

PWS

GUIDE FOR GRID INTERCONNECTION OF EMBEDDED GENERATORS

Part 1:

**Application, Evaluation and
Interconnection Procedure**

December 2000

**Ceylon Electricity Board
P O Box 540
Colombo
Sri Lanka**

CONTENTS OF PART 1 OF THE GUIDE

Glossary, Definitions and Abbreviations	7
1. Scope of the Guide	11
2. Introduction to the Guide	12
2.1 Mandatory Requirement	12
2.2 Guidelines for Design, Testing and Operation	12
2.3 Capacity and Interconnection Voltage	12
2.4 Higher Capacities, Voltages and Upgrades	12
2.5 CEB's Discretion to Waive the Requirements	13
2.6 Requirements Limited to Embedded Generators	13
2.7 Designated Officers	13
3. Embedded Generation	14
3.1 What is Embedded Generation?	14
3.2 Embedded Generators in a Distribution Network	14
3.3 Islanded Operation	14
3.4 Grid System Security	15
3.5 Availability of Capacity	15
4. Context	17
4.1 Grid Capacity, Embedded Generation and System Load	17
4.2 System Reliability and Stability	17
4.3 Future Capacity, Load and Embedded Generators	17
4.4 Types of Connection	19
4.4.1 Embedded Generators with a Substantial Captive Local Load	19
4.4.2 Embedded Generators with Minimal Captive Local Load	19
4.4.3 Separate Agreement Required to Import Energy	19
4.5 Capacities	20
4.6 Locations	20
4.7 Distribution System Arrangement	20
5. Procedural Issues	21
5.1 Initial Application	21
5.1.1 Information to be Provided	21
5.1.2 Processing Duration	21
5.2 Site Reference Number	23
5.3 Letter of Intent	23
5.3.1 Period of Validity	23
5.3.2 Reservation of the Source	23
5.3.3 Reservation of Network Capacity	25
5.3.4 Point of Interconnection	25
5.4 Exchange of information about the Interconnection	25
5.4.1 From Generating Company to the CEB	25
5.4.2 From CEB to the Generating Company	25
5.5 The Power Purchase Agreement	26
5.6 Operational Information to be Provided	26
5.7 Costs of Interconnection	27
5.7.1 Direct Costs of Interconnection and Studies	27

Part 1: Application, Evaluation and Interconnection Procedure

5.7.2 Costs of Network-side Modifications	27
5.8 Metering	27
5.8.1 Metering to be at the Point of Supply	27
5.8.2 Metering Equipment Costs	27
6. Implementation of the Guide	28
6.1 CEB to Implement the Guide	28
6.2 Revisions	28
7. Effective Date	29
7.1 Effective Date	29
7.2 Generators Under Construction by the Effective Date	29
7.3 Generators in Operation by the Effective Date	29
7.4 Final Date for Compliance	30
8. Interconnection Certificate	31
8.1 CEB to Issue the Certificate	31
8.2 Form of Interconnection Certificate	31
8.3 Validity	31
8.4 Designated Officers	31
8.5 Testing and Acceptance Procedure	31
8.6 Costs and Fees of Interconnection Tests and Certificate	31
9. Testing and Acceptance Procedures	33
9.1 General	33
9.2 Responsibilities and Witnessing	33
9.3 Test Procedures	34
9.4 Test Intervals	35
9.5 Records	35
Annex 1 Form of Initial Application	
Annex 2 Form of Letter of Intent	
Annex 3 Forms of Information to be Exchanged	
Annex 4 Form of Interconnection Certificate	
Annex 5 Form of Test Record	
Acknowledgements	
Bibliography	

FIGURES IN PART 1 OF THE GUIDE

Figure 1- Typical Distribution System Arrangement with Embedded Generators	18
Figure 2- Procedural Flowchart of Embedded Generator Connection Process	22
Figure 3- Typical Single Line Drawing	24

CONTENTS OF PART 2 OF THE GUIDE (SEPARATELY BOUND)

Glossary, Definitions and Abbreviations

1. Studies and Information to be Exchanged

- 1.1 Stability
- 1.2 Fault Level
- 1.3 Protection
- 1.4 Voltage Levels
 - 1.4.1 Interconnection Voltage
 - 1.4.2 Voltage Flicker
 - 1.4.3 Voltage Rise
 - 1.4.4 Studies on Voltage Flicker and Voltage Rise
- 1.5 Earthing
- 1.6 Load Flow

2. Fault Level

- 2.1 General
- 2.2 Fault Level Information
- 2.3 Fault Level Calculation
- 2.4 Fault Level Reduction and Mitigation

3. Voltage Regulation

- 3.1 General
- 3.2 Voltage Limits
- 3.3 Power Factor Requirements

4. Earthing of Electricity Networks and Embedded Generators

- 4.1 General
- 4.2 CEB Electricity Supply Networks
- 4.3 Compatibility of Network and Generator Earthing
- 4.4 Generator Parallel Earthing
- 4.5 Interconnection of CEB and Generator Earth Systems
- 4.6 Design of Earth Systems

5. Synchronisation of Generators

- 5.1 General
- 5.2 Voltage Fluctuation
- 5.3 Synchronous Generators
- 5.4 Asynchronous Generators
- 5.5 Other Types of Generators
- 5.6 Synchronising Check relay

6. Islanded Operation

- 6.1 General
- 6.2 Hazards of Islanding
 - 6.2.1 Unearthed Operation of the Distribution System
 - 6.2.2 Lower Fault Levels
 - 6.2.3 Out of synchronisation reclosure
 - 6.2.4 Voltage Levels
 - 6.2.5 Quality of Supply
 - 6.2.6 Risk to Maintenance Personnel
- 6.3 Common Cause Tripping

- 6.3.1 General
- 6.3.2 Risks to the Network
- 6.3.3 Risks to the Generator
- 6.4 Sources of Common Cause Tripping of Generators
 - 6.4.1 Loss of Mains Relays
 - 6.4.2 Voltage Relays
 - 6.4.3 Frequency Relays
 - 6.4.4 Local Generator Instability
- 7. Islanding Detection and Protection
 - 7.1 General
 - 7.2 Islanding Detection Systems and Settings
 - 7.2.1 General
 - 7.2.2 Over and Under Voltage
 - 7.2.3 Over and Under Frequency
 - 7.2.4 Rate of Change of Frequency
 - 7.2.5 Voltage Vector Shift
 - 7.2.6 Reverse VARs
 - 7.2.7 Intertipping
 - 7.2.8 Fault Thrower
 - 7.2.9 Restoration
 - 7.2.10 Future Developments
 - 7.3 Islanding Network Protection
 - 7.3.1 General
 - 7.3.2 Inhibiting of Reclose Devices
 - 7.3.3 Neutral Voltage Displacement (NVD) Protection
- 8. Implementation of Islanding Protection
 - 8.1 General
 - 8.2 Interconnection Protection Requirements
 - 8.2.1 Case 1
 - 8.2.2 Case 2
 - 8.2.3 Case 3
 - 8.2.4 Case 4
 - 8.2.5 Case 5
 - 8.2.6 Self Commutated Static Inverters
- 9. Surge Protection
 - 9.1 General
 - 9.2 Location of the Arrester
 - 9.3 Earthing
 - 9.4 Selection of the Lightning Arrestor
 - 9.5 Generators Directly Connected to LV Overhead Lines
- 10. Harmonics
- 11. Operational Procedures and Requirements
 - 11.1 Means of Isolation
 - 11.2 Earthing Facilities for Maintenance
- 12. Safety Aspects

Annex 1	Explanatory Notes on Earthing
Annex 2	Explanatory Notes on Islanding Detection and Protection
Annex 3	Explanatory Notes on Neutral Voltage Displacement
Annex 4	Typical AVR model
Acknowledgements	
Bibliography	

LIST OF FIGURES IN PART 2

- Figure 1- Interconnection Protection Arrangement for Case 1
- Figure 2- Interconnection Protection Arrangement for Case 2
- Figure 3- Interconnection Protection Arrangement for Case 3
- Figure 4- Interconnection Protection Arrangement for Case 4
- Figure 5- Typical Earthing Options for Networks with Embedded Generators
- Figure 6- Connection of Earthing Systems Associated with LV/33kV Generators
- Figure 7- Network Voltage During an Earth Fault
- Figure 8- Neutral Voltage Displacement Protection using a
3-phase, 5-limb Voltage Transformer with an Open Delta Winding
- Figure 9- Example of Typical AVR Modelling Information

PREAMBLE

Embedded Generators have been connected to the Ceylon Electricity Board (CEB) system under Power Purchase Agreements since 1997.

The Power Purchase Agreements between Embedded Generators and CEB are covered by the Electricity Act of Sri Lanka, and other Regulations.

This Guide covers the requirements to be fulfilled by the Interconnection between the Embedded Generator and the CEB system.

The Guide is in Two Parts:

Part 1 explains the procedure to be followed in making an application to develop an embedded generator, evaluation by CEB, and the process of conducting acceptance tests on the Interconnection.

Part 2 of the Guide (separately bound) explains the studies to be conducted by CEB to ensure the interconnection is safe, and provides guidelines for effective design and operation of the interconnection.

This Guide does not replace or supersede any of the requirements specified in the Electricity Act, Ceylon Electricity Board Act, Electricity Regulations or Power Purchase Agreements.

ASSOCIATED DOCUMENTS AND PUBLICATIONS

1. Guidelines on Private Sector Participation in Small Hydro Power Development, Ceylon Electricity Board (current issue).
2. Standardised Agreement for Purchase of Energy, Ceylon Electricity Board (current issue).

