Engineering Recommendation No.3
of the
Electricity Distribution Code

Connection of Embedded Generating Unit up to and Including 30 MW

Version 2.0

08/07/2018

Issued by:

Al Ain Distribution Company (AADC)
Abu Dhabi Distribution Company (ADDC)
Abu Dhabi Supply Company for Remote Areas (RASCO)

Approved by:

Department of Energy

Contents

1. Introduction

1.1 Preface

1.1.1 This Engineering Recommendation forms part of Annex 1 to the Electricity Distribution Code and is titled Engineering Recommendation No.3 - Connection of Embedded Generating Plant up to and including 30 MW.

1.2 Commencement

1.2.1 This Engineering Recommendation comes into force on date of Department of Energy (DoE) approval.

1.2.2 This Engineering Recommendation supersedes and replaces the following regulations:

(a) Engineering Recommendation No.3 of the Electricity Distribution Code - Connection of Embedded Generating Plant up to and Including 5 MW, Version 1.0, 30th November 2005.

1.3 Purpose

1.3.1 The purpose of this Engineering Recommendation is to provide the minimum technical requirements on the connection of Embedded Generating Plant to the DISCO Distribution System operating at or below 33 kV and where the output of the Generating Plant up to and Including 30 MW.

1.4 Scope

1.4.1 This Engineering Recommendation applies to the following Users of the Electricity Distribution System as defined in the Electricity Distribution Code :

(a) Embedded Generators

(b) Users with Own Generation (UWOG)

1.4.2 This Engineering Recommendation applies to practices where the Embedded Generating Plant may be paralleled with a DISCO System, or where either the Embedded Generating Plant or DISCO System may be used to supply the same load.

2. Definitions

2.1 Interpretation

2.1.1 Definitions used in this Engineering Recommendation align with those specified in the Electricity Distribution Code. Furthermore, the definitions specified in Section 2.2 shall also apply.

2.1.2 Words using the singular or plural number also include the plural or the singular number respectively.

2.2 Definitions

Competent Person – means a person who has sufficient technical knowledge and experience to recognise and avoid Danger and who has been appointed in writing by a nominated Entity authorising officer to carry out defined duties in accordance with a competency certificate.

Danger – means the risk of injury to people or animals from fire, electric shock, burns, explosion or from mechanical movement of electrically controlled equipment, or the risk of damage to property.

DISCO – means an electricity and water distributor which hold licences granted under Article 82 of The Law.

Entity – means an individual, company, association, society, partnership, corporation, municipality, institution, government organisation, agency or group.

High Voltage (HV) – means an a.c. voltage greater than Low Voltage and less than 36 kV between phases or 21 kV between any phase and earth (internationally referred to as Medium Voltage).

Low Voltage (LV) – means an a.c. voltage below 1000 V between phases, or below 600 V between any phase and earth or, a d.c. voltage below 1500 V between conductors, or below 900 V between any conductor and earth.

Non-parallel Operation – means the Operation of Embedded Generating Plant such that the load it supplies may be switch to the DISCO System without any possibility of a short term or momentary parallel of the two sources.

Parallel Operation – means the Operation of Embedded Generating Plant in parallel with the Distribution Network such that load may be supplied by either of the two sources or that the Embedded Generator may supply energy into the Distribution System. This definition includes ‘short-term’ parallel where the above condition may occur for a short period of time (as defined by the DISCO) for purposes such as testing or changeover of load.

Point of Common Coupling – means the point on the DISCO network, electrically nearest the Embedded Generating Plant installation, at which other Customer's loads are, or may, be connected.

Safe System of Work – means a set of safety procedures, including operational processes and procedures which are based on identified hazards, and are designed, as far as reasonably practicable, to prevent Danger.

Site Responsibility Schedule – means a schedule defining the ownership, Operation and maintenance responsibility of Plant and Apparatus at the Connection Point.

Type Test – means a conformity test made on one or more items representative of the production, which is carried out by Independent Testing Laboratories or witnessing by Certified Third Party approved by Department of Energy Commercial Directory (formerly Abu Dhabi Water and Electricity Authority (ADWEA).

3. Connection Arrangements

3.1 General

3.1.1 Each installation with appropriately Type Tested Embedded Generating Plant shall be designed to be compatible with the DISCO System to which it is to be connected. In addition to the requirements of this Engineering Recommendation, the mandatory requirements set out in the Electricity Distribution Code and Small Scale Photovoltaic Energy Netting Regulations – ED/R01/108 should also be met; attention is drawn in particular to Chapter 3 Section 7 of the Electricity Distribution Code (Requirements for Embedded Generators and Users with Own Generation).

3.2 Arrangements

3.2.1 In accordance with Section 3.1.1 Embedded Generating Plant should be designed so that it operates in one of two operating modes. These modes are termed:

(a) Parallel Operation (including 'short-term' manual or automatic paralleling)

(b) Non-parallel Operation (alternative connection)

3.3 Application for Connection

3.3.1 A standard application process for connection of the Embedded Generating Plant to the DISCO System should be adopted in all cases. The process and its requirements shall, as a minimum, meet those specified in the Electricity Distribution Code. Following agreement between the DISCO and Embedded Generator, the connection process given in Schedule 5 shall be used.

3.3.2 Technical data regarding the Embedded Generating Plant that is intended for connection to the DISCO System should be made available to the DISCO to enable an assessment to be carried out so as to identify and mitigate against any effect the Embedded Generating Plant may have of the DISCO System. Technical data shall include but not be limited to that specified in the Electricity Distribution Code.

3.3.3 The Embedded Generating Plant owner should apply to the DISCO for connection to the System using the DISCO standard application form. On receipt of the application, the DISCO will assess the need for further System studies which shall be financially subsidised by the applicant. It is also desirable for the DISCO to specify both factory and on-site pre-commissioning tests at this stage.

3.3.4 Where the results of studies assessing the impact of the Embedded Generating Plant on the DISCO System are required or where facilitating works are required at the Connection Point, the Generating Plant shall not be commissioned in part or full. Only on completion of such studies or facilitating work and following approval by the DISCO shall a firm connection offer be provided by the DISCO to the Embedded Generating Plant owner.

3.3.5 Only following acceptance of the quotation and upon satisfactory completion of all pre-determined tests, shall the DISCO sanction permanent energisation of the Embedded Generating Plant.

4. System Earthing

4.1 General

4.1.1 The earthing arrangements for Embedded Generating Plant shall satisfy the requirements of the Engineering Recommendation 8(Earthing system standards/code).

4.2 HV Embedded Generating Plant

4.2.1 The HV Embedded Generating System neutral should be earthed using one of a number of modes. It is important to recognise that the chosen mode of earthing will influence both the design and rating of the earth electrode system and the rating of associated Plant and Equipment. Typical modes include:

(a) neutral earthing resistor

(b) reactor

(c) arc suppression coil

(d) earthing transformer/zigzag transformer

4.2.2 To ensure compatibility with the DISCO earthing system, the Embedded Generator System must be designed in consultation and formal agreement with the DISCO.

4.2.3 It is recommended the Embedded Generating Plant neutral point (common point of a star connected polyphase element or the earthed mid-point of a single-phase System) is permanently connected to earth so as to minimize the risks associated with operational switching and the undesirable effects of circulating currents and harmonics associated with 'short-term' Parallel Operation.

4.2.4 When operating in parallel or short term parallel, the earthing of the Embedded Generator System must be connected by a suitable manual or automatic switching facility which is interlocked according to the methods described in Section 8.1.2. This ensures the DISCO earthing System is common to both Entities.

4.2.5 Earthing systems shall be designed, installed, tested and maintained in accordance with international standards. Minimum requirements should include but not be limited to guidance provided in ENA TS 41-24, BS EN 50522 and BS 7430. Precautions must be taken to ensure hazardous step and touch potential do not arise when earth faults occur on HV Systems. Where necessary, HV earth electrodes and LV earth electrodes must be adequately segregated so as to prevent hazardous earth potentials being transferred into the DISCO LV System.

4.2.6 Typical earthing arrangements for HV Embedded Generating Plant are given in Schedule 1, figures 1 to 4.

4.3 LV Embedded Generating Plant

4.3.1 The LV Embedded Generating Plant Earth System must be permanently connected to earth.

4.3.2 Typical earthing arrangements for LV Embedded Generating Plant are given in Schedule 2, figures 1 to 5.

5. Inter-system Connection: Requirements

5.1 General

5.1.1 The following requirements are applicable to the inter-system connection (and Operation) of the DISCO electricity Distribution System to that of the Embedded Generator for both parallel and non-parallel operating conditions.

5.2 Design

5.2.1 The DISCO System and any Embedded Generating Plant intended for connection to that System shall be designed to comply with the standard of supply specified in the Electricity Distribution Code.

5.2.2 Notwithstanding Section 5.2.1, Embedded Generating Plant shall meet a set of technical requirements in relation to its performance with respect to frequency and voltage, control capabilities, Protection coordination requirements, phase voltage unbalance requirements, neutral earthing provisions, islanding and black start capability. These technical requirements are further defined in the Electricity Distribution Code.

5.2.3 The connection of Embedded Generating Plant to the DISCO System should not increase the risk of interruption to existing Users of that Distribution System.

5.2.4 The design of any scheme for the connection of Embedded Generating Plant to the DISCO System must consider the export of short circuit current flow on the DISCO System and the effects this may have.

5.2.5 All Embedded Generating Plant and its associated protection and control Equipment must be designed for stable Operation in Parallel with the DISCO System.

5.2.6 Consideration should be given to any load flow and System Stability studies that are necessary to determine the output constraints or post fault actions necessary for given fault conditions and Planned Outage conditions as defined in Engineering Recommendation No.4.

5.2.7 Under the conditions of Section 5.2.6 and where the combination of associated factors may lead to circuit Overloading, a suitably rated means of rapid disconnect from the Embedded Generating Plant must be installed so as to protect the DISCO System, for example the use of a high speed control device.

5.3 Performance of Type Tested Embedded Generating Plant

5.3.1 To prove satisfactory Operation, all Embedded Generating Plant shall be fully Type Tested in accordance with latest IEC Standards, latest ISO 8528, and NFPA 100 Standards. Type Test results should be recorded in a legible manner using a standard form. Type Test information should be made available to the DISCO upon formal request.

5.3.2 Type Tested Embedded Generator Plant should be capable of continuous Operation when connected to and running in parallel with the DISCO System.

5.3.3 Notwithstanding Section 5.3.2 and where no tripping of Equipment occurs, consideration should be given to tolerances and measurement errors applicable to Type Test voltages and frequencies for Embedded Generating Plant. Type Testing of Embedded Generator Plant should be completed in accordance with IEC type test standards' and conditions.

