Engineering Recommendation No.3
of the Electricity Distribution Code

Connection of Embedded Generating Plant up to 5MW

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1.0 PREFACE

This Engineering Recommendation forms part of Annex 1 to the Electricity Distribution Code. It applies to the Users of the Electricity Distribution System as specified and defined by the latest edition of the Electricity Distribution Code.

This Engineering Recommendation is related to the connection of Embedded Generating plant to DISCO distribution networks, and is intended for use where the connection is to be made to systems at, or below, 20KV and where the output of the generating plant does not exceed 5 MW.

The connection of Embedded Generating plant of larger capacity and higher voltage will normally require a more technical appraisal not covered by this document. Such generating plant is therefore outside of the scope of this Engineering Recommendation.

This document applies to systems where the Embedded Generating plant may be paralleled with a DISCO's system, or where either the Embedded Generating plant or, DISCO's system may be used to supply the same load.

2.0 DEFINITIONS

For the purpose of this Engineering Recommendation the following definitions apply. All other definitions are as stated in the Electricity Distribution Code.

PCC (Point of Common Coupling): The point on the DISCO network, electrically nearest the generating plant installation, at which other customer's loads are, or may, be connected.

Point of Supply: The point of electrical connection between the apparatus owned by DISCO and the apparatus owned by an Embedded Generator.

Parallel Operation: the operation of Embedded Generation 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 (e.g. 5 minutes) for purposes such as testing or changeover of load.

Non-parallel Operation: the operation of Embedded Generating plant such that the load it supplies may be switch to the DISCO's system without any possibility of a short term or momentary parallel of the two sources.

3.0 CONNECTION ARRANGEMENTS

Each installation with Embedded Generating plant must be designed to be compatible with the DISCO's network to which it is to be connected. In addition to the requirements mentioned in this document all other relevant requirements in the Electricity Distribution Code should also be met; attention is drawn in particular to Chapter 3 Section 7 (Requirements for Embedded Generators).

The two methods of operating Embedded Generating plant that are considered in this document are described below:

(a) Parallel Operation with the DISCO's System (including 'short-term' paralleling)

(b) Non-parallel Operation (alternative connection) to DISCO's System

When it is intended to change the existing method of operation to one of the above methods, the requirements of the chosen method must be met in full.

4.0 SYSTEM EARTHING

Written agreement is required between the DISCO and the Embedded Generator which must confirm the means of connecting the two systems to earth. The DISCOs operating in the Emirate of Abu Dhabi use the TT system of earthing, in accordance with the Electricity Supply Regulations. This system requires customers to provide their own earth rather than use one provided from the DISCO's distribution network. The same would apply for an Embedded Generator.

When operating in parallel or 'short term' parallel, the earthing of the Embedded Generator (e.g. star point earth or earthing transformer) must be disconnected by a suitable manual or automatic isolator which is interlocked according to the methods described in 6.2 . When the generator is operating in isolation to supply the customer's load then it should be re-connected to its own earthing system. The guidance document ETR 113 gives further information and examples of earthing system designs (see references p11).

5.0 PARALLEL OPERATION OF EMBEDDED GENERATION

5.1 Written Agreements

The Embedded Generator must obtain in writing from the DISCO, an agreement to operate Embedded Generator in parallel with the DISCO system, this agreement shall include:

a. Means of synchronization between the Embedded Generator's system and the DISCO's system.

b. Plant maintenance and failure records.

c. Precautions for earthing

d. Means of connection and disconnection between the two systems.

e. Mark-up drawings showing compatibility of earth connections.

f. Generator Performance Chart

5.2 Responsibilities

When parallel operation takes place between the DISCO system and the Embedded Generator it is the responsibility of the two parties to ensure that:

a. Operational persons have sufficient authority and technical skills

b. Adequate means of communication are provided

c. Records are kept of all operational communications (and in particular any abnormal incidents).

e. All other operational and safety requirements are provided as detailed in the Electricity Distribution Code – chapter 4.

5.3 Technical Considerations

Fault Infeed: Embedded Generators and the DISCO must consider the cumulative fault level on both Systems. Either System must be capable of withstanding the potential fault current from both Systems.

Synchronizing: DISCO consent is required prior to making a parallel connection. The voltage fluctuation should not exceed 3% at the point of common coupling. Automatic Synchronizing equipment is preferred, but manual synchronisation may be allowed by agreement with the DISCO.

Distortion and Interference: The voltage fluctuations at the point of common coupling should not exceed 1% for changes of input/output power of generating plant. When generating plant is run up to speed (as a motor) any disturbance must be within the limits defined in Engineering

Recommendation No. 1 (harmonics) and Engineering Recommendation No. 7 (voltage fluctuations) of the Electricity Distribution Code. 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 – Voltage Unbalance).

Operational Switching: 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 of loss of the DISCO supply. Where an Embedded Generation requires his plant to continue to supply a temporarily disconnected section of the DISCO system, a special agreement will be required from the DISCO.

Points of Interconnection and Means of Isolation: Any installation or network which includes an Embedded Generator operating in Parallel with the DISCO supply must include a means of isolation, suitably labelled and capable of disconnecting the whole of the Embedded Generator infeed. This means should be readily accessible to DISCO staff in the case of an emergency or for safety reasons.

Control Equipment Requirements: Each item of Embedded Generation plant must be designed for stable operation in parallel with the DISCO's System. Any requirements for voltage or frequency control will be specified by the DISCO.

5.4 Protective Equipment

5.4.1 General requirements

In addition to protection installed by the Embedded Generator for its own purpose, the DISCO will require protective equipment to be provided by the Embedded Generator to achieve the following:

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

(b) To disconnect the Embedded Generator during any system abnormality where an unacceptable deviation of voltage or frequency occurs at the point of connection to the DISCO's network.