This Guide is based on the requirements of Ceylon Electricity Board (CEB), Sri Lanka, and the conditions and constraints under which the CEB system operates. The primary intention of this Guide is to establish procedures and equipment to protect CEB personnel, equipment and the system from any harmful effects arising out of the interconnection and operation of Embedded Generators.

Therefore, it should not be assumed that the guidelines provided would satisfy all the protection requirements of the Embedded Generators. No responsibility can be accepted for any loss or damage sustained as a result of using or relying on this Guide.

GLOSSARY, DEFINITIONS AND ABBREVIATIONS

AVC: Automatic Voltage Controller

AVR: Automatic Voltage Regulator

CEB: Ceylon Electricity Board, a body Corporate duly constituted by Act No. 17 of 1969 of the Democratic, Socialist Republic of Sri Lanka.

Captive Generation: Generating plant available at CEB customer facilities, but not connected in parallel with the CEB network.

Captive Line Load: Load, up to the 1st point of automatic isolation, which is (or may be) supplied by an Embedded Generator, excluding Captive Local Load.

Captive Local Load: Load within the Embedded Generator premises including generator auxiliaries

Captive Load: The sum of Captive Line Load and Captive Local Load

Common Mode (or Cause) Tripping: Automatic removal of two or more generating plant from the system owing to a cause that is common to both or all the generators.

Combined Heat and Power (CHP): A plant that generates electricity and supplies thermal energy, typically steam, to an industrial or other heating requirement.

EF: Earth Fault (protection)

Embedded Generator: A single generator, or a group of generators, connected to the distribution network of the CEB, at voltages between 400 V and 33 kV.

Export of Electrical Energy: Supply of Electrical Energy by a Generator to the CEB system.

Generating Company: A company, group or individual who plan to connect or has already connected an Embedded Generator to the CEB distribution network.

Part 1: Application, Evaluation and Interconnection Procedure

Grid Interconnection: A link between CEB Electricity system and Embedded Generator's Electricity System, made for the purpose of Exporting or Importing Electrical Energy.

Grid Substation: A CEB substation where electrical energy at 220 kV or 132 kV is transformed into 33 kV.

Highest (Lowest) Voltage of a System: The highest (lowest) value of operating voltage which occurs under normal operating conditions at any time and at any point in the system.

HV: High voltage, exceeding 1000 V between conductors and 600 V between conductors and earth.

Import of Electrical Energy: Receipt of Electrical Energy by the Embedded Generator from the CEB system.

Interconnection Certificate: A Certificate issued by CEB to an Embedded Generator, after testing the interconnection.

Interconnection Voltage: The nominal voltage at which the grid interconnection is made.

Initial Application: The first application by an individual or Company aspiring to develop an Embedded Generator.

Islanding: The process whereby a power system is separated into two or more parts, with generators supplying loads connected to some of the separated systems.

Islanded Operation: The situation that arises when a part of the electrical system is disconnected from the main grid and is energised by one or more generators connected to it.

Letter of Intent (LOI): Issued by CEB to a Generating Company to signify CEB's intent to purchase power from a Generating Company at a particular location.

LOM: Loss of mains (protection)

LV: Low voltage, not exceeding 1000 V between conductors and 600 V between conductors and earth.

Part 1: Application, Evaluation and Interconnection Procedure

Neutral Point Displacement Voltage: The voltage between the real or virtual neutral point and the earth.

NVD: Neutral Voltage Displacement. A technique to measure the displacement of the neutral voltage with respect to earth.

Nominal Voltage: A suitable approximate value of voltage used to designate or identify a System.

OC: Over-current (protection)

OF: Over-frequency (protection)

Operating Voltage: The value of the voltage under normal conditions at a given instant and at a given point in the system.

OV: Over-voltage (protection)

Point of Common Coupling (PCC): The location of the connection between the CEB network and the Embedded Generator, beyond which other customer loads may be connected on the CEB side. The PCC may be separate from the Point of Supply where a line is dedicated to the connection of an Embedded Generator.

Point of Supply (POS): The location of the connection between the CEB network and the Embedded Generator.

Power Purchase Agreement (PPA): An agreement between the CEB and the Generating Company for the purchase of electricity by the CEB.

ROCOF: Rate-of-change of Frequency (protection)

RP: Reverse Power (protection)

SBEF: Standby Earth Fault (protection)

Spinning Reserve: The difference between the total available capacity of all generating sets already coupled to the system and their total actual loading.

Step Voltage: The difference in surface potential experienced by a person bridging a distance of 1 m with his feet without contacting any other grounded structure.

Touch Voltage: The potential difference between the ground potential rise (GPR) and the surface potential at the point where a person is standing where at the same time having his hands in contact with a grounded structure. GPR defined as the maximum voltage that a station grounding grid may attain relative to a distant grounding point assumed to be at the potential of remote earth. The touch voltage could be from hand to hand also.

Transferred Voltage: This is a special case of the touch voltage where the voltage is transferred into or out of the station by a conductor grounded at a remote point or at the station ground, respectively.

TNS system of Earthing: In this earthing system, the supplier provides separate Neutral and Protective conductors throughout the system. The Protective Conductor is connected to the neutral of the source. All exposed conductive parts of a consumer's installation are connected to the Protective Conductor provided by the supplier via the main earthing terminal of the consumer's installation.

TT System of Earthing: An earthing system where all exposed conductive parts of an installation are connected to an earth electrode provided by the consumer which is electrically independent of the Source earth. -

UV: Under-voltage (protection)

UF: Under-frequency (protection)

Voltage Level: One of the Nominal Voltage values used in a given system.

VS: Vector Shift (protection)

1. SCOPE OF THE GUIDE

This Guide for Grid Interconnection of Embedded Generators in the Ceylon Electricity Board (CEB) system in Sri Lanka is a comprehensive analysis of issues, and provides Guidelines in determining the processing of inquiries, types of interconnections, voltages, studies required, protection requirements, and the testing and certification procedure of Embedded Generators. General information is also provided on interconnection protection systems and earthing.

For the purposes of this Guide, an Embedded Generator is defined as a single generator or a group of generating plant of total installed capacity up to 10 MW, connected to the CEB distribution system at 33 kV or below.

The Guide is intended to be followed by all Generating Companies operating/building Embedded Generators to be connected to the CEB network in Sri Lanka, irrespective of whether the Generating Company sells or intends to sell electricity to the CEB.

This Guide does not replace or supersede any of the requirements specified in the Electricity Act, Ceylon Electricity Board Act, Electricity Regulations or Power Purchase Agreements.

2. INTRODUCTION TO THE GUIDE

2.1 Mandatory Requirement

This Guide specifies mandatory requirements to be satisfied by Embedded Generators connected to the CEB network in Sri Lanka.

2.2 Guidelines for Design, Testing and Operation

In addition to specifying the mandatory requirements, this Guide provides useful information to Generating Companies and CEB, in the design and acceptance testing of the grid Interconnection of Embedded Generators.

Protection equipment and systems specified in the Guide are for the protection of the grid interconnection only. There will also be requirements for other types of protection systems to protect the Embedded Generators, which are not specified in the Guide.

2.3 Capacity and Interconnection Voltage

Requirements specified in this Guide are applicable to all Embedded Generators with a maximum installed capacity up to and including 10 MW, and for connection to CEB networks at or below 33 kV. For the purpose of this Guide, the 10 MW limit should be understood as the total installed generating capacity connected to the network through a single Point of Supply. The total generating capacity may consist of several generators.

2.4 Higher Capacities, Voltages and Upgrades

When the total installed generating capacity at the Point of Supply exceeds 10 MW, either at the time of first interconnection of the Embedded Generator or as a result of an upgrade, the requirements of this Guide will no longer be directly relevant. Similarly, when the interconnection is at a voltage higher than 33 kV, this Guide may not be directly applicable. Such requirements will be specified by CEB on a case by case basis, or will be based on other prevailing requirements, standards or Guides.

2.5 CEB's Discretion to Waive the Requirements

The General Manager of CEB may waive any one or several of the requirements of this Guide for any Embedded Generator under any one or several of the following conditions.

- (a) The Embedded Generator is designated to serve a short-term, emergency requirement of the CEB to ensure continuity of electricity supply
- (b) The Embedded Generator is of exceptionally small capacity. Typical units that qualify for exemption are small solar-electric inverter-type Embedded Generators rated up to 5 kW.
- (c) The Embedded Generator is specifically for short-term research purposes

In case (b) above (embedded generators of exceptionally small capacity), such interconnections are out of the scope of this Guide, and a separate type approval requirement will be implemented by the CEB.

In any event, no Embedded Generator of types (a) and (c) shall operate in the CEB system without the minimum protection requirements of,

- Over and under voltage
- Over and under frequency
- Islanding Mitigation Protection for Embedded Generators larger than 1 MW

2.6 Requirements Limited to Embedded Generators

The requirements of this Guide will not be applicable for generators which do not fall into the category of Embedded Generators, as defined above in Section 2.3 and explained Section 3 of this Guide.

2.7 Designated Officers

The General Manager of CEB will designate a Competent Officer to:

- Witness that the requirements of this Guide are fulfilled at the time of first interconnection, and
- Coordinate with the Generating Company who have the responsibility to ensure that the requirements are adhered to on a continuous basis.

3. EMBEDDED GENERATION

3.1 What is Embedded Generation?

Embedded generators are typically small and medium sized generators which are connected to the distribution system. There may also be captive loads. The interconnection voltage would be 400 V or 11kV or 33kV.