5.4 Operation

5.4.1 To comply with the requirements of this Engineering Recommendation, Embedded Generating Plant Operations should only be carried out by Competent Person(s) who have been given an Authorisation by the Embedded Generator to carry out specified duties. Such persons should possess sufficient skills and training to recognise and apply Safe System(s) of Work. **Note: In case of working in the interface boundary operator has to be certified by Disco's.**

5.4.2 Notwithstanding the requirements of this Engineering Recommendation, and where applicable, the Embedded Generating Plant installation must be carried out to standards specified in the manufacturer's installation instructions.

5.4.3 No parameter relating to the electrical connection or setting of the DISCO System and Embedded Generator System that is subject to Type Tested certification shall be modified at any time unless previously agreed in writing between the two Entities.

5.4.4 The DISCO shall notify the Embedded Generator of any overhead auto-reclose schemes that exist on the DISCO System that supplies the Embedded Generating Plant either directly (through HV connection) or indirectly (through LV connection). Such auto-reclose Equipment can affect the Operation of the Embedded Generating Plant.

5.5 General Interface Control

5.5.1 In accordance with the Electricity Distribution Code, the interface between the DISCO System and the Embedded Generator System should be controlled using a Site Responsibility Schedule. This content of this schedule is subject to prior agreement between the two Entities.

5.5.2 The Site Responsibility Schedule should clearly define:

(a) the mode of communication between the two Entities

(b) the ownership of each item of Equipment at the interface between the boundaries of the two Entities Systems

(c) the means of recording relevant safety documents which clearly define the safe zone(s) of work for particular items of Equipment to be worked upon

(d) Operation and maintenance responsibilities for the defined Equipment

(e) current System characteristics by means of an Operational Diagram

(f) The obligation(s) on Entities to update the Site Responsibility Schedule and the Operational Diagram to reflect any change

(g) Protection relay settings

5.5.3 The Operational Diagram should be made available at the Connection Point so that all persons carrying out operational procedures can undertake such duties safely.

5.6 Operational Safety

5.6.1 In all cases where inter-system Operation is required to be performed by persons holding appropriate Authorisation, and where the Equipment to be operated is owned by the DISCO, inter-system safety precautions shall be carried out in accordance with the Electricity Distribution Safety code(DOC6).

5.6.2 For HV connected Systems, consideration should be given to the flow of real and Reactive Power and its effect on the DISCO System. A mutually agreed procedure should be employed with operational duties controlled by the DISCO Control Person.

5.6.3 Where synchronisation of the DISCO and Embedded Generator Systems is required, this should be carried out to a mutually agreed procedure. Synchronisation should be achieved through controlled manual switching Operations or automatic synchronising Equipment. At all times, consideration should be given to the magnitude of voltage and frequency variation and voltage phase shift (or difference) so as to avoid unacceptable changes being experienced by other Users connected to the DISCO System.

5.7 Isolation and Safety Signs

5.7.1 Notwithstanding Section 4.2.4, every installation which comprises Embedded Generating Plant and operates in parallel with the DISCO System must include a means of isolation capable of disconnecting each phase and neutral of the Embedded Generating Plant from the DISCO System. Unless otherwise agreed with the DISCO this means of isolation will be the responsibility of the Embedded Generator.

5.7.2 To maintain isolation of Equipment from a potentially hazardous energy source and to mitigate the effect of Danger, the application of approved safety locks shall be used in accordance with an established procedure, for example lockout/tagout.

5.7.3 The Embedded Generator must allow the DISCO, through an established procedure, right-of-access to the means of isolation.

5.7.4 Appropriate safety signs shall be provided to convey the existence of Embedded Generating Plant. Safety signs shall meet the requirements of BS 5499-5 & HSE L64. Safety signs should be manufactured from a sufficiently robust material and be able to tolerate expected climatic conditions for the lifetime of installation. Safety signs should be unambiguous and positioned in prominent locations. Schedule 6 provides a typical example of a warning sign used where Embedded Generating Plant exists.

5.7.5 For Embedded Generating Plant connected to the DISCO HV / LV System, safety signs, specifically warning signs, shall be provided at the following locations:

(f) Connection Point

(g) meter position

(h) main distribution board

(i) and all points of isolation within the Customer premises

6. Embedded Generating Plant: Parallel Operation

6.1 Parallel Operation: Written Agreements

6.1.1 The DISCO and the Embedded Generator must agree in writing the significant technical requirements for the parallel connection of the two Systems. This formal agreement will include:

(a) the means of synchronisation between the Embedded Generator's System and the DISCO System

(b) the responsibility for Plant, Equipment, maintenance and recording of failures

(c) the precautions for earthing

(d) the means of connection and disconnection between the DISCO System and the Embedded Generator System

(e) the means of recording relevant safety documents which clearly define the safe zone(s) of work for particular items of Equipment to be worked upon

(f) the recording of key technical data, for example import and export capacities, operating Power Factor range and interface Protection settings

(g) mark-up drawings showing compatibility of earth connections

(h) Generator performance chart

(i) Generator data as in Electricity Transmission Code and Electricity Distribution Code.

6.2 Parallel Operation: Responsibilities

6.2.1 Notwithstanding Section 7.1.1 the DISCO and the Embedded Generator should agree measures that ensure an adequate and reliable means of communication exists between the two Entities.

6.2.2 The DISCO and the Embedded Generator will assess and Authorise in writing the competence of all persons carrying out Operations on their Systems.

6.2.3 The DISCO and the Embedded Generator will ensure each Entity is informed of any condition, occurrence or Incident that could affect the safety of personnel, or the maintenance of Equipment. All communications will be recorded and kept so as to demonstrate that processes have been carried out under prescribed conditions.

6.2.4 The DISCO and Embedded Generator will ensure each Entity is informed of the names of designated persons holding the authority to act and communicate on their behalf including their appropriate contact details.

6.2.5 Additional operational and safety requirements will be in accordance with the Electricity Distribution Code, in particular Chapter 4 Operating Code.

6.3 Parallel Operation: Technical Considerations

6.3.1 The DISCO and the Embedded Generator must consider the cumulative fault infeed level on both Entities Systems. When operating in a parallel condition, consideration should be given to the short-circuit rating of HV Equipment making up each System and its capability to withstand the combined potential fault current from both Systems. Fault infeed information shall be exchanged between the DISCO and the Embedded Generator in accordance with the Electricity Distribution Code. In additional to the same EG shall be capable to carry out the fault ride through and this to be subjective to the EG transient stability studies, which will be part of EG entity studies and subject to Disco's approval process before commissioning.

6.3.2 Notwithstanding Section 6.1.1, DISCO consent is required prior to any parallel connection of this Entities System to that of an Embedded Generator. In accordance with the Electricity Distribution Code Engineering Recommendation No.7, the magnitude of voltage fluctuation, whether it is a regular or irregular event, should not exceed 3% at the Point of Common Coupling.

6.3.3 The voltage fluctuations at the Point of Common Coupling should not exceed 1% for changes of input/output power of Embedded Generating Plant. When Embedded Generating Plant is run up to speed (as a motor) any disturbance must be within the limits defined in Engineering Recommendation No.1 and Engineering Recommendation No.7. The negative sequence voltage at the Point of Common Coupling on a three-phase System should not exceed 1.3% of the positive phase sequence (see Engineering Recommendation No. 10).

6.3.4 To avoid risk of out-of-synchronism closure of Circuit Breakers or switches on the DISCO System, the Embedded Generator should arrange for all plant to be disconnected in the event the DISCO supply is lost. Where the Embedded Generating Plant is required to continue the supply of electricity to a temporarily disconnected section of the DISCO System, a special agreement will be required from the DISCO.

6.3.5 Notwithstanding Section 5.7.2, the right-of-access to the means of isolation between the DISCO System and the Embedded Generator System should be mutually agreed and accessible to both Entities at all times for emergency and safety reasons. Consideration should be given to any safety procedure and associated documents that may apply.

7. Embedded Generating Plant: Non-parallel Operation

7.1 General

7.1.1 Parallel Operation with the DISCO electricity supply System is not permitted in a Non-parallel operating state. It is the responsibility of the Embedded Generator to ensure that any part of the installation which is, or may be, connected to the Embedded Generating Plant, has first been disconnected from the DISCO supply System and will remain disconnected while the Embedded Generating Plant is connected to the installation. The DISCO must be satisfied that methods of changeover and interlocking meet these requirements.

7.1.2 The changeover devices must be of 'fail-safe' design so that one circuit controller cannot be closed if the other circuit controller in the changeover sequence is closed, even if the auxiliary supply to any electro-mechanical devices has failed.

7.1.3 The direct manual Operation of Circuit Breakers or contactors must not result in the defeat of the interlock system. For example, if a Circuit Breaker can be closed mechanically, regardless of the state of any electrical interlocking, then it must have mechanical interlocking in addition to the electrical interlocking.

7.1.4 Where Embedded Generating Plant is arranged to start automatically in the event of mains failure, it should be located in a secured room accessible only to Authorised persons. A conspicuous warning notice should be securely fixed at the entrance highlighting that the room contains plant which can start automatically and without warning.

7.2 Changeover Operated at HV

7.2.1 Where the changeover operates at HV, necessary interlocks shall be provided between the mains circuit breaker and generator's circuit breaker. Electrical interlocking through the auxiliary contacts and wiring to the closing and tripping circuits of the circuit breakers shall be provided. In addition, mechanical interlocks by way of cables / key system shall also be provided. The interlocking shall be such that it prevents the parallel operation of the two systems in all conditions. Tripping of either circuit breaker due to protection operation should block both automatic and manual closing of the other circuit breaker. Detailed interlocking scheme shall be approved by the DISCO and agreed in the interface agreement. 7.2.2 Electrically operated interlocks should be in accordance with BS EN 61508.

7.2.3 Notwithstanding Section 7.2.1, consideration should be given to an interoperable software interlocking scheme which communicates through intelligent electronic devices (IEDs). Where applicable, a compatibility study should be carried out prior to the selection and installation of such a scheme. To ensure compatibility between the DISCO System and that of the Embedded Generator, the interoperable software interlocking scheme must be designed in consultation and formal agreement between the two Entities.7.2.4 The interoperable software interlocking scheme should be designed, installed and tested in accordance with IEC 61850 having the provision for information exchange between two or more IEDs, and the ability to operate through local and/or remote commands.

7.3 Changeover Operated at LV

7.3.1 Where the changeover operates at LV necessary interlocks shall be provided between the mains circuit breaker and generator's circuit breaker. Electrical interlocking through the auxiliary contacts and wiring to the closing and tripping circuits of the circuit breakers shall be provided. In addition, mechanical interlocks by way of cables / key system shall also be provided. The interlocking shall be such that it prevents the parallel operation of the two systems in all conditions. Tripping of either circuit breaker due to protection operation should block both automatic and manual closing of the other circuit breaker. Detailed interlocking scheme shall be approved by the DISCO and agreed in the interface agreement.

