Branch Procedure: Generator Connection Protection Guidelines CEOP8012

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31 May 2021 – Issue 6
Approved By: Network Substations Manager
Next review date: May 2024
UNCLASSIFIED

CONTENTS

1.0 PURPOSE

This document has been developed for the use of Essential Energy employees and Generator Proponents to allow a uniform application of Protection schemes for the connection of Private Generation to the Essential Energy system.

This document details the minimum protection requirements for private generation connected to the Essential Energy network. The protection specified is primarily for the protection and security of the Essential Energy network and does not specifically cover protection for the Generation Equipment. Essential Energy shall not be responsible for the protection of the Generation Equipment.

This document details the minimum protection requirements for private generation connected to the Essential Energy network.

These requirements shall apply to all Generating equipment to be connected to the Essential Energy network apart from;

i) Small scale inverter based generation referred to in the Service and Installation rules of NSW.
ii) SCTT Synchronous generators meeting the requirements of 8.4 in the service and installation rules of NSW
iii) Small scale inverter based generation in compliance with AS4777 (Grid Connection of Energy Systems via Inverters).

2.0 ACTIONS

2.1 Protection Design Requirements for Generators

2.1.1 Aspects to be Coordinated

The following shall be coordinated between Essential Energy and the generation proponent:

- protection and backup (including both the generating plant and the Essential Energy network effected by the new generator plant);
- control characteristics;
- communications and alarms;
- switching and isolation facilities;
- fault levels; and
- design at point of connection.

2.1.2 General Generator Protection Requirements

Protection of generators shall be sufficient to disconnect the generator from the network in the event of a fault.

The generator proponent shall provide protection and controls to achieve, including under circuit breaker fail conditions, the following functions:

- SEPARATION of the generation plant from the network in the event of operation of the generator protection.
- SEPARATION of the generation plant from the network in the event of loss of supply to the generating station from the network.
- PREVENTION of the generator plant from energising or de-energising a portion of the network without prior agreement from Essential Energy.

- PROTECTION of the generation plant installation without reliance on backup from Essential Energy's protection, other than where Essential Energy owns the CPCB in accordance with 'R2' of section 2.3.
- SEPARATION of the generation plant from the network in the event of the generator drawing more than the agreed MW/MVAr demands from the grid for a specified time.

2.1.3 Generator Synchronising

Where required, manual or automatic synchronising at the generator circuit breakers shall be provided. Prior to the initial synchronisation of the generating plant to the grid, the generation proponent and Essential Energy shall agree on the operation procedures to be followed for synchronisation.

2.1.4 System Islanding

The generation proponent shall ensure that islanding of generating plant together with part of the Essential Energy network cannot occur upon loss of supply from the network. This should not preclude a design which allows the generation supplier to island its own generation and plant load, thereby maintaining supply to that plant.

In the event of an agreement to use the generator to supply part of the network as an islanded system, the system must be adequately protected by Main Protection schemes. Protection shall include synch checking, overvoltage and earth fault protection, providing coverage for all system voltage levels in the islanded system.

Typical protection and controls systems installed to provide anti islanding monitoring:

- Rate of change of frequency.
- High/low frequency.
- Sustained high/low voltage.
- Vector shift.
- Active and Passive anti islanding systems within inverters.

2.1.5 System Earthing

System earthing requirements will vary depending on network location and configuration and shall be determined in conjunction with Essential Energy. Connections to the transmission and subtransmission network have the option to either contribute earth fault current (for example, using an earthed star winding or earthing transformer) or not contribute earth fault current (for example, using a delta connection). There will however be exceptions to this, where a certain type of connection will be required, and each connection will need to be analysed by Essential Energy to determine the system earthing requirements.

When the connection is on a distribution network, then Essential Energy require that the generator does not contribute earth fault current to the network. An example of an acceptable connection to an 11 kV distribution network would be a connection via an 11 kV delta of a Dy transformer.

If, where agreed by Essential Energy, the generator does contribute earth fault current to the Essential Energy network, the method of earthing (eg solid, impedance, etc.) shall be determined in conjunction with Essential Energy and must be consistent with the method of earthing used in the portion of the Essential Energy network the generator will be connected to.

2.1.6 National Electricity Rules

All generation connections shall comply with the National Electricity Rules. Particular attention shall be paid to clause S5.1a.8 Fault clearance times for connections above 100 kV.

2.2 Minimum Protection Requirements for the Connection of Generating Equipment to the Essential Energy Network

The minimum protection requirements for the connection of Generating Equipment to the Essential Energy network shall be assessed on the basis of each of the following:

- Network Connection – Either Distribution, Subtransmission or Transmission as defined within this document;
- Nominal Connection Voltage;
- Generator Rated MVA; and
- Type of Plant (Synchronous, Induction or Inverter).

A table listing the minimum requirements is provided in Section 2.2.1 and shall be interpreted as follows:

- **Network Connection** – The part of the network that the Generator connects to. This shall be Distribution, Subtransmission or Transmission as defined within section 4 of this document.

- **Type of Plant –** "RS" for Rotating Synchronous Generators, "RI" for Rotating Induction Generators (provided they cannot be self-excited), "IES" for Inverter Energy System.

- **Requirement** – The protection requirement. Refer to Section 2.3 for detailed particulars of these requirements.

- **Requirement Ref** – A reference number for the specific protection requirement.

- **Requirement Symbol Codes** – The symbol codes in the following table shall be interpreted as follows:

  M – Mandatory Requirement

  X – Not specifically required, but not prohibited

  P – Prohibited - shall not be used /installed

  C, C1, C2 etc – Requirement subjected to certain conditions - Refer applicable notes in Section 2.3

  RS – Rotating synchronous machines

  RI – Rotating asynchronous machines, with or without rotor circuit inverters (Induction & DFIG)

  IES – Inverter based (Excluding DFIG asynchronous machines)

2.2.1 *Table 2.2.1 – Minimum Protection Requirements for all generator connections excluding those stated in section 2.0.*