Embedded generation is being encouraged to utilise energy resources available across the country. These resources consist mainly of hydro power schemes, but will also include Combined Heat and Power (CHP), wind power and possibly other sources of generation.

It is expected that there will be a significant increase in the amount of embedded generation capacity which will make a useful contribution to the CEB grid. It is expected that the contribution of embedded generation will exceed 15% of the minimum demand on the CEB grid by 2020.

3.2 Embedded Generators in a Distribution Network

Due to the nature of the connection of Embedded Generators, and often the source of their energy supply, the security, or firmness, of their generation capacity may be lower than that of conventional power plants connected to the transmission system.

In Sri Lanka, there is a high frequency of distribution line outages caused by line faults as well as load shedding. The generation capacity of any generators connected to a distribution line that is subject to an outage will then be lost to the grid system as a whole. The distribution line load will also be lost during an outage so there will only be a net loss of generation capacity to the grid system if there was a net export of power from the distribution line before the outage.

A line that is disconnected may suffer an abnormal and unexpected load current until the disconnected generators restart. This may have protection implications and also requires the CEB to maintain a constant assessment of true line load.

3.3 Islanded Operation

For the purpose of this Guide, islanded operation is the situation that arises when a part of the electrical system is disconnected from the main grid and is energised by the embedded generation connected to it. For embedded generators connected to a distribution line, this situation will probably be caused

Part 1: Application, Evaluation and Interconnection Procedure

by the disconnection of a distribution line from a grid sub station due to a fault on the distribution line.

Islanded operation can improve the availability of the electricity supply to consumers connected to a distribution system, if the islanded system can be safely left in service and operated within the statutory limits of supply. Assessment for a typical embedded generation scenario in the CEB system clearly indicates that the cost and complexity of delivering an islanded supply with acceptable risk is not justified by the benefits in terms of supply availability.

In view of this, this Guide pre-supposes that prolonged islanded operation in the CEB system is unsafe and should be prevented by suitable means of protection.

Details of Islanded operation detection and protection are given in Sections 6 to 8 in Part 2 of the Guide.

3.4 Grid System Security

It is anticipated that embedded generation will eventually contribute in excess of 15% of the CEB grid capacity. This Guide is therefore written on the basis that generation connected in accordance with this Guide will be a significant element in securing the grid system.

The background to this Guide is the present instability of the CEB grid due to insufficient generation capacity and inadequate spinning reserve to respond to the loss of single large generators, or generator groups, upon single contingency faults. Protection methods and settings, and generation capacity limits stated in the Guide are based on the present position and will be reviewed periodically as the system develops.

The impact on grid stability of generator security is a major consideration in the selection of islanding protection, which is discussed in Sections 5 to 7 in Part 2 of the Guide.

3.5 Availability of Capacity

There is no central control, or dispatch of Embedded Generators. Generation plant power output is controlled by the operator and connection availability. Plant will usually be run at the maximum power available from the power source.

The requirement for some central control of embedded generation capacity will be reviewed when the total embedded generation capacity exceeds 10% of the

Part 1: Application, Evaluation and Interconnection Procedure

total minimum grid load. At this time there will be some experience of the effects of embedded generation on grid stability, security and management.

At run of river hydro and wind power installations, there is no control over power availability. The developer will usually run the plant at maximum available capacity which is implemented automatically. It is possible for the plant to be run at below available capacity, though this clearly leads to an imposed loss of revenue for the Generating Company.

At CHP plants, there is some control of electrical output. However, there will be an optimum electrical generation for a particular heat load. Operation away from this point will impose a reduction in efficiency and increase in cost of generation.

At a biomass-fired generation plant, there is control of electrical output. There will be constraints on the rate of change of output and storage requirements. Operation at below maximum available capacity will impose a reduction in efficiency and increase in cost of generation.

At a landfill gas powered generation plant, only limited control of gas is possible. Some profiling of output can be achieved to increase value (ie increase output at peak load periods) but large quantities of gas cannot be stored.

CEB may need to disconnect or reduce the output of an embedded generator during abnormal grid conditions in order to maintain safe operation of the grid system. This will be of occasional short time periods only.

4. CONTEXT

Some information and recommendations in the Guide are dependent on the relative magnitudes of network peak demand, minimum demand, size of Embedded Generators and the future scenario. This section describes features of the CEB network relevant to the recommendations in this Guide.

A typical CEB distribution system with embedded generators is shown in Figure 1.

4.1 Grid Capacity, Embedded Generation and System Load

The CEB grid by mid-2000 has about 1700 MW of major generating plant and about 10 MW of Embedded Generation in operation. Most Embedded Generation is small hydroelectric, except for one wind power plant and a few biomass-based Combined Heat and Power (CHP) Plants. The system peak demand is about 1300 MW and the minimum load is about 600 MW.

4.2 System Reliability and Stability

Most embedded generators are expected to be connected to long overhead radial lines, where the frequency of disconnection is high. Daily disconnections are not uncommon. Furthermore, the CEB system experiences major frequency excursions, rapid rates of frequency dips and under frequency load shedding.

4.3 Future Capacity, Load and Embedded Generators

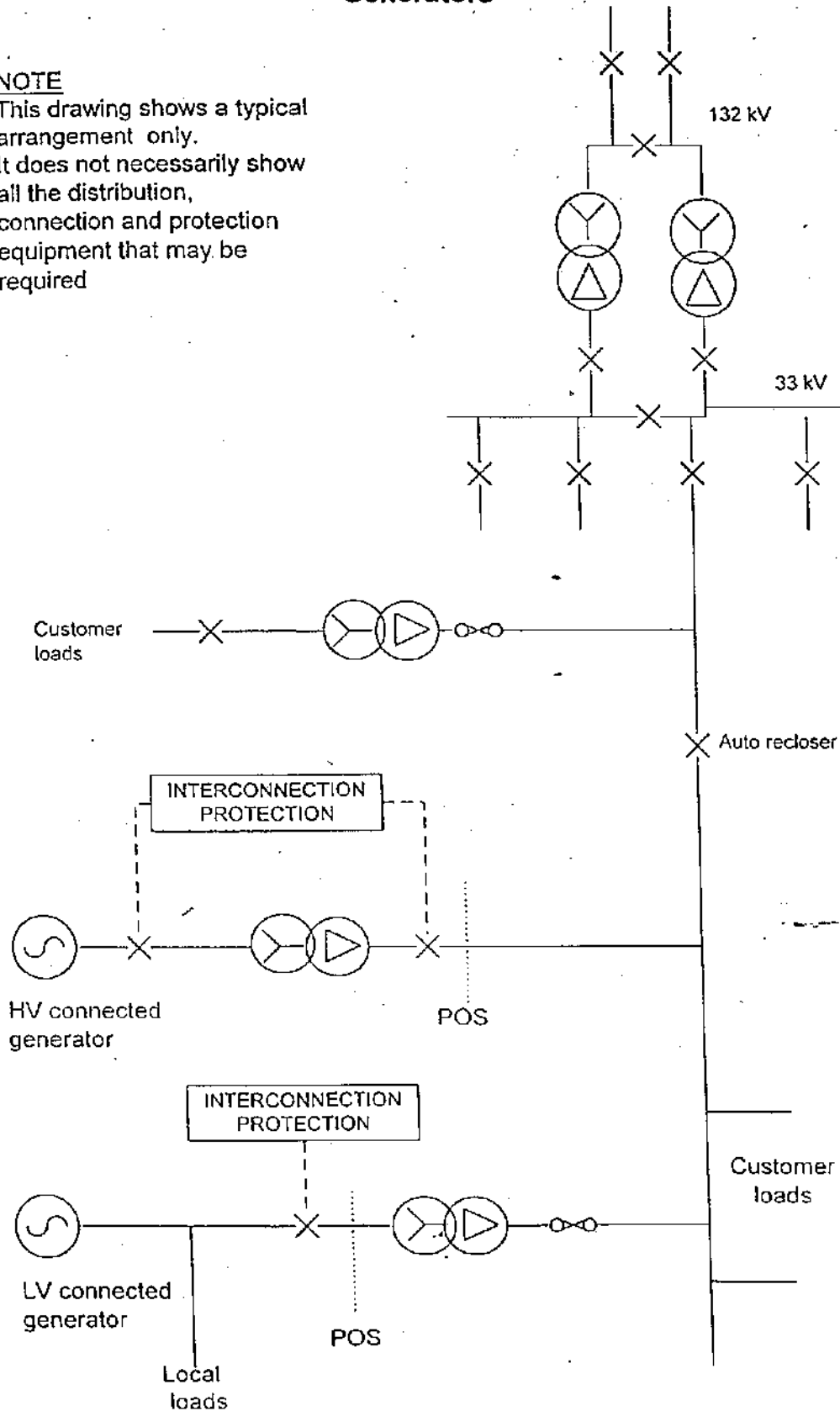
Over a period of 20 years, the system maximum demand is expected to increase to about 5000 MW, and the minimum load by then would be about 2000 MW. It is expected that about 200 MW of small hydroelectric plant will be developed over the next few years, and a significant amount of wind and Combined Heat and Power plant may be developed. By year 2020, a reasonable estimate would be a total of 300 MW of Embedded Generators in the CEB system. The total capacity of embedded generation is expected to be less than 6% of the peak load, and about 15% of the minimum load.

If there is a faster pace of development of embedded generation, CEB will review the Guide accordingly.

Figure 1 - A Typical CEB Distribution System with Embedded Generators

NOTE

This drawing shows a typical arrangement only. It does not necessarily show all the distribution, connection and protection equipment that may be required



4.4 Types of Connection

Embedded generating plants covered in this Guide are of two types.