7.3.2 Electrically operated interlocks should be in accordance with BS EN 61508.

7.3.3 The DISCO must be satisfied that any other arrangement will fulfil its obligations under this Engineering Recommendation and also the obligations of the Embedded Generator.

8. Protection and Control

8.1 General

8.1.1 The basic requirements for Protection will be in accordance with the Electricity Distribution Code so that abnormal conditions in a System are detected and fault clearance or actuating signals or indications are initiated.

8.1.2 In addition to the Protection system installed by the Embedded Generator for its own purpose, the DISCO will require protective equipment to be provided by the Embedded Generator at the Connection Point to achieve the following when called upon:

(a) to inhibit connection to the DISCO supply unless all phases are energised and are operating within the agreed Protection settings

(a) to disconnect the Embedded Generator during any System abnormality where an unacceptable deviation of voltage or frequency or voltage phase shift occurs at the point of connection to the DISCO network

(b) to disconnect the Embedded Generator for loss of one or more phases of DISCO supply

(c) to ensure automatic disconnection of Embedded Generator in the event of a failure of any supplies to protective equipment that would inhibit its correct Operation

(d) to ensure, when operating in parallel with the DISCO network, that the Embedded Generator is connected to the DISCO earthing system and is Isolated from its own earthing system (using a suitable isolation device)

(e) to ensure, when operating in isolation from the DISCO network, that the Embedded Generator is connected to its own earthing system and is Isolated from the DISCO earthing system (using a suitable isolation device)

(f) to disconnect the phase and neutral connections of any Embedded Generator connected at LV to the DISCO System, in order to provide full safety isolation

(g) Bus section breaker to be added at interface point of DISCO and Embedded Generator

8.2 Protection for HV Supply Arrangements

8.2.1 Appropriate Protection arrangements for an HV installation will include the detection of:

(a) over voltage

(b) under voltage

(c) over frequency

(d) under frequency

(e) Synchro-check relay for incomer supply /interconnection point between DISCO and Embedded Generator

(f) Loss of mains protection at interface point protection between DISCO and Embedded Generator with the following considerations:

- Built-in/integrated loss of mains protection in the PVC system would be acceptable for Embedded Generator less than 50 kW
- For Embedded Generator greater than 50 kW, separate loss of mains protection should be implemented.

8.2.2 Protection operating times, discrimination and sensitivity will need prior agreement with the DISCO in order to reduce to a minimum the impact on the DISCO System of faults.

8.2.3 Other additional Protection may be required, as specified by the DISCO, including:

(a) Neutral voltage displacement

(b) Over current

(c) Directional over current

(d) Earth fault

(e) Directional earth fault

(f) Reverse power

(g) Bus bar differential protection 87B

(h) line differential protection 87L (Dedicated feeder)

(i) Generator differential protection 87G

(j) voltage restrained over current

(k) loss of excitation

(l) under excitation

(m) over excitation

(n) Negative Phase Sequence

8.2.4 The applied settings for relays should be agreed with the DISCO. Applied settings should not be changed without the explicit agreement of the DISCO.

8.2.5 Typical Protection arrangements for HV Embedded Generating Plant are given in Schedule 3 figures 1 and 2.

8.3 Protection for LV Supply Arrangements

8.3.1 For Embedded Generating Plant in between (50 kW - 250 kVA), appropriate Protection settings need to be discussed and agreed between the Embedded Generator and the DISCO. An example of typical Protection settings for LV supply arrangements is shown in Table 8.1. These Protection settings are for the purpose disconnecting equipment at times of System abnormalities and are not intended as a back-up for the Embedded Generating Plant's own protection.

8.3.2 Notwithstanding Section 8.3.1 consideration should be given to the Protection of solar photovoltaic Systems as defined in the Electricity Wiring Regulations, Regulation 9.10.

Table 8.1: Typical Protection settings for LV supply arrangements

Protection Element	Phases	Trip Setting	Total Tripping Time
Under Voltage	All	- 10% (phase-neutral)	0.5sec
Over Voltage	All	+ 10% (phase-neutral)	0.5sec
Under Frequency	One	- 6%	0.5sec
Over Frequency	One	+ 1%	0.5sec

Notes: Total tripping time = relay time + breaker operating time

8.3.3 For Embedded Generating Plant exceeding 250 kVA, it should be considered that any increase in plant size will have a relative effect on the DISCO System to which it is connected. The Embedded Generator should consider such and confirm any additional Protection requirements through consultation with the DISCO.

8.3.4 Additional Protection should be installed in a location and on Equipment that has been mutually agreed between the DISCO and the Embedded Generator, and in-line with DISCO technical specifications.

8.3.5 Following mutual agreement with the DISCO, the additional Protection equipment may be installed and arranged so as to operate the DISCO interface Circuit Breaker or any other designated Circuit Breaker.

8.3.6 For any loss of mains event where intertripping is considered a feasible alternative to the use of discriminating Protection relays, the intertripping equipment will be installed and tested by the DISCO

8.3.7 Typical Protection arrangements for LV Embedded Generating Plant are given in Schedule 4 figures 1 to 3.

8.4 Power Factor Correction

8.4.1 Power factor correction equipment is sometimes used with asynchronous Generators to decrease Reactive Power flows on the Distribution System. Generally, for small LV installations the Protection arrangements shown in Table 9.1 is considered adequate.

8.4.2 Where an installation contains Power Factor equipment which is controlled to meet Reactive Power Demand, and for large LV and HV installations, the effects of Power Factor correction will have to be taken into account in the design of Protection.

8.5 Short-term Occasional Parallel Operation

8.5.1 Short term paralleling allows for infrequent connection of an Embedded Generator to the DISCO supply System for the purposes of maintaining the continuity of supply (e.g. where switching between Standby and alternative supply) or for testing of plant, or for maintenance. Detailed requirements, including any minimum Protection obligations, shall be specified by the DISCO.

9. Testing and Commissioning

9.1 General

9.1.1 In addition to the test, commission and monitoring requirements defined in the Electricity Distribution Code, the provisions of this Engineering Recommendation also apply.

9.1.2 It should not be overlooked that further tests may also be prescribed by the Embedded Generating Plant manufacturer, supplier or Embedded Generator. These tests will be carried out in full subject to prior agreement with the DISCO.

9.2 Specific Requirements

9.2.1 Testing and commissioning functions associated with protection and control Equipment, automated devices, logic settings and circuit topologies will be specified by the DISCO. Implementation of testing will be the responsibility of Embedded Generator and must be witnessed by the DISCO.

9.2.2 Notwithstanding the requirements of 9.2.1, the scope of testing should be agreed with the DISCO at the earliest opportunity. Subject to notification schedules, as determined by the DISCO, the Embedded Generator should submit the test procedure and test format for DISCO approval along with the specified start date and time.

9.2.3 Tests must only be carried out upon completion of the Embedded Generating Plant installation, or, in the case of a phased installation, when that part of the Embedded Generating Plant installation has been completed. Consideration should be given to the introduction of simulation testing prior to carrying out any on-site test(s).

9.2.4 Where necessary alternative testing, established and or performed for a particular purpose, may be requested by the DISCO. Such testing shall be accompanied by a detailed sequence of operation. Typically alternative testing will include but not be limited to:

(a) the determination of voltage dip on synchronising

(b) the determination of harmonic voltage distortion

(c) the confirmation that voltage levels remain within statutory limits, as defined in the Electricity Supply Regulations, following the connection of the Embedded Generator Plant.

(d) Any special system test may have effect or impact on Disco’s system, EG shall follow the Electricity Distribution Code(DOC10)

9.2.5 Test results must be recorded on appropriate commissioning forms which include a signed declaration. This declaration should be completed by the Embedded Generator with a copy released to the DISCO as agreed.

9.2.6 In the case of periodic testing carried out by the Embedded Generator, this must meet the requirements of clause 9.2.4. Periodic test intervals should be agreed with the DISCO.

10. Metering

10.1 General

10.1.1 Metering equipment must be installed in accordance with the Metering and Data Exchange Code Customer Metering Regulations ED/R01/005, Small-Scale Solar Photovoltaic Energy Netting Regulations - ED/R01/108 and in conjunction with the requirements of the DISCO. Metering may include the measurement of both import and export of active and reactive energy to and from the Embedded Generator.

10.1.2 The provision, installation, maintenance and reading of tariff metering Equipment shall be the responsibility of the DISCO.

10.1.3 Tariff metering Equipment shall be capable of remote interrogation by the DISCO at any time and be of bi-directional design having the capability to accurately record energy power flow exported by the Embedded Generating Plant to the DISCO System and the load consumed by the Embedded Generator from the DISCO System.

10.1.4 Notwithstanding Section 10.1.1 the requirement for harmonic metering should be considered to measure non-linear load which can degrade power quality of the DISCO System. Non-linear loads are caused by:

(a) industrial equipment (welding machines, arc furnaces, rectifiers etc.)

(b) variable-speed drives

(c) office equipment (photo-copying, computers, fax machines etc.)

(d) domestic household appliances (televisions, microwaves etc.)

(e) uninterruptible power supply (UPS)

11. Embedded Generating Plant System Alterations

11.1 General

11.1.1 Where a major component of the Embedded Generating Plant or its Protection system requires replacing, and in doing so the original operating characteristics of the Embedded Generating Plant is altered, the Generator must notify the DISCO of such changes.

11.1.2 Where the Embedded Generating Plant is to be decommissioned and will no longer provide a source of electrical energy in parallel with the DISCO System, the Generator must notify the DISCO accordingly.

Note Decommissioning prerequisites can be found in Appendix 13.4 of the ENA ER G59-3.