(c) To disconnect the Embedded Generator for loss of one or more phases of DISCO supply.

(d) 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.

(e) To ensure, when operating in parallel with the DISCO network, that the generator is connected to the DISCO earthing system and is isolated from its own earthing system (using a suitable isolation device).

(f) To ensure, when operating in isolation from the DISCO network, that the generator is connected to its own earthing system and is isolated from the DISCO earthing system (using a suitable isolation device).

(g) To disconnect the phase and neutral connections of any generator connected at LV to the DISCO system, in order to provide full safety isolation.

5.4.2 Protective Equipment for HV Supply Arrangements

Suitable protection arrangements and settings for a HV installation will depend on the requirements of each individual case and these must be agreed with the DISCO. These arrangements must, as a minimum, include detection of:

a. Over Voltage
b. Under Voltage
c. Over Frequency
d. Under Frequency
e. Loss of Mains

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

a. Neutral Voltage Displacement
b. Over Current
c. Earth Fault
d. Reverse Power
e. Differential protection
f. Voltage restrained overcurrent
g. Loss of excitation
h. Negative phase sequence

The settings of relays should be agreed with the DISCO. Further advice on protection arrangements is given in the guidance document ETR 113 (see references p11).

5.4.3 Protective Equipment for LV Supply Arrangements

(a) Small Generating Plant below 150KVA

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 1 over leaf. These protection settings are for the purpose disconnecting equipment at times of system abnormalities and are not intended as a back-up for the generator's own protection.

Table 1: Typical protection settings for LV supply arrangements

Protection	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

Note: total tripping time = relay time + breaker operating time

(b) Large Generating Plant Exceeding 150KVA

As the plant increases, its affects on the distribution system also increase; additional protection to that stated above may be required similar to that discussed under 5.4.2 above.

5.4.4 Power Factor Correction

Power factor correction equipment is sometimes used with asynchronous generators to decrease reactive power flows on the distribution system. For small LV installations the typical protections arrangements shown in Table 1 would normally be adequate.

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. Guidance document ETR113 (see References p11) gives examples of how such considerations can be taken into account.

5.5 Testing and Commissioning

Full tests on the protective equipment shall be specified by the DISCO. These tests will be the responsibility of Embedded Generator and must be witnessed by the DISCO. A record should be kept of test results and routine tests at regular intervals (e.g. yearly) may be specified by the DISCO.

The type of tests specified by the DISCO may include determination of:

a. Voltage dip on synchronizing;
b. Harmonic voltage distortion;
c. Voltage levels as a result of connection of the generator.

5.6 Metering

Metering equipment must be installed as required by the DISCO in accordance with the Metering and Data Exchange Code (MDEC). This may include measurement of import and export of active and reactive energy to and from the Embedded Generator.

5.7 Short Term Occasional Paralleling

Short term paralleling (e.g. 5min, once per month) 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. For this mode of operation the protection requirements are generally less onerous than for full parallel operation discussed above. The detailed requirements for individual cases will be specified by the DISCO but as a minimum would include under/over voltage and frequency protection. Guidance document ETR113 provides further details (see References p11).

6.0 NON-PARALLEL OPERATION OF EMBEDDED GENERATION

6.1 General

No parallel operation with the DISCO supply system is allowed with this form of connection. It is the responsibility of the Embedded Generator to ensure that any part of the installation which is, or may be, connected to the Generating Plant, has first been disconnected from the DISCO supply system and will remain disconnected while the generating plant is connected to the installation. The DISCO must be satisfied that methods of changeover and interlocking meet these requirements.

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.

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.

Where 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.

6.2 Changeover Operated at HV

Where the changeover operates at HV, a minimum of two of the following provisions must be provide, with at least one of these being mechanical:

a. Electrical interlock between the closing and tripping circuits of the changeover circuit breakers
b. Mechanical interlock between the operating mechanisms of the changeover circuit breakers
c. Electromechanical interlock in the mechanisms and in the control circuit of the changeover circuit breakers
d. Mechanical interlocks operated by transferable key system.

In addition to these provisions suitable arrangements will be required to meet the requirements for earthing (see section 4.0 and 5.4.1)

6.3 Changeover Operated at LV

Where the changeover operates at LV at least one of the following provisions must be adopted:

a. Manual break-before-make changeover switch;
b. Two separate switches or fuse switches mechanically interlocked so that it is impossible for one to be moved when the other is in the closed position.
c. An automatic break –before –make changeover contactor
d. Two separate contactors which are both mechanically and electrically interlocked.
e. A system of locks with single transferable key.

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.

In addition to these provisions suitable arrangements will be required to meet the requirements for earthing (see section 4.0).

7.0 REFERENCES

i. **Electricity Distribution Code**: Version 3.0 [2005]

ii. **G59/1: Connection of Embedded Generation to the UK Electricity Supply System [1991]**
Energy Networks Association[1], UK

iii. **G5/4: Limits For Harmonics In The UK Electricity Supply System [2001]**
Energy Networks Association, UK

iv. **P28: Planning Limits For Voltage Fluctuations In The UK Electricity Supply System [1989]**
Energy Networks Association, UK

v. **ETR 113: Notes of guidance for the Connection of Private Generating Plant up to 5MW**
Energy Networks Association, UK

vi. **P29: Planning Limits For Voltage Unbalance In The UK Electricity Supply System [1990]**
Energy Networks Association, UK

1 the Energy Network Association was previously known as the Electricity Association. All documents issued by EA have now been re-labelled under the ENA, but keeping the same document number. These can be purchased online from www.energynetworks.org.

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