4.4.1 Embedded Generators with a Substantial Captive Local Load

These generators will regularly operate in parallel with the CEB network, but supply the power requirements of a localised industrial or other facility. The Embedded Generator and the load, when considered together, may either be a net importer or a net exporter of electric energy from the CEB. Usually, there will be no special transmission or distribution lines built for the specific purpose of connecting the Embedded Generator. The connection will be through the point of supply from the CEB to the captive local load.

Hydroelectric power plants located within tea factories and biomass-fired power plants located in sugar industries are examples of this type of Embedded Generator.

The agreements, if any, between the Embedded Generator and the captive local load, are beyond the scope of this Guide. This Guide applies at the Point of Supply to the CEB network.

4.4.2 Embedded Generators with Minimal Captive Local Load

These are Embedded Generators specifically built to harness a source of energy, usually a renewable source of energy. These generators are typically connected to the CEB network through a dedicated line. Typically, there will be no other customer loads between the Point of Common Coupling and the Embedded Generator. The Embedded Generator is always operated in parallel with the CEB network.

There are several embedded hydroelectric power plants and a wind power plant presently in operation, with minimal captive local load. This minimal captive local load supplies the requirements of the Generating Plant only.

4.4.3 Separate Agreement Required to Import Energy

Embedded Generators should enter into a Service Agreement with CEB for the import of energy from the CEB system.

Part 1: Application, Evaluation and Interconnection Procedure**4.5 Capacities**

Most Embedded Generators presently in operation in Sri Lanka are below 2 MW. With several small hydroelectric sites with higher potential, Embedded Generators in the 1 – 5 MW range will be operational within the next few years. Similarly, new biomass-fired power plants and new wind power plants, are expected to be in the range up to 10 MW.

Embedded generators larger than 10 MW are also possible at a few of the small hydroelectric sites and at prospective wood-fired thermal power plants. Larger wind power plants over 10 MW may also be a reality.

4.6 Locations

Embedded Generators are typically located away from grid substations of the CEB. Often there are long lines, supported on concrete poles or steel pylons, between the Embedded Generator and the nearest grid substation or distribution line.

Typically there are only a few customer loads on these lines, mostly supplies to households or small commercial purposes.

4.7 Distribution System Arrangement

The typical system arrangement in the CEB was shown in Figure 1. The recommendations in this Guide should be understood in the context of the conditions and constraints under which the CEB electric power system operates.

5. PROCEDURAL ISSUES

A flowchart showing the application process up to commercial operation is shown in Figure 2.

5.1 Initial Application

5.1.1 Information to be Provided

A Generating Company planning to build an Embedded Generator, or to connect an existing generating facility, shall initially apply to CEB. This application shall be in the form of a letter, which, in the minimum, explains the following:

- a) Name and address of the promoter (and Generating Company or other Company name)
- b) Proposed location of the Embedded Generator
- c) Primary Energy Source (hydro, biomass, wind, etc.)
- d) Details of the Primary Source (summary stream flow data, biomass availability data, wind potential estimates, etc.)
- e) Expected rated capacity and annual energy contribution to CEB network
- f) Expected costs and sources of finance (for new developments)
- g) Expected construction duration (for new developments)
- h) Financial Information

The form of this Initial Application is given in Annex 1.

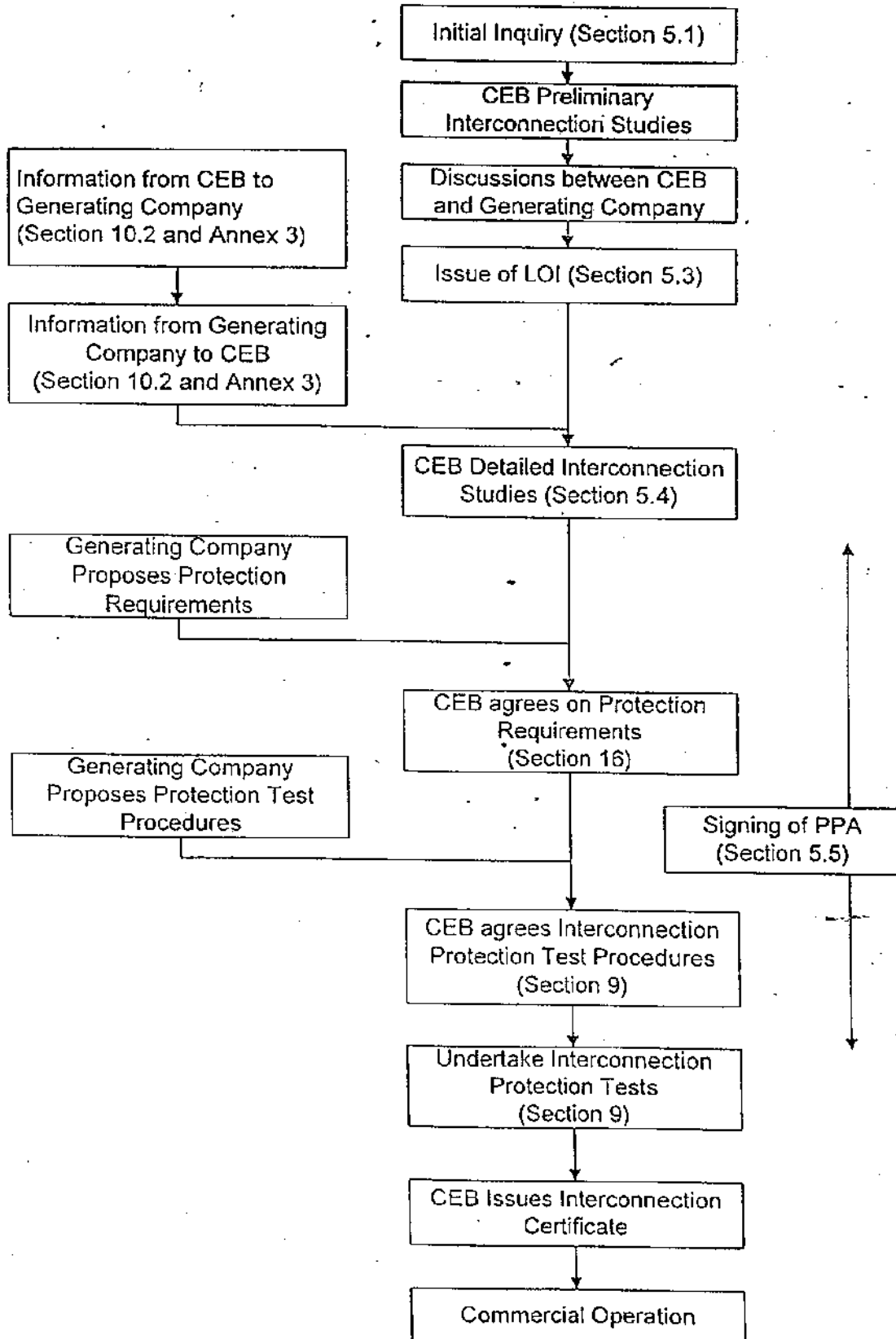
For hydroelectric power plants, additional information listed in "Guidelines on Private Participation in Small Hydro Power Development" should also be provided.

For power plants other than hydroelectric, additional information listed in any other relevant CEB Guidelines should also be provided.

5.1.2 Processing Duration

CEB would respond to an Initial Application within a reasonable time to acknowledge receipt, to request more information or by the issue of an LOI. CEB will also complete the process of evaluation of an Initial Application within a reasonable time from the date of the Initial Application.

Figure 2 - Procedural Flow Chart of Embedded Generator Connection Process



5.2 Site Reference Number

After a preliminary review of the basic feasibility of the proposed development and interconnection, CEB shall allocate a Site Reference Number to the Inquiry. This number will be used to refer to the Site in all subsequent documentation about the interconnection, including the LOI, Power Purchase Agreement or any other Agreement, Interconnection Certificate and the Interconnection Test Record.

5.3 Letter of Intent

CEB, after receiving the initial application shall examine the site, the possible points of interconnection, status of the network, and if satisfied about the feasibility of the proposed Interconnection, shall issue a Letter of Intent (LOI) to the Generating Company.

The Form of the LOI is given in Annex 2.

5.3.1 Period of Validity

A Letter of Intent (LOI) issued to a Generating Company shall be valid for a period of six(6) months from the date of the LOI. At the sole discretion of CEB, the validity of the LOI may be extended six (6) months at a time, for a maximum of two (2) years from the date of the LOI.

If the Generating Company does not apply for a Power Purchase Agreement (PPA) before the validity of the LOI expires, CEB may issue an LOI to a different Company for the same site.