Network Connection		Low Voltage			Distribution			Subtransmission OR Transmission		
Type of Plant		RS	RI	IES	RS	RI	IES	RS	RI	IES
Requirement	Ref									
Protection Analysis Report	A1	M	M	M	M	M	M	M	M	M
Switching Station Connection	R1	X	X	X	C	C	C	M	M	M
Connection Point CB (CPCB)	R2	M	M	M	M	M	M	M	M	M
Generator CB (GCB)	R3	M	M	M	M	M	M	M	M	M
Anti - Islanding Protection	R5	M	C	M	M	C	M	M	C	M
CPCB OC (51) Protection	R8	M	M	M	C	C	C	C	C	C
CPCB EF (51N) Protection	R9	C2	C2	C2	C1	C1	C1	C1	C1	C1
CPCB Inst OC (50) Protection	R10	C	C	C	C	C	C	X	X	X
CPCB Inst EF (50N) Protection	R11	C	C	C	C	C	C	X	X	X
CPCB NVD (59N) Protection	R12	C3	C3	C3	C1	C2	C1	C1	C2	C1
CPCB Negative Phase Seq OC (46) Protection	R14	X	X	X	C1	C2	C1	C1	C2	C1
Duplicated CPCB protection	R15	X	X	X	X	X	X	M	M	M
Reverse (32R) / Low Power (32L) Relay	R18	X	X	X	M	M	X	M	M	X
Synchronising Check (25) Before closing GCB	R19	M	X	X	M	X	X	M	X	X
Block Close GCB onto dead line/bus	R20	M	C	X	M	C	X	M	C	X
Synchronising VT Supervision	R21	M	X	X	M	X	X	M	X	X
Auto Reclose (79) on GCB or CPCB	R22	P	P	P	P	P	P	P	P	P
GCB OC (51) Protection	R23	M	M	M	M	M	M	M	M	M
GCB (51N) Protection	R24	C	C	C	M	M	M	M	M	M
Local Backup (CB Fail) for GCB by CPCB	R25	X	X	X	M	M	M	M	M	M
Backup (CB Fail) for CPCB	R26	X	X	X	C	C	C	C	C	C
Low DC Volts/ Control Volts (27S) Protection	R27	M	M	M	M	M	M	M	M	M
Manual Close of GCB	R28	P	P	P	P	P	P	P	P	P
Undervoltage (27) Protection	R29	M	M	M	M	M	M	M	M	M
Overvoltage (59) Protection	R30	M	M	M	M	M	M	M	M	M
Underfrequency (81U) Protection	R31	M	M	M	M	M	M	M	M	M
Overfrequency (81O) Protection	R32	M	M	M	M	M	M	M	M	M
Rate of Change of Frequency (81R) Protection	R33	M	C1	C2	M	C1	C2	M	C1	C2

Vector Surge/Shift (96) Protection	R34	M	C1	C2	M	C1	C2	M	C1	C2
Protection Maintenance Plan	R35	M	M	M	M	M	M	M	M	M
High Speed Protection of CP Voltage Equipment	R37	X	X	X	X	X	X	M	M	M

2.3 Generator Protection Requirements Detail

Requirement	Ref	Detail
Protection Analysis Report	A1	A protection analysis report shall be provided by the Generator Proponent and should clearly address with supporting evidence each of the relevant items R1->R37 detailed in this policy. In addition, the report shall address the following: i Provide maximum and minimum connection point fault level contributions. ii Provide positive, negative and zero-sequence source impedances of the generating plant or the equivalent for inverter based current contributions. iii Demonstrate no impact to existing feeder near/far end and backup clearing times, unless specifically approved by Essential Energy.
Switching Station Connection	R1	A switching station shall be required where a generator connects into an existing subtransmission or transmission line. In this case a switching station shall consist of CB's on all connected circuits. A switching station will also be required for tees into a distribution line for generation >1MVA. In this case a switching station shall consist of CB's on all connected circuits, although an incoming CB (ZS side) may be omitted if protection studies show that upstream backup can be achieved without it (**C**). These requirements ensure that the feeder protective devices are able to be set to operate in a satisfactory time by segmenting the feeder using CB's. This requirement shall be deemed to be complied with if the generator is connected through its own dedicated feeder from a zone substation or is connected through a tee with a three way line differential scheme.

Requirement	Ref	Detail
Connection Point CB (CPCB)	R2	A connection point CB (CPCB) shall be placed as close as practically possible to the Connection Point. The CPCB shall be suitably rated for the system voltage, maximum load current and to interrupt the prospective asymmetrical fault current. Where duplicate protection requirements dictate, the CPCB shall be fitted with a second trip coil. No equipment associated with the generation system (other than instrument transformers and isolation switches) may be located between the CPCB and the connection to the Essential Energy network. Where multiple generators are installed, only one CPCB need be installed. Where a switching station is provided for the connection of a generating plant and duplicate intertripping between the generating plant and the switching station is provided, the CB feeding the generating plant at the switching station may be deemed to be the Connection Point CB. Such a decision is at the sole discretion of Essential Energy. For connection of a single generation source where the customer has no other load on the generator side of the Generator Circuit breaker, and the generator circuit breaker is at the connection point, Essential Energy may at its sole discretion deem the generator CB to be the Connection Point CB.
Generator CB (GCB)	R3	A GCB shall be installed between the CPCB and any individual Generator. In the case of inverter based systems, the GCB may be considered to be one or more CB(s) installed between the CPCB and the generator, for the purposes of protecting the generating plant (including associated cables and transformers) The GCB shall be suitably rated for the service voltage, maximum load current and to interrupt the prospective asymmetrical fault current. The GCB shall normally only be closed when the generator is running and synchronised to the network or, in the case of an asynchronous generator, the rotor is being driven at sufficient speed to cause generation (see also R18 & R20). This does not preclude the closing of the GCB (without synchronising) provided adequate precautions and operating systems are in place to ensure the output of the generator cannot become paralleled with any Essential Energy supply.

Requirement	Ref	Detail
Anti - Islanding Protection	R5	Anti-Islanding systems shall be installed to ensure that the generation plant is disconnected from the network on the loss of supply from Essential Energy under all load and generation scenarios. Anti-islanding shall operate 1.0 (one) second faster than the time of upstream auto reclosing and shall not exceed 4.0 (four) seconds. Essential Energy feeders are provided with Auto-Reclose and are not fitted with synchronising checking. It is the responsibility of the Generating Plant operator to ensure that effective generator disconnection occurs within the prescribed time. For inverter connected generators and other inverter energy sources, active anti islanding protection in addition to passive anti islanding protection should be considered. Where active anti islanding protection is not used the passive anti islanding protection in sections R29->R34 shall be assessed by the generator proponent and reasonably demonstrated to Essential Energy. A range of scenario's should be assessed, and this shall include but is not limited to; high, medium, and low generation with realistic loads that are as aligned to the generation profile as practical. Where a generator proponent cannot demonstrate disconnection in the times above, an intertripping scheme will be required. **C** – Anti-Islanding protection is not required for induction machines provided it can be determined that the generator is NOT capable of self-exciting.
CPCB OC (51) Protection	R8	A three phase overcurrent device shall be provided to trip the CPCB for generating plant or Essential Energy network faults. For Low Voltage systems, the required overcurrent protection may be integrated in the CPCB provided that an inverse-time operating characteristic is available. For all other systems, the required overcurrent protection shall be capable of IEC 60255 IDMT operating characteristics. The CT (or similar current sensing device) shall be located as near as practical to the CPCB and be suitably rated to avoid saturation under worst case fault conditions. This device shall be set to effectively operate for phase-phase faults on the Essential Energy network. Where effective operation cannot be ensured due to low generator fault current capacity, a voltage controlled overcurrent device (or element) may be required. The device will need to coordinate with Essential Energy upstream protection settings. **C** – CPCB OC is not required where additional local protection is installed for the purposes of protection of the Essential Energy network. For example, a switching station connection with appropriate feeder distance and busbar differential protection.