12. References

i. British Standards Institution (2002), *BS 5499-5:2002 Graphical symbols and signs – Safety signs, including fire safety signs – Part 5 Signs with specific safety meanings.* London: British Standards Institution.

ii. British Standards Institution (2011), *BS 7430:2011 Code of practice for protective earthing of electrical installations.* London: British Standards Institution.

iii. British Standards Institution (2010), *BS EN 50522:2010 Earthing of power installations exceeding 1kV a.c.* London: British Standards Institution.

iv. British Standards Institution (2010), *BS EN 61508 Series – Functional safety of electrical/electronic/programmable electronic safety-related systems, Parts 1 – 7.* London: British Standards Institution

v. Energy Networks Association (2013), *Engineering Recommendation ENA ER G59-3 Recommendations for the Connection of Generating Plant to the Distribution Systems of Licensed Distribution Network Operators, Issue 3.* London: Energy Networks Association.

vi. Energy Networks Association (1992), *Technical Specification ENA TS 41-24 Guidelines for the Design, Installation, Testing and Maintenance of Main earthing Systems in Substations, Issue 1, Addendum, Section 15, Incorporated November 2009.* London: Energy Networks Association.

vii. Health and Safety Executive (2009), *Safety signs and signals, The Health and Safety (Safety Signs and Signals) Guidance on Regulations, L64 Second edition. 2009.* Sudbury: Health and Safety Executive.

viii. International Electrotechnical Commission (2003-2013), *IEC 61850 Series – Communication networks and systems in substations, Parts 1 – 10.* Geneva: International Electrotechnical Commission

ix. The Abu Dhabi Transmission and Despatch Company (2008), *Metering and Data Exchange Code, Version 4.0. 2017.* Abu Dhabi: Transco

x. The Regulation and Supervision Bureau (2005), *the Electricity Distribution Code, Version 3.0. 2005.* Abu Dhabi: The Regulation and Supervision Bureau

xi. The Regulation and Supervision Bureau (2018) *Electricity Supply Regulations ED/R01/012 Second Edition, January 2018.* Abu Dhabi: The Regulation and Supervision Bureau

xii. The Regulation and Supervision Bureau (2005), *Engineering Recommendation No. 1 of the Electricity Distribution Code, Limits for Harmonics in the Electricity Supply System, Version 1.0. 2005.* Abu Dhabi: The Regulation and Supervision Bureau

xiii. The Regulation and Supervision Bureau (2007), *Engineering Recommendation No. 4 of the Electricity Distribution Code, Security of Supply Standard for the Electricity Distribution System, Version 2.0. 2007.* Abu Dhabi: The Regulation and Supervision Bureau

xiv. The Regulation and Supervision Bureau (2005), *Engineering Recommendation No. 10 of the Electricity Distribution Code, Limits for Voltage Unbalance in the Electricity Supply System, Version 1.0. 2005.* Abu Dhabi: The Regulation and Supervision Bureau

xv. The Regulation and Supervision Bureau (1998), *Law No (2) of 1998 Concerning the Regulation of the Water and Electricity Sector in the Emirate of Abu Dhabi (as amended).* Abu Dhabi: The Regulation and Supervision Bureau

xvi. The Regulation and Supervision Bureau (2013), *Consultation Document CP/T02/101 Policy guideline – connections for generation sites to the electricity network at 11kV and above, Version 1.0. 2013.* Abu Dhabi: The Regulation and Supervision Bureau

xvii. The Regulation and Supervision Bureau (2018) *Customer Metering Regulations - ED/R01/005, Second Edition, January 2018.* Abu Dhabi: The Regulation and Supervision Bureau

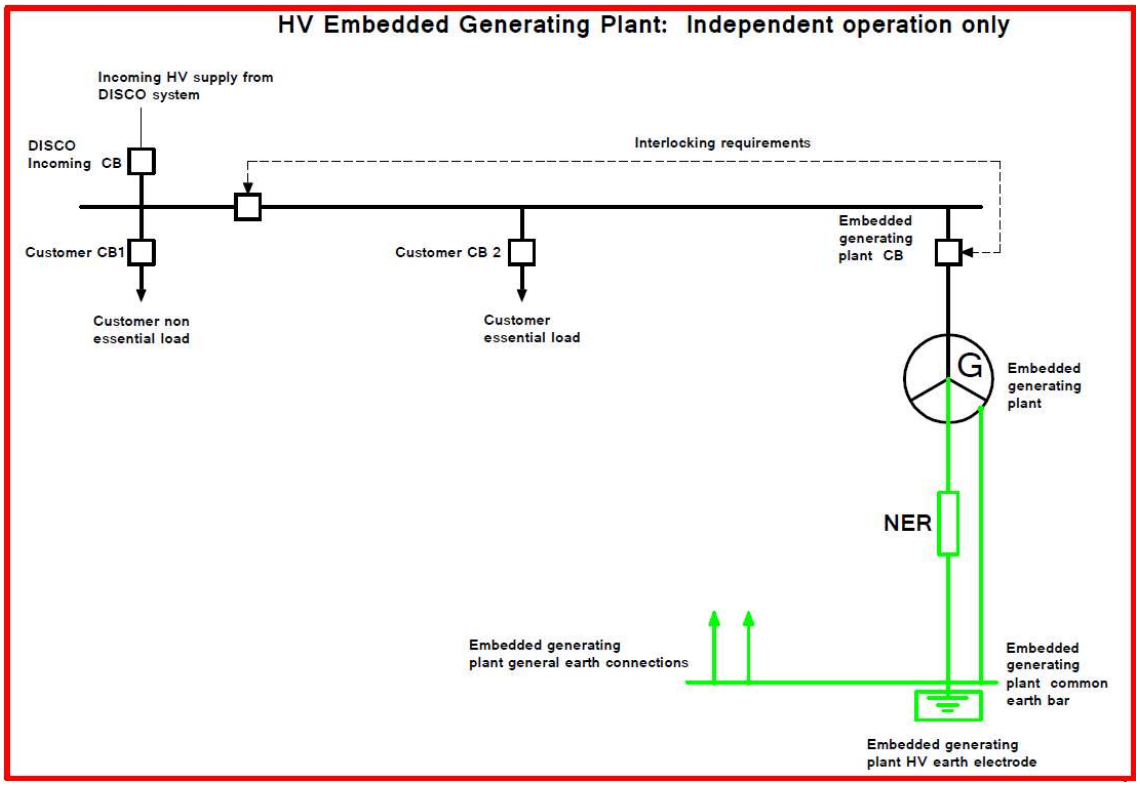
xviii. The Regulation and Supervision Bureau (2017) *Small-Scale Solar Photovoltaic Energy Netting Regulations - ED/R01/108,First Edition, January 2017*. Abu Dhabi: The Regulation and Supervision Bureau

xix. The Regulation and Supervision Bureau (2017) *Installation of Solar PV Systems – Guidance Document - EP/P04/101, January 2017. Abu Dhabi*: The Regulation and Supervision Bureau

Note : The above standards are the minimum requirements. The latest revisions of all standards mentioned herein shall apply. If the equipment conforms to any alternative standards than those listed above, this shall be equal or superior to the corresponding standard.

Schedule 1: Typical HV earthing Arrangements

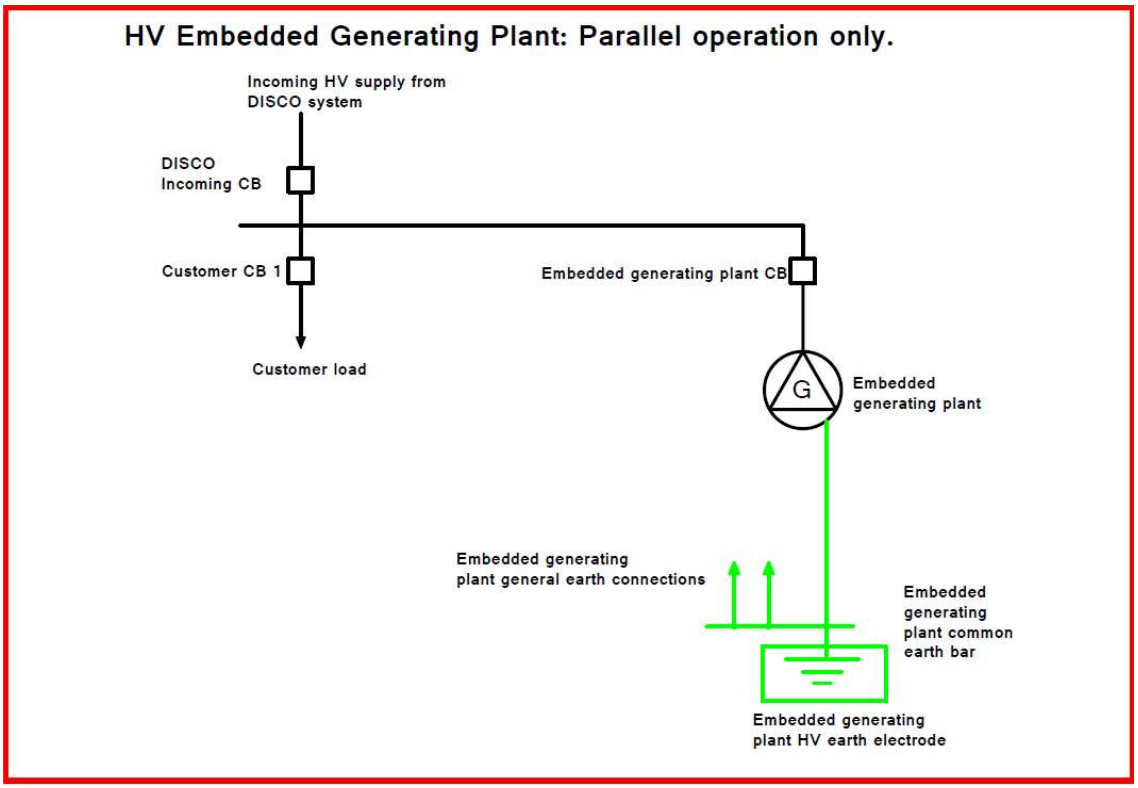
1.1 HV Embedded Generating Plant: Independent Operation Only



Schedule 1, figure 1.

Standard earthing configuration for HV embedded generating plant operating independent to the DISCO system.