5.3.2 Reservation of the Source

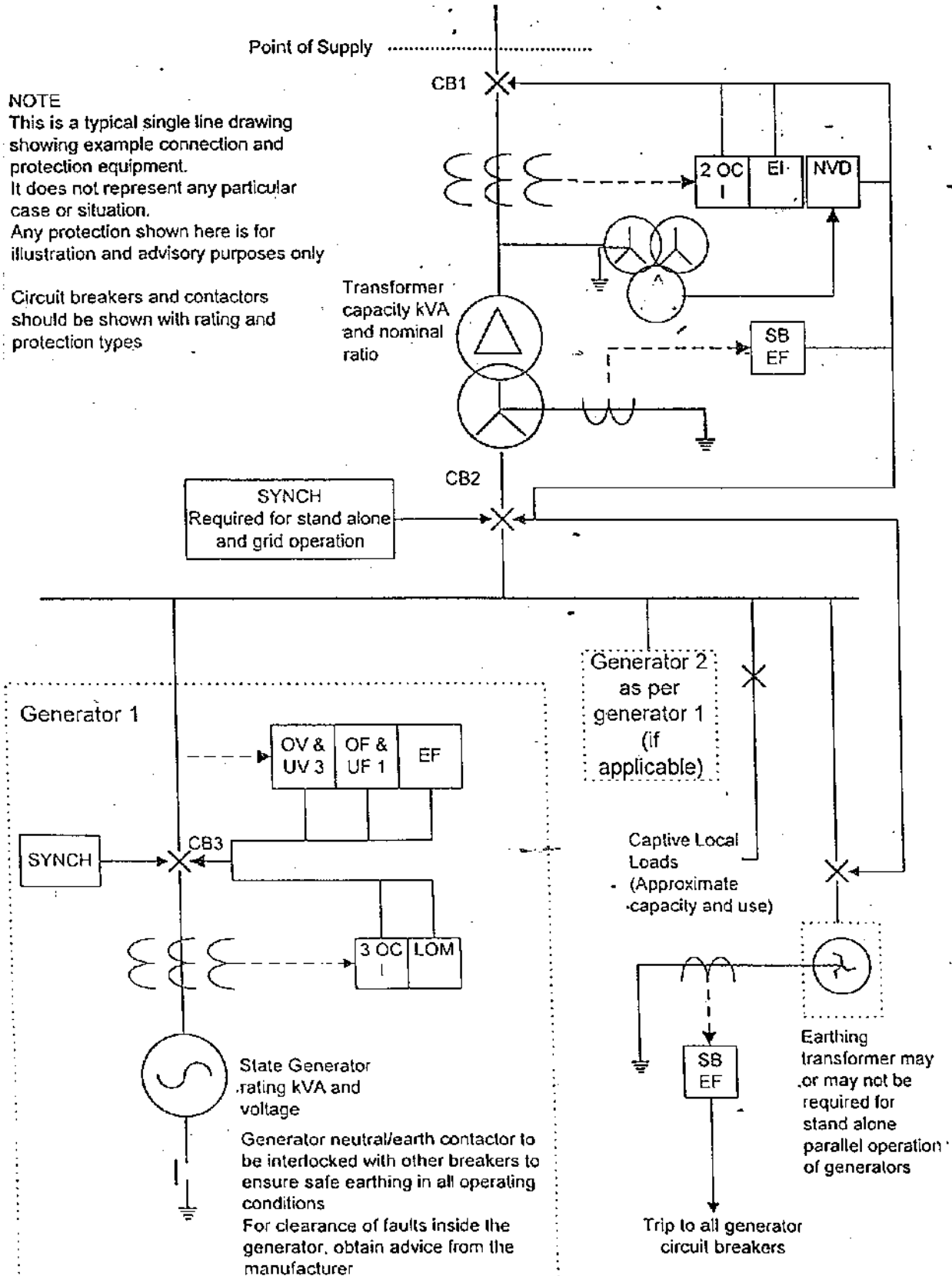
The LOI in the case of sites operating on hydroelectric or wind power, or any other primary source of energy which is site-specific by way of its availability, will also imply the exclusivity of the site assigned to the Generating Company, within the period of validity of the LOI. However, it is the responsibility of the Generating Company to obtain the necessary approvals and rights to use the primary energy source from the owners of the site, Local Authorities and other regulatory agencies.

Figure 3 - Typical Single Line Drawing of Embedded Generator Interconnection

NOTE

This is a typical single line drawing showing example connection and protection equipment. It does not represent any particular case or situation. Any protection shown here is for illustration and advisory purposes only

Circuit breakers and contactors should be shown with rating and protection types



5.3.3 Reservation of Network Capacity

The LOI does not necessarily imply that network capacity is reserved for the Embedded Generator throughout the period of validity of the LOI.

5.3.4 Point of Interconnection

The LOI shall specify the Point of Common Coupling and the Point of Supply, to enable the Generating Company to develop the cost estimates for the interconnection.

5.4 Exchange of Information about the Interconnection

5.4.1 From Generating Company to the CEB

Within the period of validity of the LOI, and when the detailed specification of the Embedded Generator are being prepared, the Generating Company shall submit to CEB, the Technical Data about the Embedded Generator, shown in Annex 3. CEB may request additional, reasonably required, information from the Generating Company, over and above those included in Annex 3.

The Generating Company shall provide a single-line drawing of the electrical system of the Embedded Generating plant up to and including the Point of Supply. All protection relays and associated instrument transformers shall also be shown on the single-line drawing.

A typical single-line drawing is shown in Figure 3.

The Generating Company shall also provide CEB with the proposed settings of all protection relays and switchgear.

5.4.2 From CEB to the Generating Company

Following the issue of an LOI and after receiving the information shown in Annex 3, CEB, after satisfying itself that the detailed design of the Embedded Generator is in progress, shall conduct the necessary studies, including those explained in Section 1 of Part 2 of the Guide, and provide the required information to the Generating Company.

5.5 The Power Purchase Agreement

A Power Purchase Agreement (PPA) shall be signed between the Generating Company and the CEB before commencement of Commercial Operation of the Embedded Generator.

If the Generating Company does not intend to supply electric energy to the CEB, too, a PPA shall be signed with the necessary amendments.

The PPA shall specify that the Interconnection should follow the requirements specified in this Guide, and that an Interconnection Certificate shall be obtained prior to Commercial Operation of the Embedded Generator.

5.6 Operational Information to be Provided

Embedded Generators are usually not within the purview of the Dispatch Control of CEB. However, Embedded Generators shall provide the following information to CEB on an annual basis, within the period of a valid PPA.

The aim of providing this information is for CEB to establish a database to assist in their planning of system operation, transmission and distribution.

At the end of each year of operation,

- (a) Net energy export to the CEB network in kWh
- (b) Maximum and minimum net power export in kW
- (c) List of outages, with date, time, duration, probable cause (identifying whether external or internal), damages (if any)
- (d) Planned outages (purpose, date, duration) over three calendar months ahead
- (e) Expected date of reconnection if there are long term outages, partial or total, at the time of submission of information.

In addition to the above information, obligations to provide an annual forecast of the operation of the Embedded Generator, specified in the PPA, should be fulfilled.

On Embedded Generators larger than 3 MW: provide information monthly, within a month from the last day of each calendar month.

On Embedded Generators equal to or less than 3 MW: provide information annually, within one month from the end of the calendar year.

5.7 Costs of Interconnection

5.7.1 Direct Costs of Interconnection and Studies

Costs of all equipment, protection systems, transformers, switchgear and transmission line(s), as specified in this Guide, and the costs incurred by the CEB in developing/providing site-specific Technical Data about the Interconnection, shall be borne by the Generating Company.

All distribution lines and equipment on the CEB-side of the Point of Supply shall be owned, operated and maintained by the CEB.

5.7.2 Costs of Network-side Modifications

As a result of Interconnection of Embedded Generators, it is possible that certain modifications or upgrades may be required on circuit breakers, other switchgear or transformers located at a CEB substation.

Any costs of modifications or upgrades to the CEB side of the Point of Supply shall be borne by the Generating Company. However, CEB shall own, operate and maintain such modifications and upgrades after the interconnection.

5.8 Metering

5.8.1 Metering to be at the Point of Supply

Energy and other metering required to measure the power transfer between the CEB and the Embedded generator shall normally be at the Point of Supply. An alternative metering point may be agreed between CEB and the Generating Company. This agreement may include an allowance for the increase or reduction in losses to CEB due to the change in the metering location.

The type and accuracy of the meters shall be similar to those of the CEB used to meter CEB's bulk customers.

5.8.2 Metering Equipment Costs

The initial costs of metering equipment shall be borne by the Generating Company. The meters and metering equipment shall be procured, owned, operated and maintained by CEB.

6. IMPLEMENTATION OF THE GUIDE

6.1 CEB to Implement the Guide

CEB will implement the requirements of this Guide where an Embedded Generator is connected to CEB network.

CEB reserves the right to disconnect Embedded Generators that do not conform to the requirements specified in this Guide.

6.2 Revisions

This Guide may be revised by the CEB from time to time, and it is the responsibility of Embedded Generators to ensure that the Grid Interconnection complies with the latest version of the Guide.

Any costs incurred by the Generating Company in complying with the revisions to the Guide shall be borne by the Generating Company.

7. EFFECTIVE DATE

7.1 Effective Date

The requirements of the Guide will be mandatory for all Embedded Generators connected to the CEB network for the first time, from 1st January 2001 onwards, subject to the provisions in Sections 7.2 and 7.3.

Embedded Generators shall be connected to and/or operate in parallel with the CEB system only with a valid Interconnection Certificate, subject to the provisions in Sections 7.2 and 7.3.

7.2 Generators Under Construction by the Effective Date

All Embedded Generators under construction (meaning that they have never been connected to the CEB network for Commercial operation under a Power Purchase Agreement, and that construction has commenced and orders have been placed for protection equipment) as of 1st January 2001, shall comply with the requirements of this Guide from 1st January 2003.

If such an Embedded Generator is ready for interconnection between 1st January 2001 and 1st January 2003, the technical feasibility of such interconnection that violates any of the requirements of this Guide will be determined by the General Manager of CEB, and approval granted to operate without an Interconnection Certificate until 1st January 2003. Until then the minimum protection requirements shall be,

- Over and under voltage
- Over and under frequency
- Loss of Mains Protection

7.3 Generators in Operation by the Effective Date

For Embedded Generators in commercial operation as of 1st January 2001, the General Manager of CEB or his authorised staff shall conduct the required tests within a period of twelve (12) months from 1st January 2001. Any deviations from the requirements of the Guide will be notified to the respective Generating Companies in writing.