Requirement	Ref	Detail
CPCB EF (51N) Protection	R9	An Earth Fault device shall be provided to trip the CPCB for generating plant faults, and Essential Energy network faults (for instances where earth fault current can return to the generating plant). For Low Voltage systems, the required earth fault protection may be integrated in the CPCB provided that an inverse-time operating characteristic is available. For all other systems, the required Earth Fault protection shall be capable of IEC 60255 IDMT operating characteristics. The CT (or similar current sensing device) shall be located as near as practical to the CPCB and be suitably rated to avoid saturation under worst case fault conditions Where a generator contributes earth fault this device shall be set to effectively operate for earth faults on the Essential Energy network. Where effective operation cannot be ensured, due to low generator fault current capacity, a voltage controlled earth fault device (or element) may be required. The device will need to coordinate with Essential Energy upstream protection settings. **C1** – CPCB EF is not required where additional local protection is installed for the purposes of protection of the Essential Energy network. For example, a switching station connection with appropriate feeder distance and busbar differential protection. **C2** – For Low Voltage systems which reticulate a neutral, this required earth fault protection will not work, and thus is not required.
CPCB Inst OC (50) Protection	R10	Where required, an instantaneous overcurrent device shall be provided primarily for tripping the CPCB for generating plant faults. This protection might be required on distribution networks if high speed protective devices are used upstream. The same CT's/Current sensors as the CPCB OC protection should be used. **C** – Compliance with this requirement is not mandatory provided that all sections of the generating plant, which may prospectively be within the range of upstream high speed protection, are fitted with instantaneous differential protection. **X** – Compliance not required as Generator will be covered by satisfying the requirements of R37.

Requirement	Ref	Detail
CPCB Inst EF (50N) Protection	R11	Where required, an instantaneous earth fault device shall be provided primarily for tripping the CPCB for generating plant faults. This protection might be required on distribution networks if high speed protective devices are used upstream. The same CT's/Current sensors as the CPCB EF protection should be used. **C** – Compliance with this requirement is not mandatory provided that all sections of the generating plant, which may prospectively be within the range of upstream high speed protection, are fitted with instantaneous differential protection. **X** – Compliance not required as Generator will be covered by satisfying the requirements of R37.
CPCB NVD (59N) Protection	R12	Neutral voltage displacement protection shall be required for detection of earth faults, should the Essential Energy supply be lost whilst the generator is in service. In such instances, the power system will be operating without being connected to earth. The neutral voltage displacement relay shall be supplied by a VT connected between the CPCB and the generator transformer. Where multiple CPCB's exist, the system must be designed such that it is not possible for the generating plant to energise the Essential Energy network without a NVD VT being energised. **C1** – This protection is not required on subtransmission networks which are effectively earthed on the Essential Energy side via, a star generator transformer winding or an earthing transformer, provided it can be shown that the "CPCB EF (51N)" protection (refer requirement "R8") is capable of tripping the CPCB for earth faults on the Essential Energy network, with only the generator contributing to the fault. **C2** – NVD protection is not required for induction machines provided it can be determined that the generator is NOT capable of self-exciting and continuing to run without generator protection operating. **C3** – This protection is not required for Low Voltage systems which reticulate a neutral.
CPCB Negative Phase Seq OC (46) Protection	R14	CPCB Negative Phase Sequence (NPS) OC protection is primarily required for additional protection of the Essential Energy network for phase-earth and phase-phase faults, whilst the generating plant is synchronised with the Essential Energy network. The CT's/Current sensors for the NPS OC shall be in the same location (or the same CT) as those required for OC (51) protection. **C1** – This protection is not required where it is proven that other forms of protection can provide sufficient clearance of all faults on the Essential Energy network. **C2** – NPS protection is not required for induction machines provided it can be determined that the generator is NOT capable of self-exciting and continuing to run without generator protection operating.

Requirement	Ref	Detail
Duplicated CPCB protection	R15	Duplicated CPCB protection (ie No2 Protection) is required where the possibility of failure of one CPCB device may result in major supply loss or damage to the Essential Energy network. Where required by table 1, the devices that shall be duplicated are: i CPCB OC (51) Protection. ii CPCB EF (51N) Protection. iii CPCB NVD (59N) Protection. iv CPCB NPS (46) Protection v High speed CP protection as required by section R37. Note that the requirements for duplicated protection shall be deemed to be complied with, provided that each of the protection functions listed above are active in at least two (2) physically separate protection devices. Where current based protection is required to be duplicated, the No1 Protection and No2 Protection shall use different CT cores. Where voltage based protection is required to be duplicated, both protections may share a VT output, provided they are fused separately.
Reverse / Low (32R/32L) Power Relay	R18	This protection is required to prevent the generator from being run as a motor in the event of loss of prime mover Typically this protection should operate the relevant GCB.
Synchronising Check (25) Before closing GCB	R19	Synchronising equipment must be provided to ensure that the generator supply and the Essential Energy supply are within limits with regards to: i Voltage ii Phase angle iii Phase rotation prior to the Generator Circuit Breaker being closed.
Block Close GCB onto dead bus	R20	Protection shall be provided to prevent the GCB being closed onto a de-energised bus. The GCB may be closed onto a dead bus provided that mechanical interlocks are used to prevent the generator output energising the Essential Energy network, without the correct synchronisation process occurring. **C –** The stator of an induction machine shall not be energised by closing the GCB unless the rotor is being driven at sufficient speed to cause generation.
Synchronising VT Supervision	R21	Synchronising VT to be supervised in order to prevent GCB being closed during a VT failure. Monitoring of the VT supply fuses/CB is considered adequate.
Auto Reclose (79) on GCB or CPCB	R22	Under no circumstances is automatic reclosure of the GCB or CPCB allowed following a protection trip.

