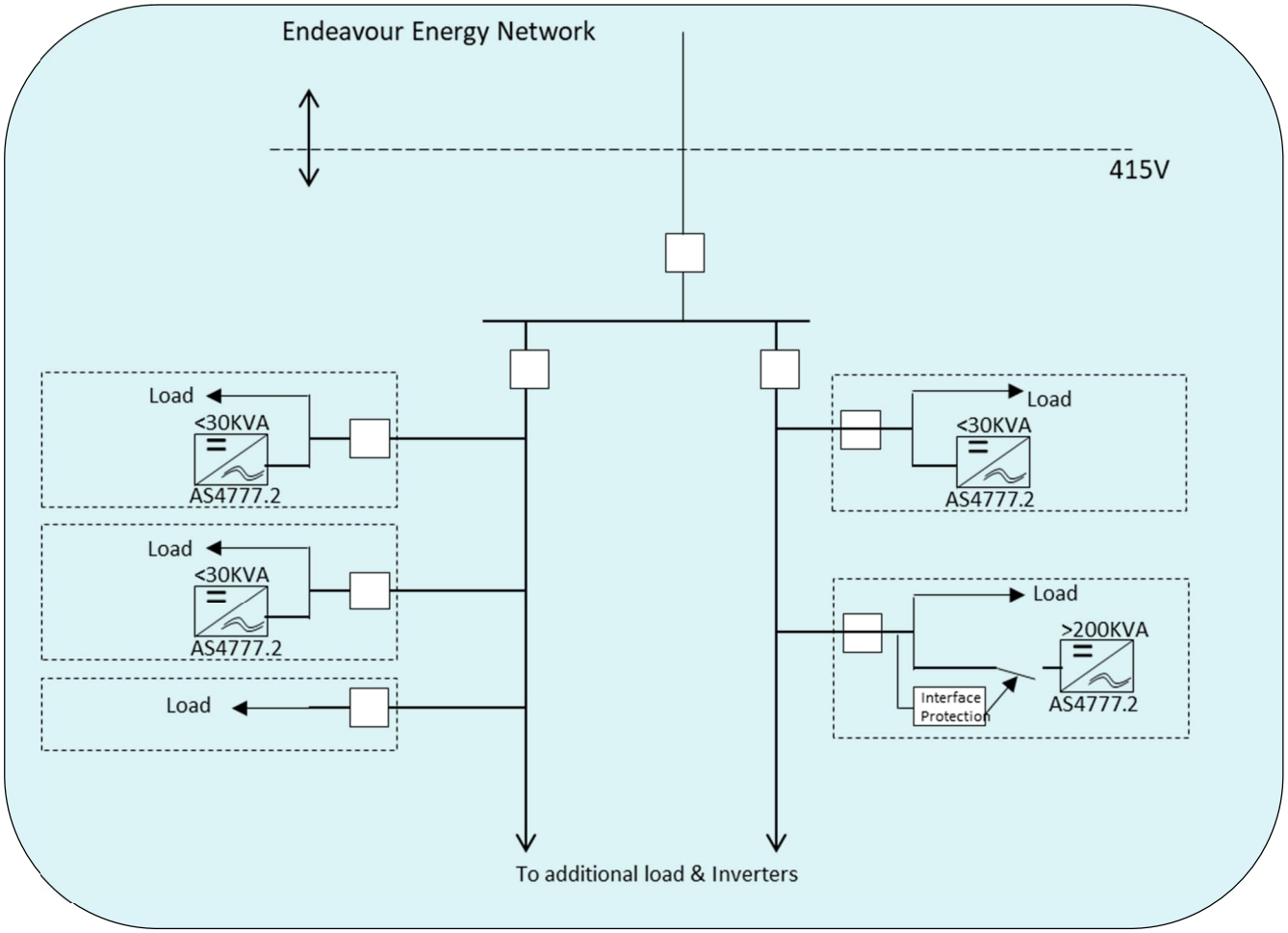
Note 1: OC, EF can be integrated in circuit breaker.
Note 2: On loss of mains or relay fail, CB will trip (Watch dog). UV coil on CB.
Note 3: OCEF generally used to discriminate between multiple loads and generation feeder.
Note 4: Only applicable if required as per connection study.
Note 5: OC,EF shall also detect and clear the faults on Endeavor Energy LV Network.
Note 6: GLFP,GRP trip signal is representative only. The circuit breaker to be tripped by GLFP,GRP relay is to be nominated by Proponent.

Example 5: Export rotating generator and Inverter generator (Different ride through capabilities)



Note 1: OCEF generally used to discriminate between multiple loads and generation feeder.
Note 2: On loss of mains, OCEF(non-IES) or relay fail, CB will trip (Watch dog). UV coil on CB. Unless duplicate scheme.
Note 3: CBF either by CBF scheme or back up clearance by upstream relays.
Note 4: OCEF shall detect the fault on Endeavour Energy LV Network.
Note 5: OCEF can be a separate relay. Fail Safe arrangement for of OCEF function is not mandatory for IES.

Example 6: Multi Customer Residential Cluster at 415V



Appendix C: Static data and information

Refer to the latest version of Endeavour Energy static data and information checklist generator connection.

Endeavour Energy

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