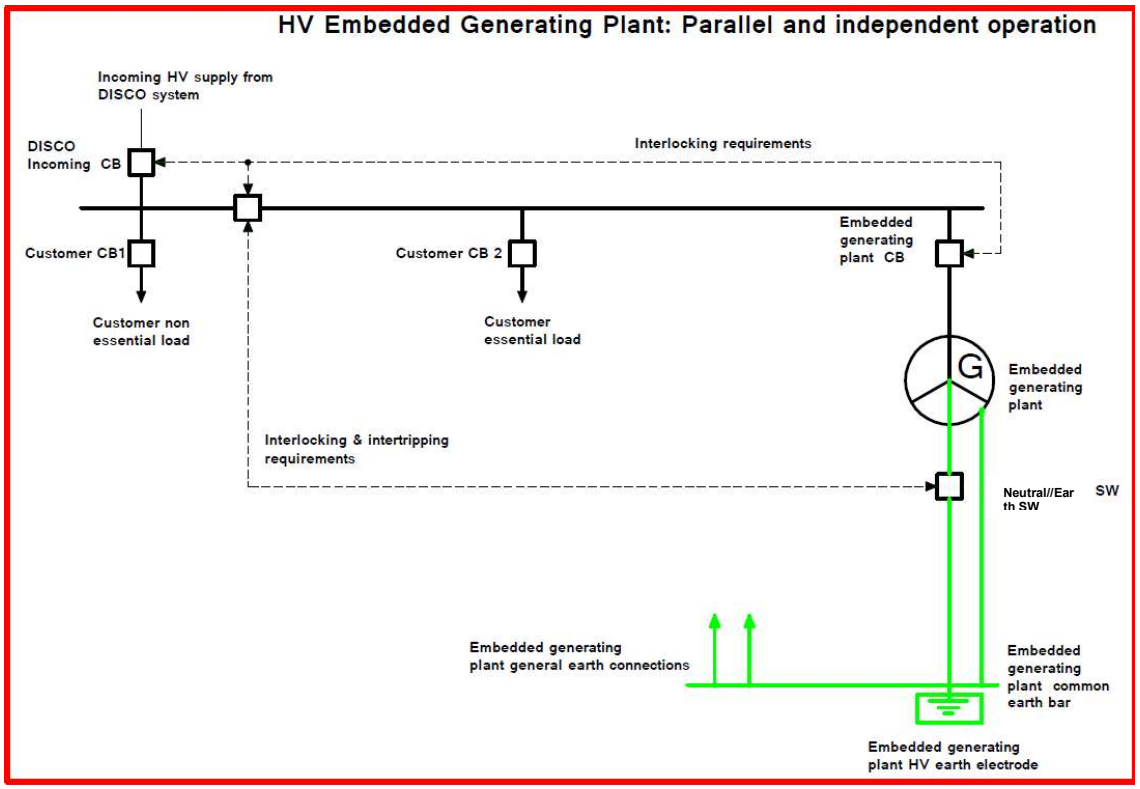
1.2 HV Embedded Generating Plant: Parallel Operation Only



Schedule 1, figure 2.

Standard earthing configuration for HV embedded generating plant operating in parallel with the DISCO system.

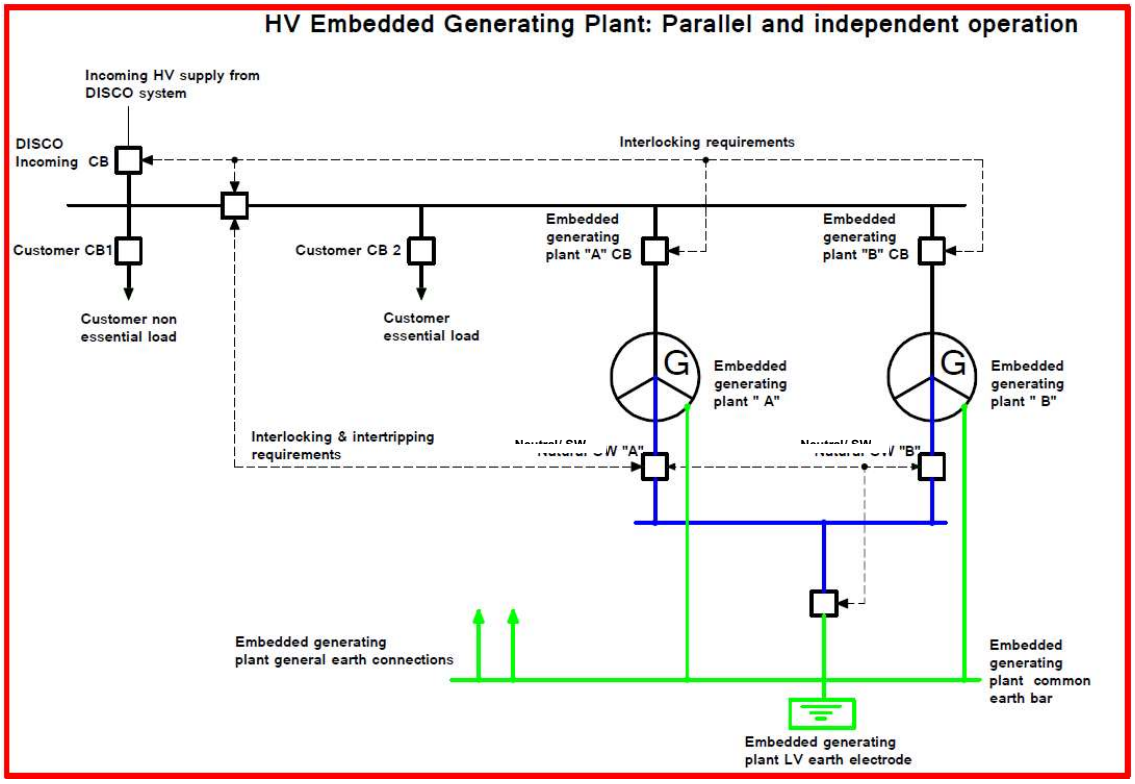
1.3 HV Embedded Generating Plant: Parallel and Independent Operation



Schedule 1, figure 3.

Standard earthing configuration for HV embedded generating plant operating in parallel with and independent to the DISCO system.

1.4 HV Embedded Generating Plant: Parallel and Independent Operation

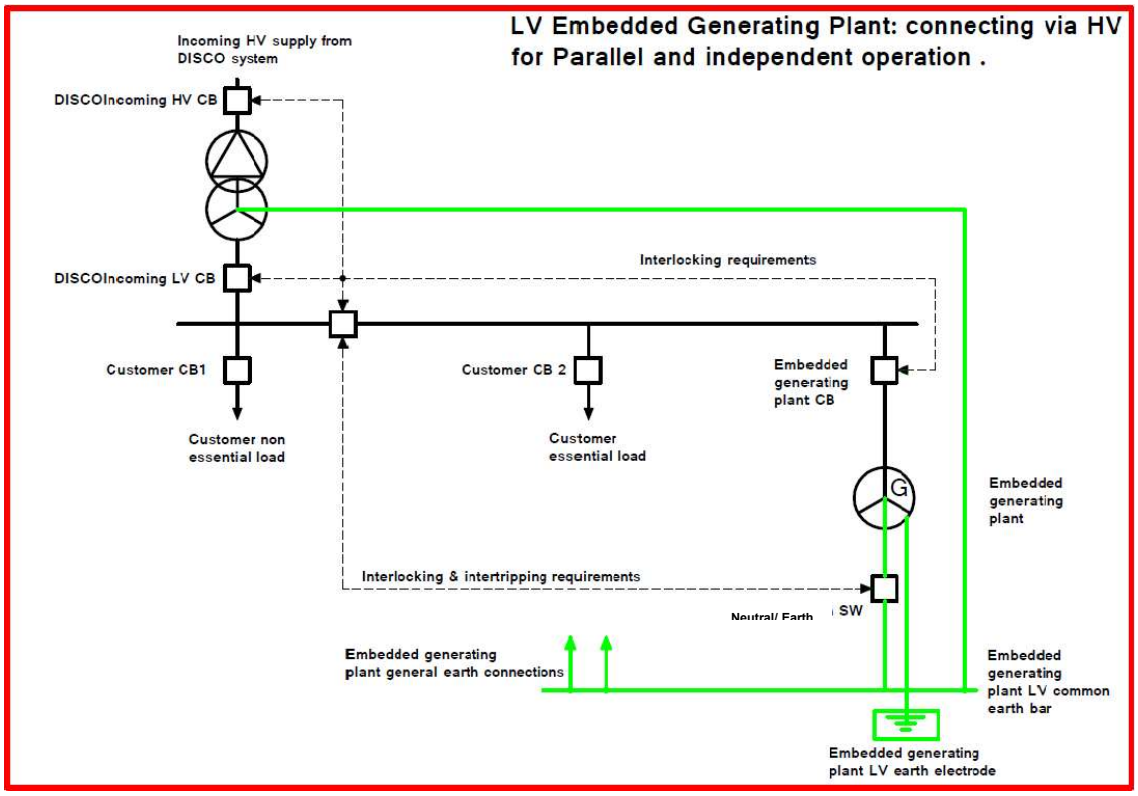


Schedule 1, figure 4.

Standard earthing configuration for two HV embedded generating plants operating in parallel with and independent to the DISCO system.

Schedule 2: Typical LV earthing Arrangements

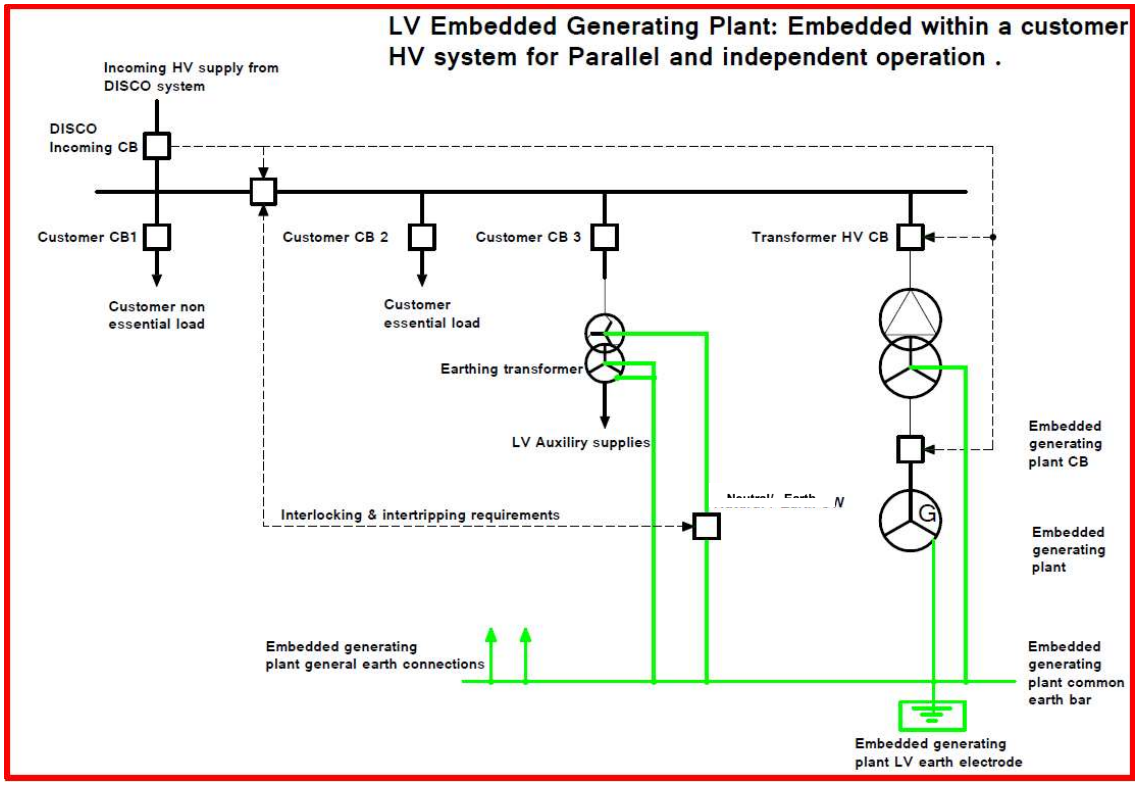
2.1 LV Embedded Generating Plant: Connected via HV for Parallel and Independent Operation



Schedule 2, figure 1.