Requirement	Ref	Detail
GCB OC (51) Protection	R23	An overcurrent device shall be provided to trip the GCB for generating plant faults. For Low Voltage systems, the required overcurrent protection may be integrated in the GCB provided that an inverse-time operating characteristic is available. For all other systems, the required overcurrent protection shall be capable of IEC 60255 IDMT operating characteristics. The CT (or similar current sensing device) shall be located as near as practical to the GCB and be suitably rated to avoid saturation under worst case fault conditions. Where the GCB is the same as CPCB in accordance with section R2 then the GCB OC will need to comply with section R8 and R10.
GCB EF(51N) Protection	R24	An Earth Fault device shall be provided to trip the GCB for generating plant faults. For Low Voltage systems, the required earth fault protection may be integrated in the GCB provided that an inverse-time operating characteristic is available. For all other systems, the required Earth Fault protection shall be capable of IEC 60255 IDMT operating characteristics. The CT (or similar current sensing device) shall be located as near as practical to the GCB and be suitably rated to avoid saturation under worst case fault conditions. Where the GCB is the same as CPCB in accordance with section R2 then the GCB EF will need to comply with section R9 and R11. **C** – For Low Voltage systems which reticulate a neutral, the specified earth fault protection will not work, and thus is not required.
Local Backup (Circuit Breaker Fail) for GCB by CPCB	R25	Faults on the generator side of the generator transformer may not be detected by Essential Energy upstream protection, therefore it is required that all faults in the generating plant be cleared by local protection. A single CB generation site allowed under R2 will be exempt from this requirement provided it can be proven that a CB fail can be covered remotely. Each GCB shall be provided with Circuit Breaker Failure protection which shall trip the relevant CPCB(s) in the event that a particular GCB fails to operate. A GCB shall be allowed a maximum of 0.5 seconds to operate following a trip, unless required otherwise by the NER. If GCB operation does not occur within this time, the CPCB's must be tripped immediately.

Requirement	Ref	Detail
Backup (Circuit Breaker Fail) for CPCB	R26	**C** – Essential Energy cannot guarantee backup of the generation site for faults on the generator side of the CPCB. It is the responsibility of the generation owners to do the following; a) For connection voltages above 100kV to ensure that suitable CB fail measures are put in place. b) For connection voltages below 100kV to assess the hazard caused by the failure of the CPCB to both the generating site and Essential Energy network and determine appropriate measures to mitigate the risk. Such steps may include: i) Duplication of the CPCB ii) Communication assisted intertripping to a remote CB (generator operating restrictions on communication failure may be required unless communications are duplicated) iii) Installation of fault thrower (subject to Essential Energy approval and suitability of Essential Energy network to have fault thrower fitted).
Low DC Volts/ Control Volts (27S) Protection	R27	The CPCB(s) must be tripped immediately in the event that the Protection Control Voltage (DC or AC) drops below a level at which operation of protective devices and CB tripping can be guaranteed. This may require the installation of undervoltage coils in the CPCB or capacitor tripping units to trip the CPCB. The two above requirements shall be deemed to be complied with if two separate DC batteries and chargers (“systems”) are installed, with the first “system” supplying the No1 CPCB protection and the second “system” supplying the No2 CPCB protection An alarm for low Protection Control voltage shall be installed.
Manual Close of GCB	R28	Where sync checking is required (refer to R19) under no circumstances is a GCB allowed to be closed without being correctly synchronised. An exemption to this will be during maintenance and with agreement by Essential Energy. All generation will need to be isolated to prevent the generator output energising the Essential Energy network, without the correct synchronisation process occurring.
Undervoltage (27) Protection	R29	Undervoltage protection is required to ensure that generator volts are maintained within specified limits. Undervoltage protection must measure the CP voltage and must result in the tripping of the GCB, or the CPCB.
Overvoltage (59) Protection	R30	Overvoltage protection is required to ensure that generator volts are maintained within specified limits. Overvoltage protection must measure the CP voltage and must result in the tripping of the GCB, or the CPCB.
Underfrequency (81U) Protection	R31	Underfrequency protection is required to ensure that generator frequency is maintained within specified limits. Underfrequency protection operation must result in the tripping of the GCB, or the CPCB.

Requirement	Ref	Detail
Overfrequency (81O) Protection	R32	Overfrequency protection is required to ensure that generator frequency is maintained within specified limits. Overfrequency protection operation must result in the tripping of the GCB, or the CPCB.
Rate of Change of Frequency (81R) Protection (ROCOF)	R33	Rate of change of frequency protection shall be provided for the prevention of islanding. **C1** – Rate of Change of Frequency protection is not required for induction machines provided it can be determined that the generator is NOT capable of self-exciting and continuing to run without generator protection operating. **C2** – ROCOF protection is not required for an inverter based generator where the proponent considers the requirements of section R5 can be met by active or passive inverter anti islanding systems.
Vector Surge/Shift (96) Protection	R34	Vector Surge/Shift protection shall be provided for the prevention of islanding. **C1** – Vector Surge/Shift protection is not required for induction machines provided it can be determined that the generator is NOT capable of self-exciting and continuing to run without generator protection operating. **C2** – Vector surge/shift protection is not required for an inverter based generator where the proponent considers the requirements of section R5 can be met by active or passive inverter anti islanding systems.
Protection Maintenance Plan	R35	A protection maintenance plan and record shall be produced by the Generator Owner detailing: i Frequency of Protection Maintenance. ii Records of Protection Maintenance and relay testing. iii Storage of Protection settings. iv Storage of Protection settings reports.
High Speed Protection of CP Voltage equipment	R37	High speed (less than 2 cycle operation) protection shall be provided for all generator site assets beyond the CPCB which are energised at the CP voltage. Examples of such protection would be busbar and transformer differential protection. In the case of transformers, this protection shall extend to at least the transformer secondary terminals. This is to permit the use of high speed distance protection upstream.