The requirements of the Guide may be waived by CEB for existing Embedded Generators for the lifetime of their protection systems. The Generating

Part 1: Application, Evaluation and Interconnection Procedure

Companies may then obtain exemption from certain requirements of this Guide and obtain an Interconnection Certificate.

The minimum protection requirements of such generators are,

- Over and under voltage
- Over and under frequency
- Loss of Mains Protection

7.4 Final Date for Compliance

In any event, no Embedded Generator that does not have an Interconnection Certificate, shall be connected or remain connected to the CEB network in Sri Lanka beyond 1st January 2003.

8. INTERCONNECTION CERTIFICATE

8.1 CEB to Issue the Certificate

CEB shall issue an Interconnection Certificate after the tests required in this Guide are performed.

8.2 Form of Interconnection Certificate

The Form of the Interconnection Certificate is given in Annex 4. The Embedded Generator Test Record of the Form given in Annex 5 should be attached to the Interconnection Certificate. The Originals of the Interconnection Test Certificate and the Embedded Generator Test Record shall be retained at the address shown in the Interconnection Certificate and the Test Record.

8.3 Validity

The Interconnection Certificate is valid for a period of three (3) years from the date of the Embedded Generator Test Record, after which, the Embedded Generator shall arrange a fresh Test to be conducted and request CEB for a fresh Interconnection Certificate to be issued.

CEB reserves the right to inspect the protection systems of the interconnection, any time within the validity of an Interconnection Certificate.

8.4 Designated Officers

CEB will designate an Officer or Officers to witness the interconnection tests specified in this Guide, and to issue an Interconnection Certificate. CEB may also designate one or several third party certification bodies or individuals to perform the necessary inspection and testing, and to witness the tests, and to recommend to CEB about the issue of the Interconnection Certificate.

8.5 Testing and Acceptance Procedure

Testing and Acceptance Procedures are explained in Section 9.

8.6 Costs and Fees of Interconnection Tests and Certificate

The cost of conducting the Interconnection Tests either by the CEB or their designated third party certification bodies or individuals, will be met by the

Part 1: Application, Evaluation and Interconnection Procedure

Generating Companies. CEB may charge a fee for the issue of an Interconnection Certificate.

9. TESTING AND ACCEPTANCE PROCEDURES

9.1 General

This section of the Guide covers:

- guidelines for testing and acceptance
- information requirements before testing
- personnel requirements and test witnessing
- standard form to be completed

9.2 Responsibilities and Witnessing

The Generating Company will nominate a qualified person to act as their representative for protection inspection and testing.

The General Manager, CEB will nominate a qualified person to act as the CEB representative to witness protection testing. This person will coordinate with the Generating Company representative, to agree test procedures and equipment to be used for the testing.

It is the responsibility of the Generating Company representative, to organise, agree procedures with the CEB and undertake protection equipment testing. The Generating Company may use staff and equipment provided by CEB, or a third party, to assist in the tests.

Prior to testing, the Generating Company representative will certify by signature that,

- (i) the earthing system conforms to the provisions in this Guide and other relevant standards.
- (ii) the design and implementation of the generation and protection system complies with the requirements of the Guide, and any protection specified in the PPA.
- (iii) the generating system is safe to operate and complies with all the relevant requirements for electrical installations.
- (iv) the commissioning tests have been completed, including all CT and VT ratio testing.

It is the responsibility of the Generating Company representative to provide and complete the test forms.

Part 1: Application, Evaluation and Interconnection Procedure

The Generating Company representative should give as much notice as possible of the requirement for testing. CEB shall make a suitable representative available within four (4) weeks of notice by the Generating Company that testing is required.

Testing is to be witnessed by the CEB representative. The CEB representative is to certify by signature that the protection tests were witnessed as successful.

9.3 Test Procedures

The test procedures shall be proposed by the Generating Company. They will be agreed between the Generating Company representative and the CEB representative prior to the testing day.

The procedures will be designed to demonstrate the operation of all the protection functions required by this Guide and specified in the PPA between the Generating Company and the CEB.

The procedures will include, as appropriate:

- Earthing System
- Secondary injection of test voltages and currents into test relays and the operation of the relays observed
- Demonstration that the operation of a protection relay opens, or inhibits the closure of the appropriate breaker or contactor.
- Primary current injection tests, where practical, to demonstrate the operation and ratio of CTs.
- Other tests as required. For example earth resistance, insulation resistance, contact resistance.

A single line drawing of the installation showing the main power connections, breakers, contactors, protection VTs, CTs and protection relays shall be provided by the Generating Company to the CEB prior to the test day. A copy of this drawing is to be maintained at the site.

A detailed protection arrangement drawing shall also be provided by the Generating Company.

The test equipment used for measurements during testing shall be suitably calibrated and have a valid calibration certificate.

Part 1: Application, Evaluation and Interconnection Procedure

The Embedded Generator Test Record to be completed for acceptance testing and subsequent tests is given in Annex 5.

9.4 Test Intervals

The required grid connection protection is to be tested at the following times:

- i) Prior to acceptance of new generation plant for connection to the grid. Short term connection may be allowed to set up and test the protection equipment.
- ii) Re-testing at intervals of no greater than three years to enable a new Interconnection Certificate to be issued.
- iii) Following any significant change in generation or protection equipment.
- iv) Following any maintenance or repair, which involved the disconnection or rearrangement of any protection equipment.

When re-testing is undertaken, the protection settings set at the original commissioning shall be entered on the test record form.

9.5 Records

A written record in the form of Embedded Generator Test Record (Annex 5) shall be maintained by the Generating Company. The storage location of this original record shall be stated on the Test Record. A copy of this Test Record shall be provided to the CEB. The Test Record will cover all the tests required.

ACKNOWLEDGEMENTS

This CEB Guide for Grid Interconnection for Embedded Generators, Sri Lanka, was developed for Ceylon Electricity Board under the Sri Lanka Energy Services Delivery Project.

The Guide was prepared by,

Dr Tilak Siyambalapitiya, Resource Management Associates (Pvt) Ltd., Sri Lanka.

Mr David Roberts, Dulas Ltd., UK.

Mr Andrew Causebrook, Econnet Ltd., UK

with the assistance of,

Mr Jayasiri Karunanayake, Sri Lanka

Mr M D J Anthony, Sri Lanka

Mr Bill Rogers, UK.

The Team of Consultants thank Mr P L G Kariyawasam, Project Coordinator of Ceylon Electricity Board (CEB), and all the staff of CEB for their support during studies associated with this project. The Team also thanks the Owners and Operators of several existing Embedded Generators, Contractors and Consultants, for their support with information, discussions and plant visits.

BIBLIOGRAPHY

Electricity Act (of Sri Lanka) No 19 of 1950, No. 55 of 1955, and subsequent amendments.

Guidelines on Private Sector Participation in Small Hydro Power Development, Ceylon Electricity Board, 1997.

Standardised Agreement for Purchase of Energy, Ceylon Electricity Board.

UK Engineering Recommendation G.59/1: Recommendations for the connection of embedded generating plant to Public Electricity Suppliers' distribution systems.

UK Engineering Technical Report No 113 (Revision 1) (1995): Notes of guidance for the protection of private generating sets up to 5 MW for operation in parallel with Public Electricity Suppliers' distribution systems.

Engineering Recommendation G75 (1996): Recommendations for the connection of embedded generation plant, to Public Electricity Suppliers' systems above 20kV, or with outputs over 5 MW.

UK Engineering Recommendation P.28 (1989): Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom public distribution systems.

BS EN 61000-3-3 (1995): Electromagnetic Compatibility (EMC) Part 3- Limitations of voltage fluctuations and flicker in low voltage supply systems for equipment with rated current less than 16A.
Equiv. IEC 1000-3-3: 1994.

BS EN 61000-3-2 (1995) + A12 (January 1996): Electromagnetic Compatibility (EMC) part 3, Limits Section 2: Limits for harmonic current emissions (equipment input current <16 A per phase). Equiv. IEC 1000-3-2: 1995

UK Engineering Recommendation P.29 (1990): Planning limits for voltage unbalance in the United Kingdom.

Part 1: Application, Evaluation and Interconnection Procedure

UK EA Engineering Recommendation G5/3 (1976): Limits for Harmonics in the United Kingdom Electricity Supply System.

UK Engineering Recommendation P.2/5: Security of Supply.

European CENELEC Standard BS EN 50160: Voltage characteristics of electricity supplied by Public Distribution Systems.

IEC255, (BS 5992) Electrical Relays.

BS 7430 (1991) Code of Practice for Earthing.

BS 7671 (1992) Requirements for Electrical Installations; IEE Wiring Regulations, Sixteenth Edition.

Electromagnetic Compatibility; BS EN 50081-1: 1992 (emissions) and BS EN 50082-1: 1998 (immunity).

IEC 909 (1988); Short-circuit current calculation in three-phase AC systems.

UK Engineering Recommendation G74: Procedure to meet the requirements of IEC909 for the calculation of short-circuit currents in three-phase AC power systems.

ANNEX 1- FORM OF INITIAL APPLICATION

Date:

General Manager
Ceylon Electricity Board.

Initial Application to Build an Embedded Generating Plant

I/we submit this Initial Application to express my/our desire to develop, construct, connect to the CEB network and operate an Embedded Generating Plant, the details of which are given below.