Standard earthing configuration for LV embedded generating plant connected via HV and operating in parallel with and independent.

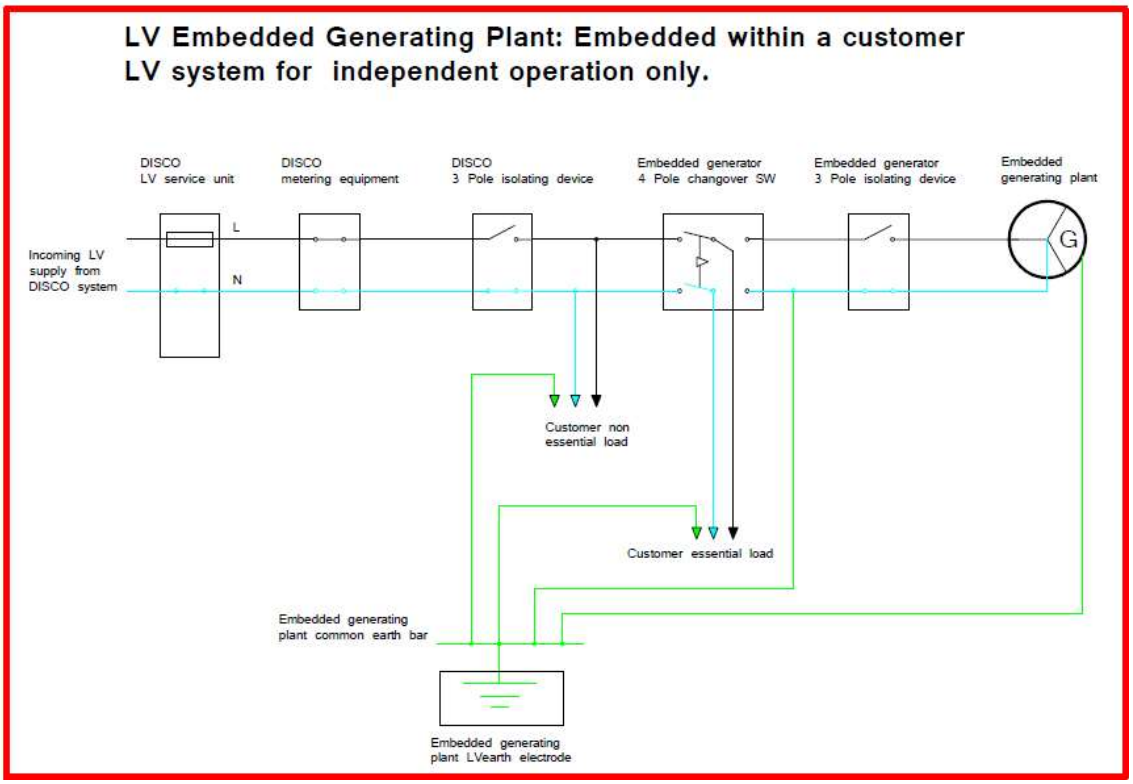
2.2 LV Embedded Generating Plant: Embedded within a Customer HV System for Parallel and Independent Operation



Schedule 2, figure 2.

Standard earthing configuration for LV embedded generating plant set in a customer HV system and operated in parallel with and independent to the DISCO system.

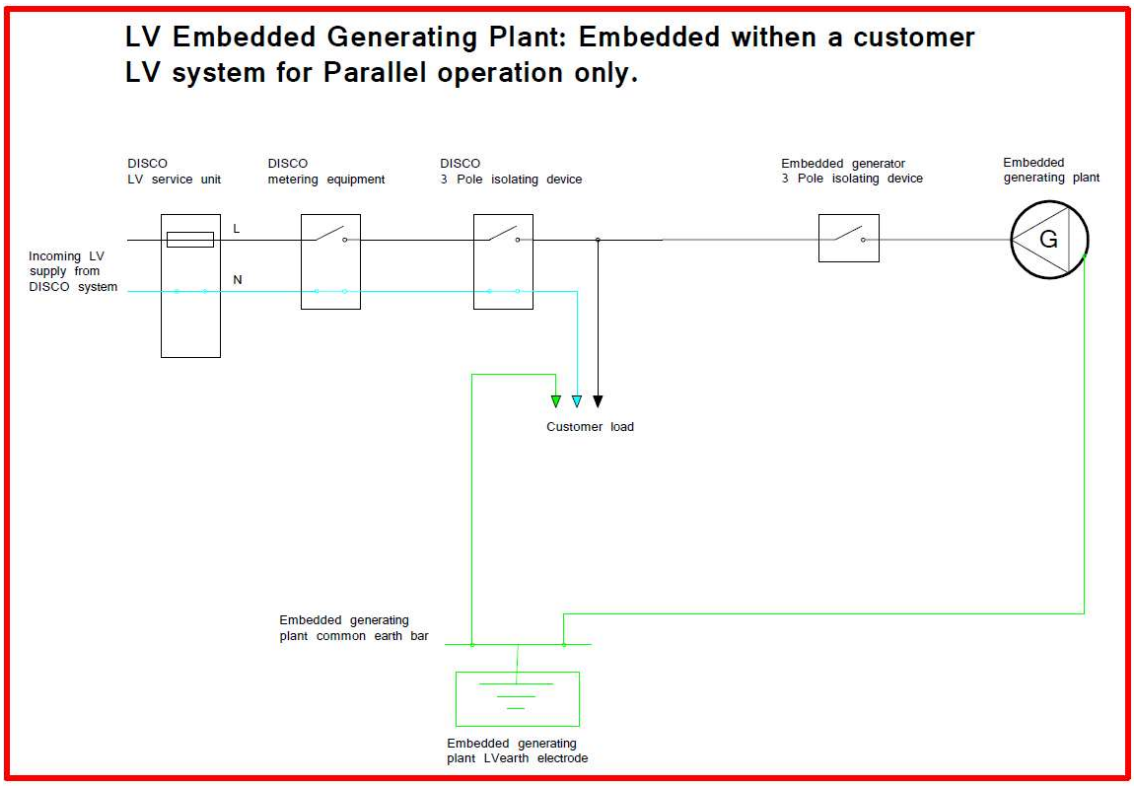
2.3 LV Embedded Generating Plant: Embedded within a Customer LV System for Independent Operation Only



Schedule 2, figure 3.

Standard earthing configuration for LV embedded generating plant set in a customer LV system and operating independent to the DISCO system.

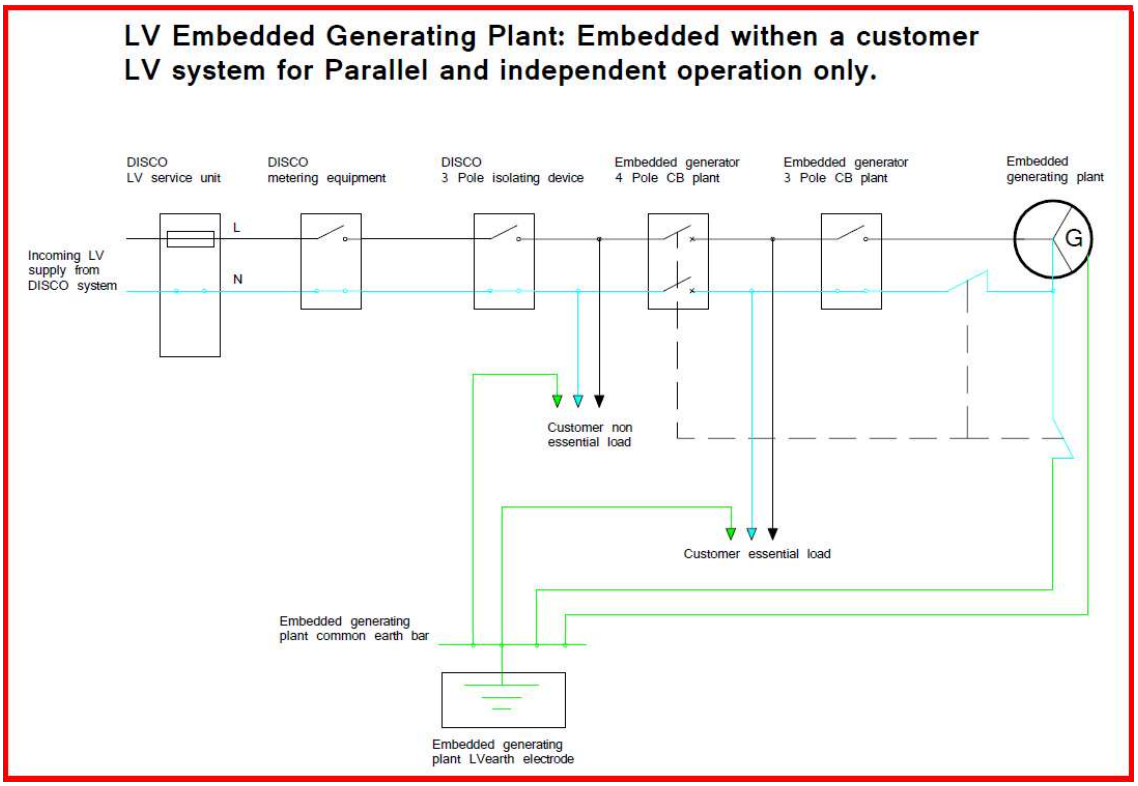
2.4 LV Embedded Generating Plant: Embedded within a Customer LV System for Parallel Operation Only



Schedule 2, figure 4.

Standard earthing configuration for LV embedded generating plant set in a customer LV system and operating in parallel with the DISCO system only.