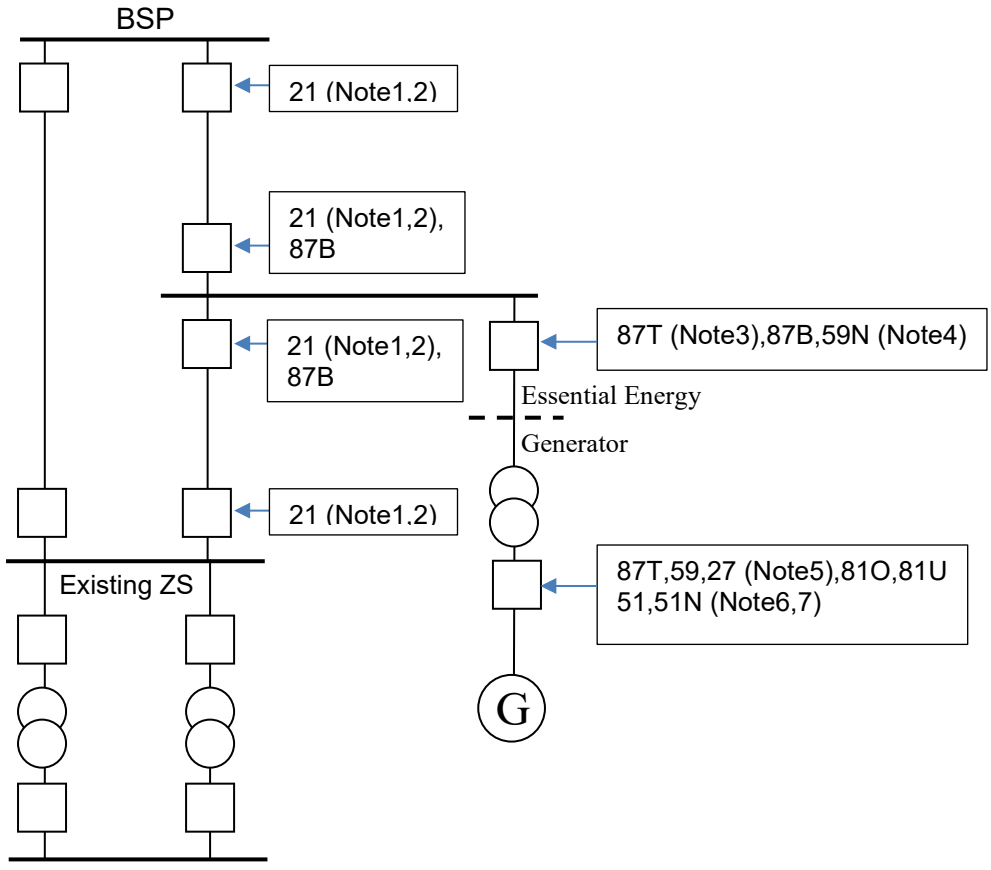
2.4 Example Generator Connections Compliant with Section 2.2 & 2.3

The following diagrams are some examples of connections compliant with Section 2.2 and 2.3 of this document. In case of ambiguity, the requirements of sections 2.2 & 2.3 shall take precedence.

Explanation of symbols and terminology used in the following diagrams and notes.

21 – Distance Protection
87T – Transformer Differential Protection
87B – Busbar Differential Protection
59N – Neutral Displacement Protection
59 – Over Voltage Protection
27 – Under Voltage Protection
81U – Under Frequency Protection
81O – Over Frequency Protection
51 – Overcurrent Protection
51N – Earth Fault Protection

2.4.1 Subtransmission line connection via a 3 way switching station



Note1: Where the subtransmission feeder is >100kV then duplicated communicated assisted distance or line differential will be required instead of distance. If single communications are used protection will need to meet NER clearing times for loss of communications.

Note2: Where one feeder is substantially shorter than another differential protection may be required to avoid time coordinating zone 2 protections.

Note3: Essential Energy to own the connection breaker and supply CT's to the generator for duplicated transformer differential protection.

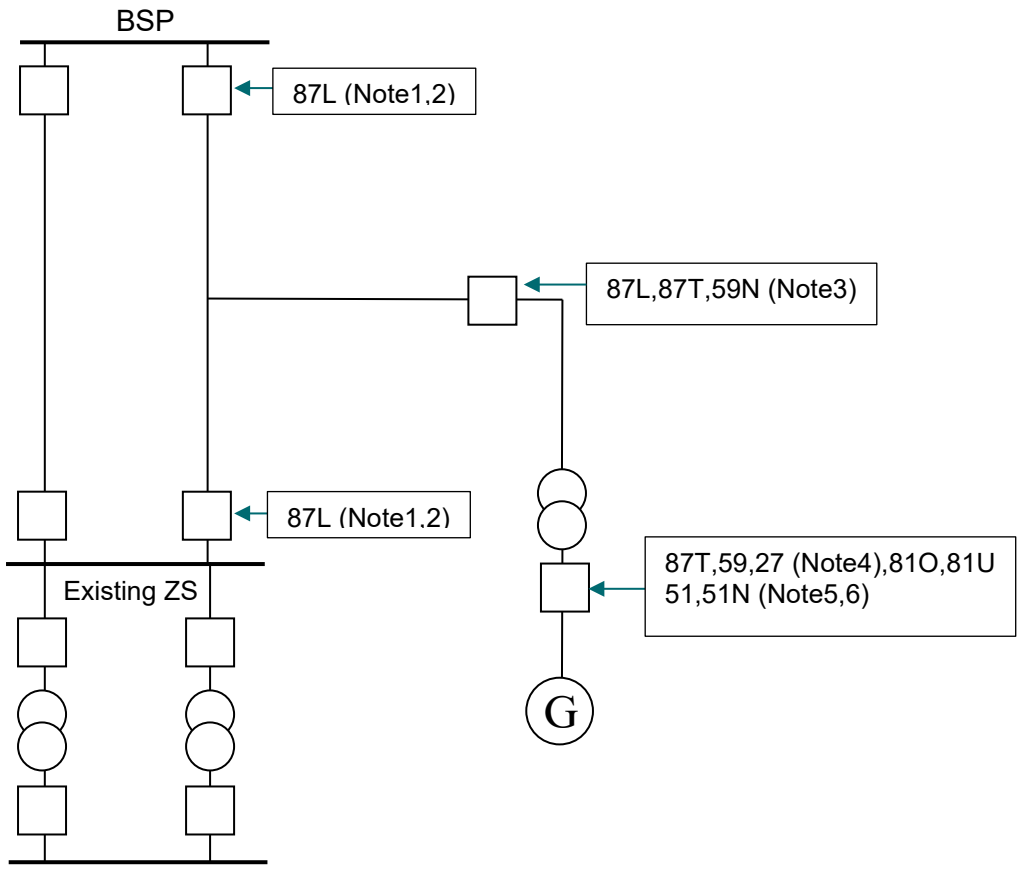
Note4: Neutral voltage displacement protection is conditional. Refer to section R12.