- (a) Name and address of the promoter (Generating or other Company name, if any)
- (b) Proposed location of the Embedded Generator (attach maps, extracts of previous reports, etc., to identify the location, grid reference)
- (c) Primary Energy Source (hydro, biomass, wind, etc.)
- (d) Details of the Primary Source (summary stream flow data, biomass availability data, wind potential estimates, etc.)
- (e) Expected rated capacity and annual energy contribution to the CEB network
- (f) Types of Captive Loads (such as a tea factory, Company residential loads), if any, and the daily maximum and minimum demand of such captive loads.
- (g) Expected cost of the Embedded Generating Plant and expected sources of finance
- (h) List available project information (Pre-feasibility study, Feasibility study, Conceptual design, Detailed Design, Drawings)
- (i) Expected construction duration
- (j) Financial information, including a cash flow statement for the term of the PPA, if relevant. All costs should be estimated and any assumptions made shall be stated.

I/we agree to provide any further information required by CEB to process this Initial Application.

Yours truly,

[Name (and Company, if any)]

ANNEX 2- FORM OF THE LETTER OF INTENT

Date:

Generating Company Name and Address:

Embedded Generating Plant Name and Address:

Site Reference Number:

Letter of Intent

This refers to your Initial Application dated [date of initial application], expressing your desire to develop the Embedded Generating Plant described above. The proposed Embedded Generating Plant has been allocated the Site Reference Number shown above, which should be used in all future correspondence with CEB and documentation about the Plant.

Details of the Embedded Generating Plant are the following:

[location, Province, District, land ownership details, map references and any other information useful to clearly identify the site]

The primary source of energy of the Embedded Generating Plant: [hydro, wind, biomass (specify the type such as saw dust, paddy husk, wood), etc.]

The Point of Supply (POS) location is []

The Point of Common Coupling (PCC) location is []

CEB is pleased to inform you that we are agreeable to purchase electrical energy from the proposed Embedded Generating Plant (hereafter referred to as the Plant), subject to the Terms and Conditions shown below.

Part 1: Application, Evaluation and Interconnection Procedure

1. The Plant shall be built by [name of individual or Company], and shall remain under your ownership until such time the Plant enters Commercial Operation.
2. This Letter of Intent is not transferable, without the written consent of the CEB.
3. If at any time you decide not to proceed with development of the proposed Plant, you shall promptly inform the CEB about your decision.
4. The Plant shall be designed, built, commissioned and operated to satisfy the Standards and Requirements determined by the CEB.
5. The design, construction, testing, commissioning and operation of the Interconnection of the Plant with the CEB network shall be according to the requirements and procedure specified in the "CEB Guide for Grid Interconnection of Embedded Generators, Sri Lanka" (hereafter referred to as the Guide). A copy of the Guide will be provided to you upon request.
6. The physical location of the Point of Supply, at which the CEB shall meter and receive the Plant output, is shown in the attached single-line diagram.
7. The physical location of the Point of Common Coupling, beyond which other CEB customers may be connected, is also shown in the attached single-line diagram.
8. The CEB shall design and build the facilities (including transmission lines, distribution lines, switchgear and protection) required for the interconnection on the Utility-side of the Point of Supply. The CEB may also authorise some or all the facilities required for the interconnection to be built by you, according to the CEB standards and other IEC Standards.
9. The CEB shall assist you to obtain any rights of way or easements required to build the interconnection facilities, including the transmission line.

Part 1: Application, Evaluation and Interconnection Procedure

10. The costs of all facilities explained in 8 above and the cost of any rights of way to be secured, shall be borne by you.
11. All equipment and transmission line(s) on the CEB side of the Point of Supply shall be maintained by the CEB.
12. [Tariff information to be defined by the CEB].
13. This Letter of Intent is valid for a period of six (6) months (unless extended as stipulated in the Guide), during which period you should submit to the CEB the Feasibility Study and an outline plan for the construction of the Plant. You should also provide the CEB the information required to proceed with studies required to specify the requirements for the Interconnection.
14. A Power Purchase Agreement (PPA) shall be signed between [name of individual or Generating Company] and the CEB, within the period of validity of this LOI, as extended by the CEB.
15. THE CEB reserves the right to examine the detailed designs of the Plant and equipment, and the facilities required for the interconnection with the CEB network.
16. Commissioning tests of the Plant will be conducted by you, at your expense, and the CEB shall be notified when such tests are conducted.
17. Commissioning tests of the Interconnection facilities (without actually making an interconnection) shall be conducted by you, at your expense, and the CEB shall be notified when such tests are conducted, and may attend such tests.
18. Tests on the Interconnection between the Plant and the CEB network shall be conducted by [Generating Company] and witnessed by CEB, as specified in the Guide. The costs of such tests shall be borne by you.
19. It would be your sole responsibility to obtain all the necessary approvals for the construction of the Plant and Interconnection facilities from the relevant Government and other agencies. These may include, but not limited to,

Central Environmental Authority, Provincial Environmental Authorities, Local Authorities, National Water Supply and Drainage Board and the Irrigation Department.

20. It will be necessary for you to obtain a license from the [name of Ministry supervising the subject of electricity or other Regulatory Agency] to generate and sell electricity to the CEB prior to commencement of construction of the Plant.
21. Any costs incurred by you in the fulfillment of requirements specified in this letter are at your sole risk and expense, with no claim whatsoever on the CEB.
22. The detailed feasibility report and the plan for construction, including the design details, should be submitted to the CEB within six (6) months of the date of this LOI.
23. The progress of the project should be reported to the CEB every three (3) months from the date of this LOI.

Yours truly,

General Manager, CEB.

ANNEX 3 - FORMS OF INFORMATION TO BE EXCHANGED

**Information to be Provided by the CEB
to the Generating Company**

This information shall include the planned (or prospective) fault levels expected by the CEB in 10 years from the time of connection application.

Site Name

Site Reference Number

Location

Generating Company Name

Contact

Point of Supply (location)

Maximum fault levels (for equipment selection and earthing design):
Network design symmetrical fault level (kA or MVA)

Peak asymmetrical fault level at half cycle (kA)

3-phase symmetrical fault level at half cycle (MVA or kA)

X/R ratio for 3 phase symmetrical fault

1-phase to earth fault level (kA) (neglecting earth system resistances)
.....

X/R ratio for 1-phase to earth fault (neglecting earth system resistances)
.....

Minimum fault levels (for protection design):
3-phase steady state symmetrical fault level (MVA or kA)

X/R ratio for 3 phase symmetrical fault

1-phase to earth fault level (kA) (Neglecting earth system resistances)
.....

X/R ratio for 1-phase to earth fault (neglecting earth system resistances)
.....

**Information to be Provided by the Generating Company
to the CEB**

Synchronous Generators with an installed capacity above 500 kW

Site Name

Location

Site Reference Number

Generating Company Name

Contact

Point of Supply (location)

Maximum export capacity

Maximum import capacity

Power factor operating range

Generator (for each synchronous generator):

Terminal voltage (kV)

Machine rating (MVA)

Stator resistance (pu) tolerance %

Sub-transient reactance (pu) tolerance %

Transient reactance (pu) tolerance %

Synchronous reactance (pu) tolerance %

Sub-transient time constant (ms) tolerance (ms)

Transient time constant (ms) tolerance (ms)

Transformer (for each generator transformer):

Rating (MVA)

Reactance (pu) tolerance %

Resistance (pu) tolerance %

Voltage Ratio vector group

**Cable or Line between the Generator and Point of Common Coupling
where this cabling distance exceeds 50 metres**

Voltage (V)

Reactance (Ohm) Resistance (Ohm)

**Information to be Provided by the Generating Company
to the CEB**

Synchronous Generators with an installed capacity below 500 kW

Site Name

Location

Site reference

Generating Company Name

Contact

Point of Supply (location)

Maximum export capacity (kW)

Maximum import capacity (kW)

Power factor operating range

Generator (for each synchronous generator):

Terminal voltage (kV)

Machine rating (MVA)

Stator resistance (pu)

Transformer (for each generator transformer):

Rating (MVA)

Reactance (pu)

Resistance (pu)

Voltage Ratio Vector group

**Cable or Line between the generator and Point of Common Coupling where
this cabling distance exceeds 50 metres**

Voltage

Reactance (Ohm) Resistance (Ohm)

ANNEX 4- FORM OF INTERCONNECTION CERTIFICATE

Interconnection Certificate

Issued on: Valid from: [date of Test Record]
Until: [date three years from Test Record]

Generating Company Name and Address:

Embedded Generating Plant Name and Address:

Site Reference Number:

This is to certify that upon a request made by [Generating Company], Ceylon Electricity Board (CEB) has conducted the necessary inspection and testing of the interconnection of [name of embedded generating plant], to CEB network, on [date].

CEB is satisfied that [embedded generating plant] complies with the mandatory requirements specified in the "CEB Guide for Grid Interconnection of Embedded Generating Plants, Sri Lanka" [dated (state date of the Guide)].

The Embedded Generator Test Record is attached.

Exemptions, waivers or conditions allowed by CEB are listed below.

- 1.
- 2.
- 3.

(signed by General Manager
of CEB or Authorised Nominee)

The originals of this Interconnection Certificate and the attachment are retained at
[Generating Company name and address or
Embedded Generating Plant name and address]

ANNEX 5 – EMBEDDED GENERATOR TEST RECORD

Note: Full details are required of all generators to be tested. A separate copy of this form shall be used for each generator.

1. Site Information

Site Reference Number

Generator identification or number (if more than one generator at the site)
.....

2. Generating Company Details:

Name and Address:
.....
.....

Telephone Numbers and Contact Person.....
.....

The original of this document is stored at:

3. CEB Details:

Name and Address of Contact Person:
.....
.....