2.5 LV Embedded Generating Plant: Embedded within a Customer LV System for Parallel and Independent Operation Only

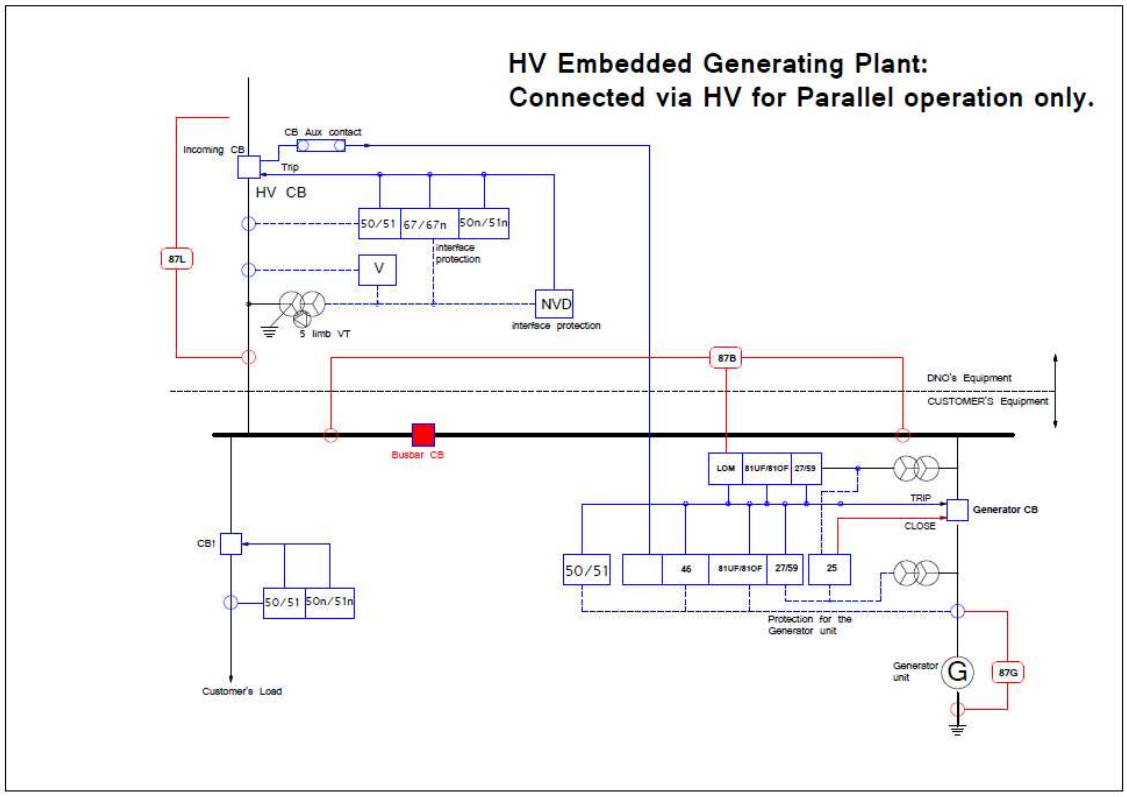


Schedule 2, figure 5.

Standard earthing configuration for LV embedded generating plant set in a customer LV system and operating in parallel with or independent to the DISCO system.

Schedule 3: Typical HV Protection Arrangements

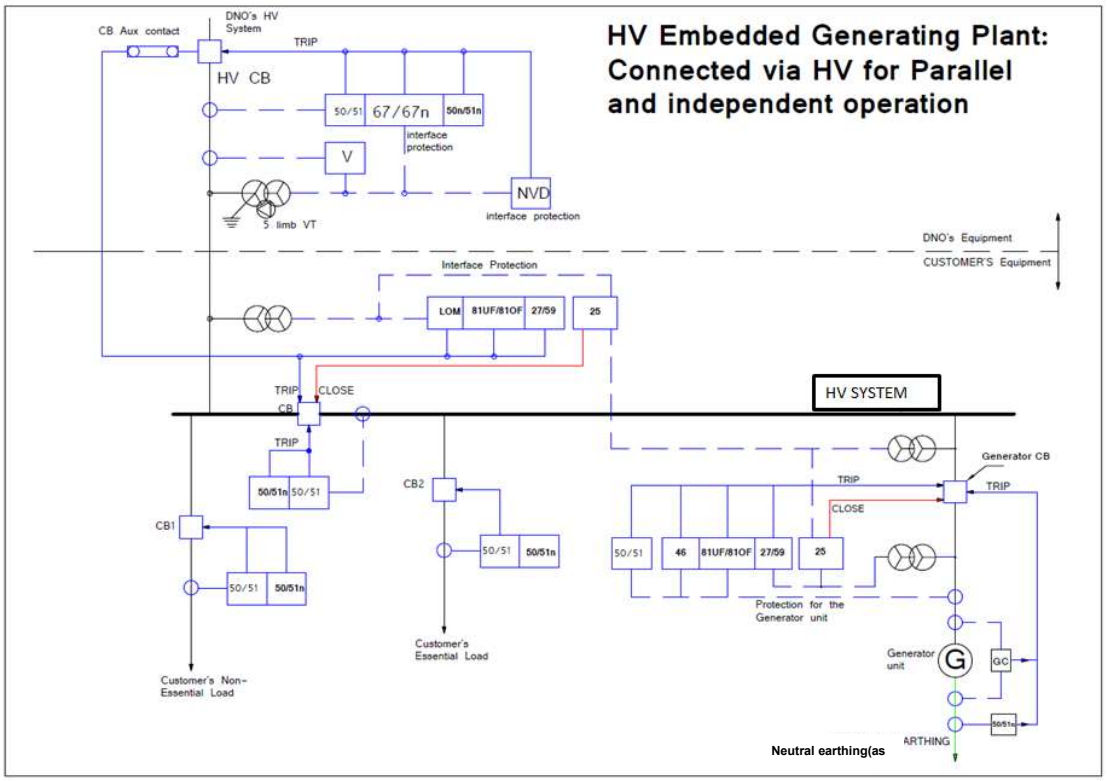
3.1 HV Embedded Generating Plant: Connected via HV for Parallel Operation Only



Schedule 3, figure 1 Typical Protection arrangement for HV Embedded Generating Plant designed for Parallel Operation only

Note. All protection arrangements shall be subject to the formal agreement between the DISCO and the embedded generator.

3.2 HV Embedded Generating Plant: Connected via HV for Parallel and Independent Operation

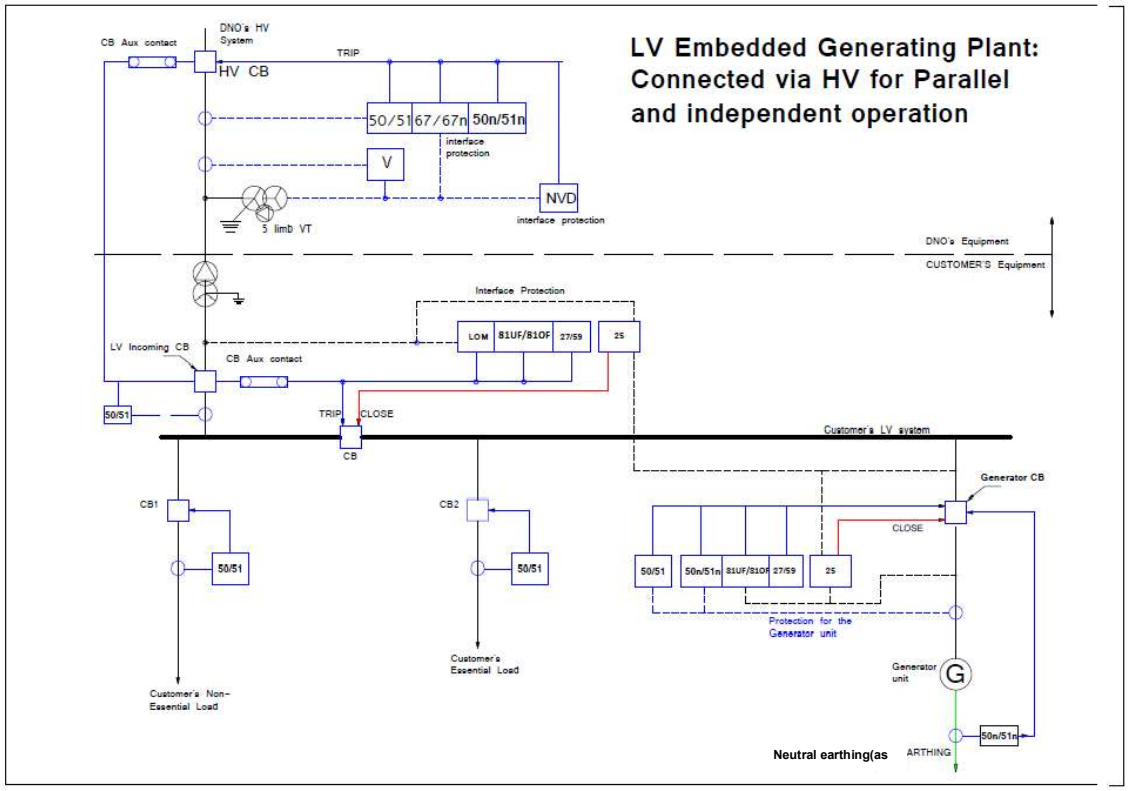


Schedule 3, figure 2: Typical Protection arrangement for HV Embedded Generating Plant designed for parallel and independent Operation

Note. All protection arrangements shall be subject to the formal agreement between the DISCO and the embedded generator.

Schedule 4: Typical LV Protection Arrangements

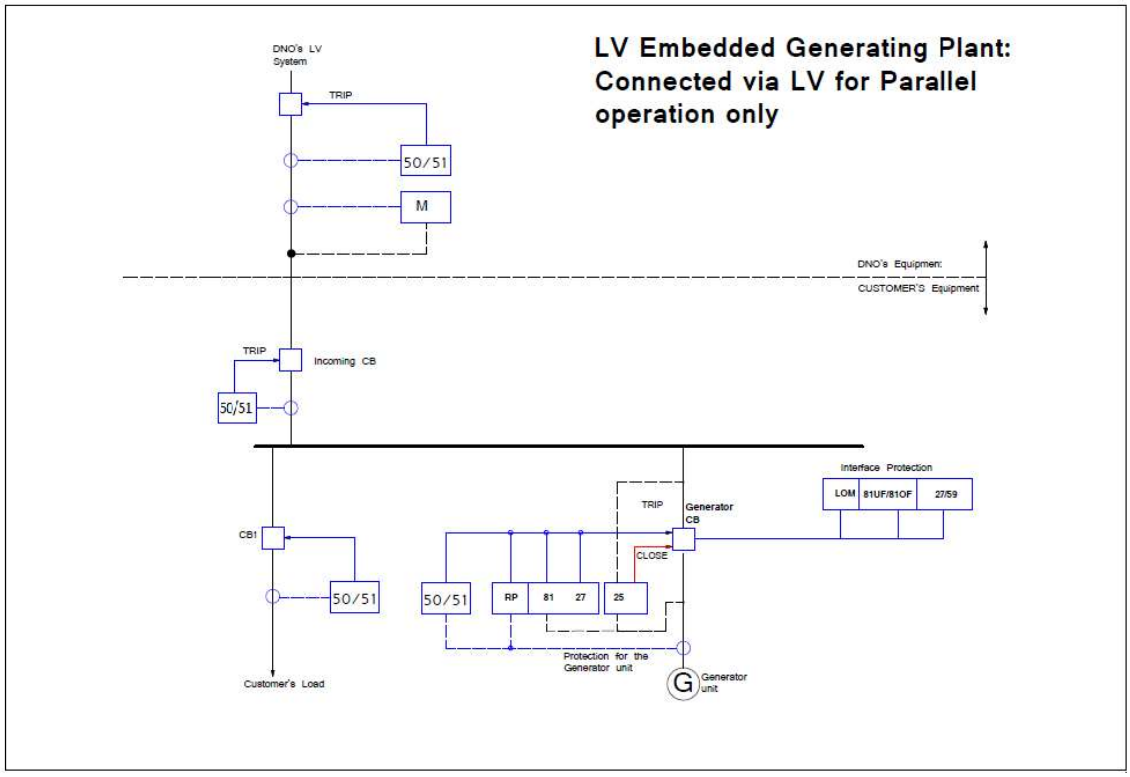
4.1 LV Embedded Generating Plant: Connected via HV for Parallel and Independent Operation



Schedule 4, figure 1: Typical Protection arrangement for LV Embedded Generating Plant connected via HV and designed for parallel and independent Operation

Note. All protection arrangements shall be subject to the formal agreement between the DISCO and the embedded generator.