Note5: Under and over voltage elements are to measure the connection point voltage.

Note6: Where upstream distance relays see into the generators secondary bus then clearing times on the secondary network will need to be fast enough to ensure coordination. In some cases, this may require less than 100ms relay operating times.

Note7: Other generator protection may be required depending on generation type.

*2.4.2 **Subtransmission line connection via a direct line Tee***



Note1: Where the subtransmission feeder is >100kV then duplicated line differential with duplicated communications are required.

Note2: Where the subtransmission feeder is <100kV then duplicated line differential with duplicated communications is advised. If single communications is used then distance backup will need to be sufficient to cover all line faults including the consideration of generator infeed. Distance backup will also be required to see the generator secondary bus for CB fail, this will not be possible if earth fault limitation is used.

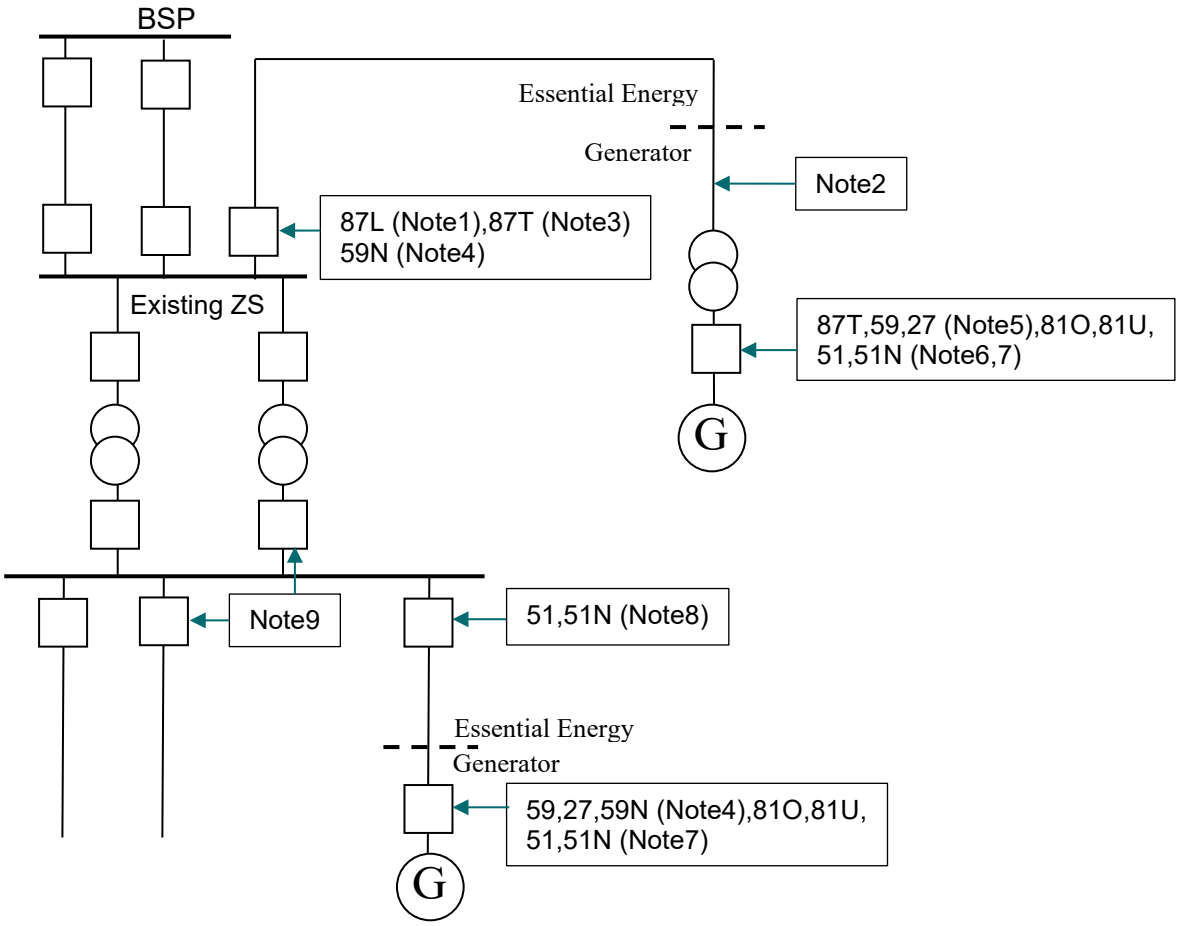
Note3: Neutral voltage displacement protection is conditional. Refer to section R12.

Note4: Under and over voltage elements are to measure the connection point voltage.

Note5: Where upstream distance relays see into the generators secondary bus then clearing times on the secondary network will need to be fast enough to ensure coordination. In some cases, this may require less than 100ms relay operating times.

Note6: Other generator protection may be required depending on generation type.

2.4.3 Subtransmission or distribution dedicated feeder to a non-radially fed ZS



Note1: Where the feeder is >100kV then duplicated line differential with duplicated communications is required. If <100kV then duplicated communications advised.

Note2: At a minimum CT's will be required for duplicated line differential and duplicated transformer differential

Note3: Generator to send duplicated transformer trips to Essential Energy. If single communications is used then distance backup will need to be sufficient to see the generator secondary bus for CB fail, this will not be possible if earth fault limitation is used.

Note4: Neutral voltage displacement protection is conditional. Refer to section R12.

Note5: Under and over voltage elements are to measure the connection point voltage.