4. Names of Representatives

Generating Company representative

Name

Designation

Manufacturer's Representative (optional) Name

Designation

CEB Witnessing Engineer

Name

Designation

5. CEB Supply Details

Voltage

Maximum Fault Level

Point of Common Coupling location

Point of Supply location

6. Generating Plant Details

Type (synchronous, asynchronous, inverter)

Manufacturer

Serial No.

Rated:

Voltage (V)

Current (A)

Frequency (Hz)

Power Factor

Capacity (kVA)

Output Winding Delta or Star

Earthing arrangement

.....

.....

.....

7. Protection details

Check availability of single line drawing and protection drawings tick

8. AVR and Power Factor Control

Record details of the mode agreed for the generator AVR and Power Factor control operation or constraints placed on output.

.....

.....

.....

.....

Part 1: Application, Evaluation and Interconnection Procedure

9. Installation Inspection:

- Measured earth resistance from commissioning: ohm
- Earth continuity checked tick
(Generating Company to provide a commissioning or test record)
- Earth bonding of all equipment is satisfactory tick
(Main bonding viewed by Witnessing Engineer)
- Generator neutral earthed in isolated mode tick
- Generator neutral disconnected when connected to the grid tick
- View rating and settings of main breakers and fuses tick
- Generator isolating switch is locable in the OFF position,
and provides suitable safe isolation tick

If this is the first acceptance test of the plant following construction and commissioning, or following major maintenance or upgrading, the Witnessing Engineer should have sight of all appropriate commissioning test documentation. Particularly relating to interconnection protection relays and their sensing CTs and VTs, as appropriate tick

Nominal Voltage for test and measurement V

(calculate the nominal test voltage from the HV voltage and the transformer ratio, if this is an HV connection. For an LV connection, the nominal test voltage is 230V)

10. Protection Relay Tests

Identify which interconnection protection relays have been specified and fitted.

List here the interconnection protection functions that have been implemented, and the maximum and minimum relay operation levels, that have been specified for this site. The levels will be those specified in the Guide unless by other agreement.

For example:

"Rocof Hz/second" "UndervoltageV, overvoltageV"

.....

.....

.....

.....

- Complete the tripping tests of the protection relays and record the test results on the following pages.
- The testing is to demonstrate the operation of the interconnection protection relays as required by the Guide.
- The testing is not intended to verify detailed relay performance such as levels of pick up and drop off.
- The generator should be off and isolated during the following tests on Interconnection Protection.

Operation Time Recording

- The operating time for each relay test shall be recorded.
- The operating time of the relay shall be measured, including any delay set in the relay.
- If practical, the operating time should be measured as far as the auxiliary contacts on the appropriate breaker, and include any time delay units or other features.
- The time being measured for each test shall be recorded with each test.
- The total maximum tripping time specified in the Guide includes the operation time of the appropriate breaker.

The breaker operating time is: ms (from commissioning tests)

EMBEDDED GENERATOR PROTECTION CALIBRATION AND TRIPPING TESTS

OVERVOLTAGE

MANUFACTURER TYPE

SERIAL NUMBER

Line or phase tested	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Volt	Time (ms)	Volt	Time (ms)	Volt	Time (ms)	
R-N OR R-Y							
Y-N OR Y-B							
B-N OR B-R							

* Show designed values, if the present test is the first Acceptance Test.

UNDERVOLTAGE

MANUFACTURER TYPE

SERIAL NUMBER

Line or phase tested	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Volt	Time (ms)	Volt	Time (ms)	Volt	Time (ms)	
R-N OR R-Y							
Y-N OR Y-B							
B-N OR B-R							

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT

State what time is being measured, e.g. relay only or relay and breaker auxiliary"

.....

MEASURING EQUIPMENT

Type Serial number

Calibration Certificate: YES/NO

OVERFREQUENCY

MANUFACTURER TYPE

SERIAL NUMBER

	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Hz	Time (ms)	Hz	Time (ms)	Hz	Time (ms)	
PHASE TESTED							

* Show designed values, if the present test is the first Acceptance Test.

UNDERFREQUENCY

MANUFACTURER TYPE

SERIAL NUMBER

	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Hz	Time (ms)	Hz	Time (ms)	Hz	Time (ms)	
PHASE TESTED							

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT

State what time is being measured, e.g. "relay only" or "relay and breaker auxiliary"

.....

MEASURING EQUIPMENT

Type Serial number

Calibration Certificate: YES/NO

LOSS OF MAINS (1) (IF APPLICABLE)

LOSS OF MAINS FUNCTION MANUFACTURER
 TYPE SERIAL NUMBER

PHASE	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Hz/s or angle degrees	Time Delay (ms)	Hz/s or angle degrees	Time Delay (ms)	Hz/s or angle degrees	Time Delay (ms)	

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT

State what time is being measured, e.g. "relay only" or "relay and breaker auxiliary"

MEASURING EQUIPMENT

Type Serial number
 Calibration Certificate: YES/NO

LOSS OF MAINS (2) (IF APPLICABLE)

LOSS OF MAINS FUNCTION MANUFACTURER
 TYPE SERIAL NUMBER

PHASE	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Hz/s or angle degrees	Time Delay (ms)	Hz/s or angle degrees	Time Delay (ms)	Hz/s or angle degrees	Time Delay (ms)	

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT

State what time is being measured, e.g. "relay only" or "relay and breaker auxiliary"

MEASURING EQUIPMENT

Type Serial number
 Calibration Certificate: YES/NO

LOSS OF MAINS – REVERSE VAR (IF APPLICABLE)

MANUFACTURER TYPE

SERIAL NUMBER

PHASE	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	kVAr	Time (s)	kVAr	Time (s)	kVAr	Time (s)	

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT

State what time is being measured, e.g. relay only or relay and breaker auxiliary"

MEASURING EQUIPMENT

Type Serial number

Calibration Certificate: YES/NO

LOSS OF MAINS INTERTRIP (IF APPLICABLE)

Ensure Inter-trip details are shown on the Single Line and Protection Drawings tick

Check existence of suitable voltage barriers on trip signal systems, if appropriate tick

Record details below, or on attached sheets no., of each Inter-trip arrangement.

Operate intertrip from remote location and check signal and operation of the trip tick

NEUTRAL VOLTAGE DISPLACEMENT (NVD) (IF APPLICABLE)

MANUFACTURER TYPE

SERIAL NUMBER

Test to be undertaken with NVD relay disconnected from VTs

	MEASURED VALUES AT COMMISSIONING*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Volt	Time (s)	Volt	Time (s)	Volt	Time (s)	
SECONDARY INJECTED VOLTAGE TO OPERATE							

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT

State what time is being measured, for example "relay only" or "relay and breaker auxiliary"

MEASURING EQUIPMENT

Type Serial number

NVD VT Operation

Demonstration of Operation of NVD

To demonstrate the operation of the NVD protection, the supply to the NVD detection VTs should be removed on the HV side.

Each phase should be disconnected in turn. Disconnection may be achieved by removing the HV fuse feeding the VT. When a phase is removed the NVD should operate and the breaker(s) tripped.

- Red phase Tick
- Yellow phase Tick
- Blue phase Tick

An experienced qualified person should undertake the removal of HV fuses.

If the above test results are acceptable to the CEB Witnessing Engineer, the Generator may now be synchronised and connected to the grid.

11. Synchronisation of Machine

Synchronisation method: Auto/Manual

Check commissioning test record of grid and machine phase rotation,
 or undertake test now

tick

12. Voltage Fluctuation at Synchronisation

System Voltage	R-N or R-Y	Y-N or Y-B	B-N or B-R
Generator OFF			
Generator connected			

The voltage fluctuation should not exceed 3% at the Point of Common Coupling.

Machine load currents during this test

RA YA BA

Voltage measuring equipment

Type Serial number

Current measuring equipment

Type Serial number

13. Loss of Phase Protection

With the machine running and in parallel with the CEB system, remove each phase supply in turn, followed by a 3-phase disconnection. This test may be undertaken at any power level. Disconnection may not be effective at low power levels, in which case, restrictions on minimum sustained generator output may be made.

Red Phase Tick

Yellow Phase Tick

Blue Phase Tick

3 Phase Tick

The generator should stop and further operation be disabled until the grid or the relay is reset.

14. Loss of Tripping and Auxiliary Supplies

Prove all protection is 'fail safe' by de-energising the protection relay power supplies

Machine should shutdown and be unable to restart

until the power supply is restored

(Alternatively alarm to be made dead)

Tick

15. CERTIFICATION

On behalf of [the Generating Company], I certify that the generating equipment in the above has been installed and tested, and complies with the requirements of the CEB Guide for Grid Interconnection of Embedded Generators, Sri Lanka.

Signature -

Name:

Designation

Date

On behalf of Ceylon Electricity Board, I certify that I have witnessed the above tests.

Signature

Name:

Designation

Date

Exceptions

Details of any restrictions on power output.

Details of abnormal loads.

Note of changes or actions requested.

Indications of any future changes.

Record details of any power, voltage or current fluctuations.

Continue on a separate sheet if required and state number of sheets here

..... extra pages attached.

Notes

- (a) These tests are to safeguard the CEB system. They do not certify that the whole installation has been tested, or meets the requirements of the Wiring Regulations, or any statutory requirements.
- (b) The overvoltage and undervoltage protection should be tested using an external variable voltage supply.
- (c) Where the frequency of the plant is dependent on the mains frequency, an external variable frequency signal generator, with suitable voltage and current output should be used for the under and over frequency protection tests.
- (d) The loss of mains protection should be tested by application of a frequency ramp or step frequency change, in accordance with the manufacturer's instructions.