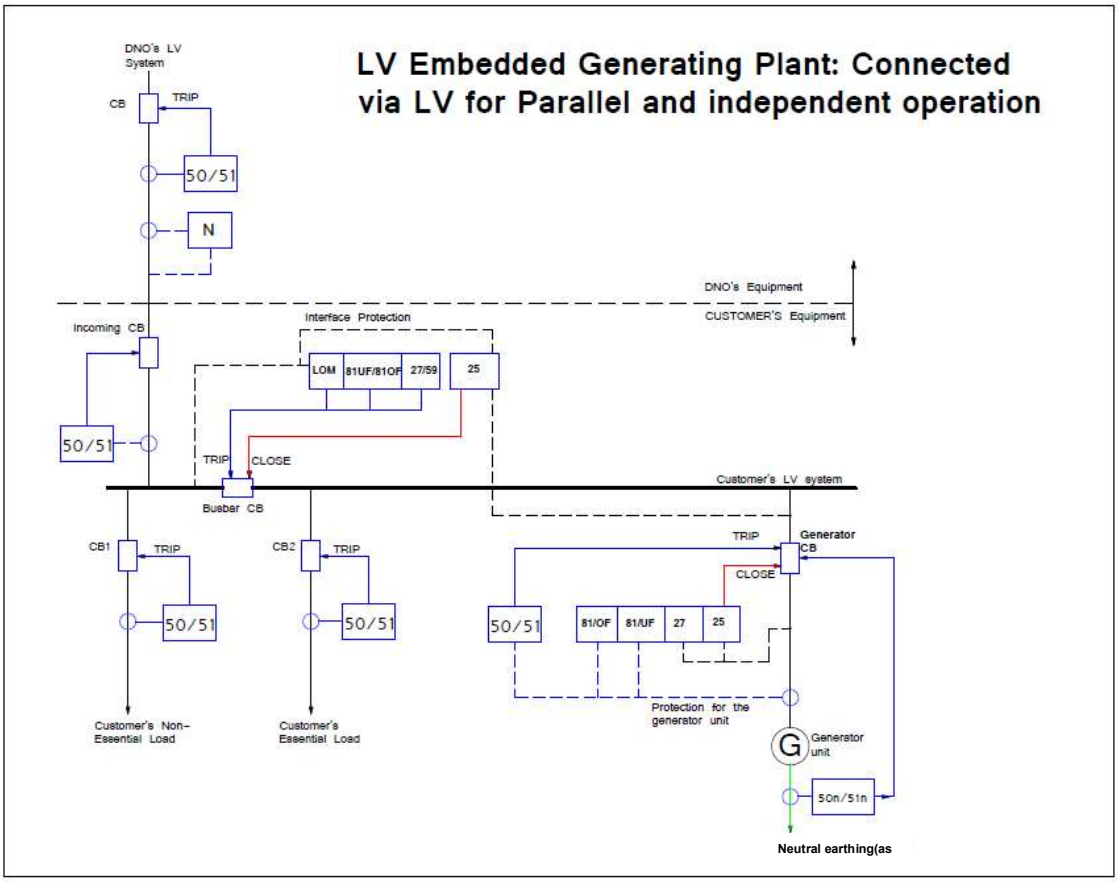
4.2 LV Embedded Generating Plant: Connected via LV for Parallel Operation Only



Schedule 4, figure 2: Typical Protection arrangement for LV Embedded Generating Plant connected via LV and designed for Parallel Operation only

Note. All protection arrangements shall be subject to the formal agreement between the DISCO and the embedded generator.

4.3 LV Embedded Generating Plant: Connected via LV for Parallel and Independent Operation

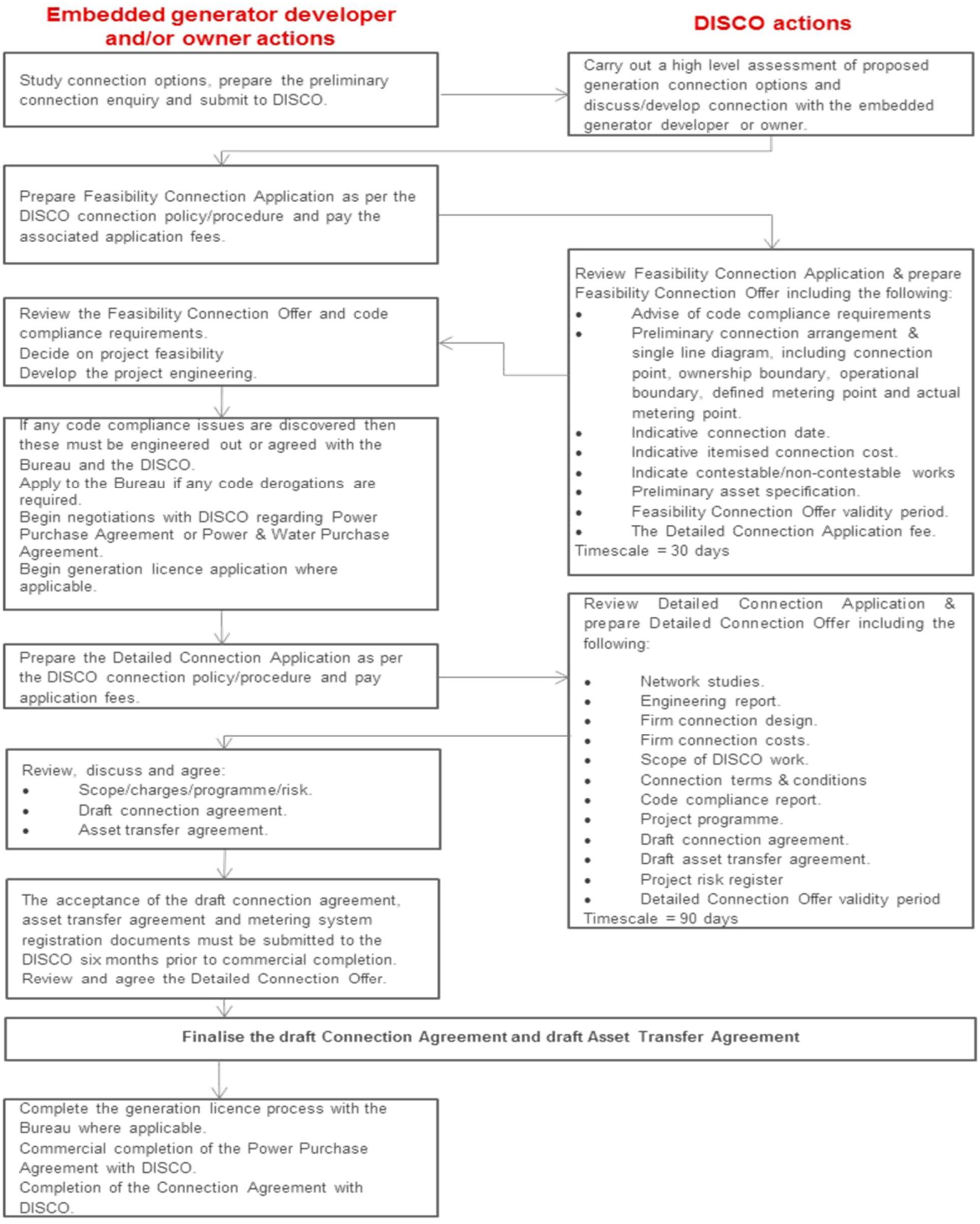


Schedule 4, figure 3: Typical Protection arrangement for LV Embedded Generating Plant connected via LV and designed for parallel and independent Operation

Note. All protection arrangements shall be subject to the formal agreement between the DISCO and the embedded generator.

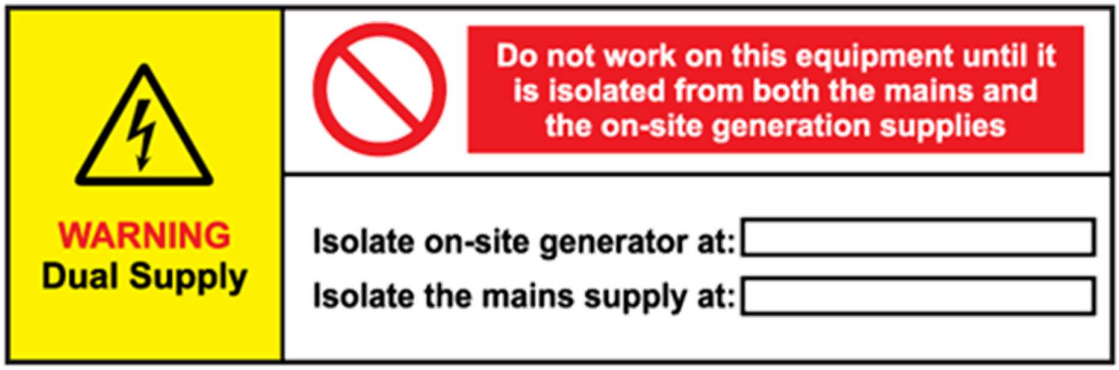
Schedule 5: Application for Connection Process

5.1 Connection Process Flow Chart



Schedule 6: Safety Signage

6.1 Safety Sign: Warning Label



Schedule 6, figure 1: Typical warning label located at the point of supply

Note. It is preferred all safety signage incorporate both Arabic and English text.