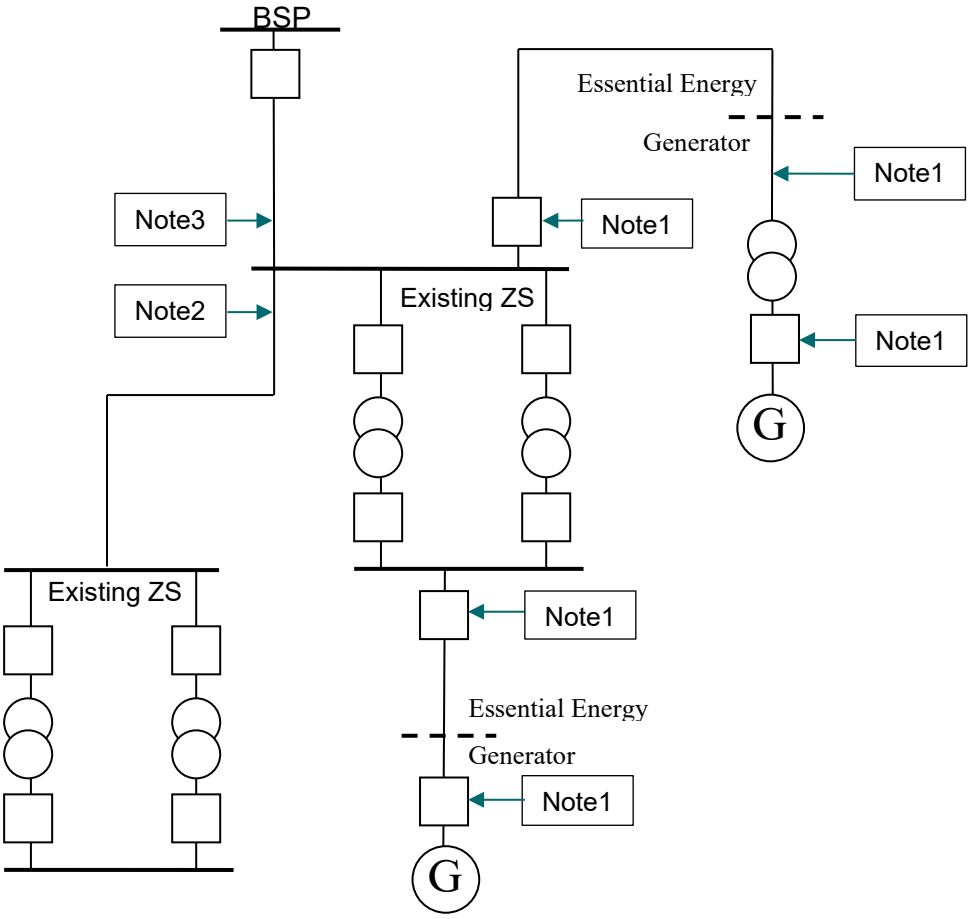
Note6: Where upstream distance relays see into the generators secondary bus then clearing times on the secondary network will need to be fast enough to ensure coordination. In some cases, this may require less than 100ms relay operating times.

Note7: Other generator protection may be required depending on generation type.

Note8: Duplicated OC&EF are required.

Note9: Where single feeder protection exists, consideration will need to be given to backup OC on adjacent feeders due to the infeed of the generator. Possible solutions will be duplication of the feeder protection, CB Fail schemes, summated OC schemes or distribution works to raise the required backup fault level.

2.4.4 Subtransmission or distribution dedicated feeder to a radially fed ZS

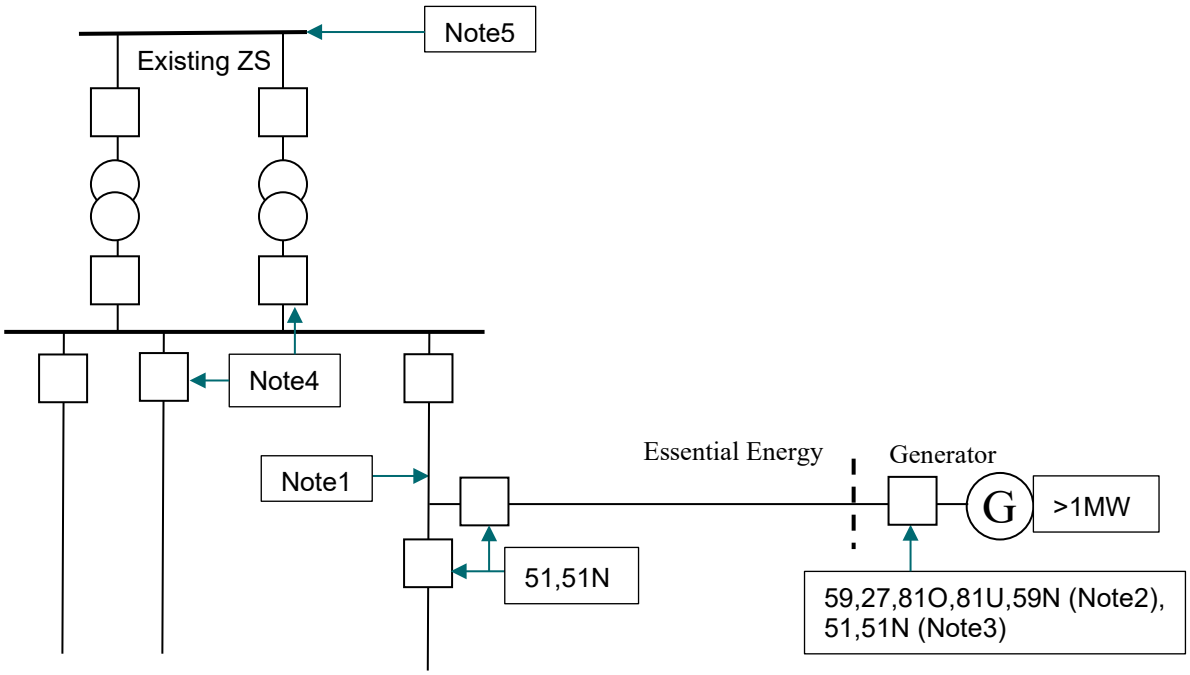


Note1: As per protection requirements discussed in example 2.4.3

Note2: Consideration will need to be given to the primary and backup protection on the line and the downstream substation due to the infeed of the generator. It is possible that a CB will be required due to the reduced reach from the BSP distance or OC relay, this will be assessed by Essential Energy on a case by case basis.

Note3: Where the subtransmission feeder is >100kV a CB will be required looking back to the bulk supply point to meet the clearing times required by the NER.

2.4.5 Distribution line connection via a switching station



Note1: CB may be required if backup cannot be achieved from remote devices. This will be determined on a case by case basis by Essential Energy.

Note2: Neutral voltage displacement protection is conditional. Refer to section R12.

Note3: Other generator protection may be required depending on generation type.

Note4: Where single feeder protection exists, consideration will need to be given to backup OC on adjacent feeders due to the infeed of the generator. Possible solutions will be duplication of the feeder protection, CB Fail schemes, summated OC schemes or distribution works to raise the required backup fault level.

Note5: Where the substation is radially fed the requirements discussed in example 2.4.4 will need to be considered.

3.0 AUTHORITIES AND RESPONSIBILITIES

Position / Title	Responsibility
Zone Substation Engineering Manager	• Approve this procedure • Ensure Essential Energy's minimum protection design requirements are complied with • Assign appropriate responsibility to managers to carry out their functions in accordance with this procedure • Inform employees and contractors of their responsibilities under this procedure
Protection Manager	• Provide engineering subject matter expertise relevant to the application of protection requirements. • Ensure that adequate protection systems are applied to private generators in a uniform manner to ensure the security and reliability of the Essential Energy system and connected customers. • Monitor compliance with this procedure; and Ensure that adequate protection systems are applied to private generators in a uniform manner to ensure the security and reliability of the Essential Energy system and connected customers.
Protection Employees & Network Planning Officers	• Ensure they have reviewed and are familiar with the protection requirements of this document and the systems detailed are installed to at least the minimum requirement. • Ensure that adequate protection systems are applied to private generators in a uniform manner to ensure the security and reliability of the Essential Energy system and connected customers.
Generator Equipment Owners	• The supply, setting and maintenance of equipment for the protection of the Generation Equipment, in accordance with the requirements specified in this document. • Ensure that adequate protection systems are applied to private generators in a uniform manner to ensure the security and reliability of the Essential Energy system and connected customers.

4.0 DEFINITIONS

Backup Protection
A protection scheme separate or remote from the Main Protection designed to operate if the Main Protection or Circuit breaker fails to operate correctly. A Backup Protection scheme shall be completely independent of the Main Protection and operate separate circuit breaker(s).

BSP
Bulk Supply Point

CB
Circuit Breaker.

CP
Connection Point

CPCB
Connection Point Circuit Breaker as per R2 of section 2.3 of this document.

CT
Current Transformer.

Co-Generation
The production of electrical power by converting another form of energy in a generating unit as a by-product of an associated primary function.

DFIG
Doubly Fed Induction Generator

Distribution
Distribution voltage equipment outside a substation boundary, including the lines from that boundary.

Distribution Voltage
In this document, 6.35kV, 11kV, 22kV, 33kV, 12.7kV SWER, or 19.1kV SWER. Note that 33kV may be either distribution or subtransmission refer to the definition of subtransmission for more information.

Document control
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Embedded Generation
A generating unit connected within a distribution network and not having direct access to the transmission or subtransmission network.

GCB
Generator Circuit Breaker as per R3 of section 2.3 of this document.

Generation
The production of electrical power by converting another form of energy in a generating unit.

Generator
Any machine or electronic device delivering electrical power. This may include (but is not limited to) synchronous and induction machines and inverters.

Inverter
A device that uses semiconductor devices to transfer power between a D.C. or A.C. source or load and the A.C. distribution network. As per AS4777, this document is written on the basis that A.C. to A.C. converters that use semiconductor devices are considered to be inverters as well as D.C. to A.C. converters.

Main Protection
A protection scheme designed to be the primary protective scheme covering an item or a group of items of power supply plant.

Network
Essential Energy's electrical Transmission, Subtransmission and Distribution System.

Primary Protection Zone
The portion on the network (usually to the next downstream circuit breaker or protection device) for which the assigned relay must clear faults. Typically zones 1 & 2 of an impedance ("distance") relay are set to provide protection for the primary zone. Zone 2 is time delayed to ensure coordination with downstream protection devices.

Primary System
Equipment connected directly to the high voltage system.

Protection No 1
A Main Protection scheme (either the Main Protection or one of a pair of similar capability Main Protection schemes). This is sometimes referred to as 'X' protection by other organisations.

Protection No 2
Usually the second of two Main Protection schemes. Same primary source inputs and CB(s), different CT cores and protection relays. This is sometimes referred to as 'Y' protection by other organisations.

Secondary System
Equipment associated with the Primary System usually by secondary connections. This includes (but is not limited to) VT&CT wiring, DC control and protection wiring systems as well as associated control and protection relays.

Shall
In this document, the word "shall" means mandatory.

Should
In this document, the word "should" means advisory.

Subtransmission
Any part of the network which operates to deliver electricity from transmission to distribution. This includes equipment energised at 33kV, 66kV, 110kV & 132kV, and the distribution voltage circuit breakers and equipment within a substation boundary fence. Note that 33kV systems may be considered distribution provided they do not supply an Essential Energy zone substation.

Transmission
Any part of the network operating at or above 220kV and any part of the network operating between 66kV and 220kV that operates in parallel to and provides support to the higher voltage network (>220kV).

VT
Voltage Transformer.

ZS
Zone Substation

5.0 REFERENCES

Internal
Branch Procedure – Transmission and Sub-transmission Protection Guidelines – CEOP8002.01
Branch Procedure – Distribution Protection Guidelines – CEOP8002.02

External
AS4777 – Grid Connection of Energy Systems via Inverters
Service and Installation Rules of NSW

6.0 RECORDKEEPING

The table below identifies the types of records relating to the process, their storage location and retention period.

Type of Record	Storage Location	Retention Period
Protection Studies	Network drive	Retain minimum of 7 years after action completed, then destroy- GA40 6.2

* The above retention periods are subject to change eg if the records are required for legal matters or legislative changes. Before disposal, retention periods should be checked and authorised by the Records Management Team.

7.0 REVISIONS

Issue No.	Section	Details of changes in this revision	Change Risk Impact?
2	Section 4.3	- Heading should read "Minimum Protection Requirements for ***the Connection*** of Generating Equipment to Essential Energy Network"	Low
	Section 4.3	1st line should read "basis ***of*** each"	
	Section 4.3	Requirement should read "Refer to section 4.4", not 3.4, and just above Table 1 - C, C1, C2 etc should also "Refer applicable notes in section 4.4", not 3.4.	
	Section 4.4 Ref R12	The word "**whilst**" is spelled incorrectly in the first dot point section, and the word "**a**" should replace "as" in the second dot point should read "**a** separate NVD VT".	
	Section 4.4 Ref R14	in C part "**NVD** protection" should read "**NPS** protection"	
3	All	Update to rebrand to Essential Energy.	Low
4	All	Renamed from Cogeneration Protection Guidelines. Amended section 2, added 4.2.5, 4.2.6, amended 4.3, 5	Low
5	All	Amended all sections. Table 1 and Table 2 combined and updated.	Low
6	Section 2.2, 2.3, 2.4	Replaced 'Inv' with 'IES' in 2.2, Changed NVD requirements for LV generation in table 2.2.1 & 2.3 by adding 'C3' to R12, added item to A1 regarding clearing times to table 2.3, altered the wording in R5 for anti-island requirements, removed line of ownership for tee connection in 2.4.2, migrated to the new template.	Low