

## **GRID CONNECTION REQUIREMENT FOR SOLARPOWER PLANTS – ADDENDUM TO THE CEB GUIDE FOR GRID INTERCONNECTION OF EMBEDDED GENERATORS, DECEMBER 2000**

### **1.1 DATA PROVISION**

This is in addition to the information requested under Exchange of Information about the Interconnection as stipulated in CEB GUIDE FOR GRID INTERCONNECTRION OF EMBEDDED GENERATORS; December 2000 hereinafter refers as CEB guide.

### **1.2 Data requirement for grid impact studies**

The interconnection request for a prospective solar PV power plant shall accompany following data which requires for conducting grid interconnections studies.

- (a) Single line diagram of the solar PV power collector system up to the main installation circuit breaker. This shall include, listed in a separate sheet if necessary, all the technical parameters related to the conductors, and step up transformers of the power collector system.
- (b) Details of voltage support facilities such as switched capacitors, static var compensators and, dynamic var compensators including the intended power factors for full MW range. (Curve depicting power factor Vs solar PV plant out put power)
- (c) Solar PV model data from the manufacturer, format acceptable to PSS/E software, and general plant characteristics including power curve to conduct simulation studies at 33 kV and 132 kV level.
- (d) Solar PV plant layout, on a 1:10,000 map.

### **2.1 PLANT MONITORING**

This is a new requirement introduce for embedded solar PV power plants whose installed capacities less than or equal to 10MW.

### **2.2 On line Data Provision**

The generating company should build the necessary data transmission facility to provide on line data delivery to the System Control Centre of the Ceylon Electricity Board (CEB) at least with one (1) minute interval with time stamp for following parameters.

- (a) Status of the main circuit breaker
- (b) Active power export from the solar PV plant.
- (c) Active power import by the solar PV plant.. (or instead of (b), (c) net active power flow indicating direction)
- (d) Reactive power import by the solar PV plant.
- (e) Reactive power export from the solar PV plant.(or instead of (d), (e) net reactive power flow indicating direction)
- (f) Voltage at the main circuit breaker of the solar PV plant.
- (g) Wind speed from the site wind mast
- (h) Wind direction from the site wind mast
- (i) Solar irradiance level
- (j) Temperature and weather data (optional)

### 2.3 Applicability of On Line Data Provision

The online monitoring facility of aforesaid parameters shall be updated on each 1 minute interval during the entire period of grid connection.

However, sequence event data with time stamp shall be stored and made available to CEB in Excel format for any major breakdown such as sudden tripping of solar PV plant.

### 2.4 Data Provision on Monthly Basis

The monthly summary report on plant performances shall be provided within first week of each month and shall include the following (both hard copy and Excel format shall be submitted);

- (a) Project name and location, solar panel and inverter details, total installed capacity, total generation hours
- (b) Total monthly generation, plant factor, availability factor, cumulative generation since commissioning and generation in the same month in the previous year.
- (c) Daily generation, Generator hours, Composition of down time hours such as due to inadequate solar irradiation, plant system fault, PV plant shut down for maintenance, grid fault, grid shut down for maintenance etc.
- (d) Solar PV system performances

### 3.1 Communication Facility

Online Data as per clause 2.2 shall be access through a common web server at CEB for online monitoring of plant performance.

### 4.0 PROTECTION REQUIREMENT

The following protection functions shall be built in to the inverter;

- Over/under frequency
- Over/under voltage
- Anti-islanding

Following protection functions shall be provided as backup protection to the inverter protection functions at the main LV circuit breaker of the facility;

- Over/under frequency
- Over/under voltage
- Anti-islanding (RoCoF or vector shift)
- NVD

Protection relays shall be of suitable quality to provide reliable and consistent operation. The performance levels of the relays shall be declared by the manufacturer.

It is preferable to use proven protection equipment supplied by a reputable manufacturer with a track record in this type of application. The performance of all protection relays shall be within the scope of IEC protection product family Standard IEC 60255.

It is recommended that control and protection panels are soak tested (i.e. the protection relay panels are energized for several hours or days) prior to being put into operation. During the soak test the operation of the protection relays should be checked periodically.

Protection relays and the associated sensing circuits must be designed to maintain accuracy and operation in fault conditions. Particular consideration should be made of the requirements for current transformers to sustain operation when fault currents occur. Current and voltage transformers should be appropriately selected and comply with product standards IEC 61869.

All protection relays to have indication of operation.

It is useful if the relay system can indicate which relay or function operated first to disconnect a generator during a fault condition. The indication may be reset at next breaker or contactor closure. This indication is not a requirement.

Secondary injection test points should be provided where practical to facilitate commissioning and later testing of relay settings and operation.

#### 4.1 Frequency Requirement

As per section 7.2.3 of CEB guide (PART 2). The embedded solar PV plant shall operate throughout the full range of frequencies depicted below. (i.e. 47 HZ to 52 HZ)

Over Frequency:	1.04 PU	-	Continuously
Under Frequency:	0.94 PU	-	Continuously

#### 4.2 Voltage Requirement

As per section 7.2.2 of CEB guide (PART 2). The embedded solar PV plant shall operate though out the full range of voltages (+/- 10%) with time base capabilities depicted below.

Over Voltage:	1.10 PU	-
Continuously		

> 1.10 PU, 1sec - Should remain connected to the grid for 1 second and trip.

Under Voltage: < 0.90 PU, 3 sec - Should remain connected to the grid for 3 seconds and trip.

#### 4.3 Power Factor and Reactive Power Support

The range of reactive power support by the solar PV plant shall be from 0.90 lagging to 0.90 leading.

#### 4.4 Neutral Voltage Displacement Relay

The provision of NVD facility shall be in accordance with the CEB guide.

#### 4.5 Low Voltage Ride Through (LVRT) Capability

The solar PV plant shall be connected to the grid during voltage disturbances (Under voltage conditions) of the power system for a short period of time. The low voltage margin required in the LVRT capability is beyond the low voltage margin stipulated under "4.2 Voltage Requirement". If the grid voltage at the point of interconnection reduces to 40% of the nominal voltage and remain at 40% of nominal voltage for a period less than 100 ms and then recover to a voltage level of 90% or higher within 3 seconds, the solar PV plant shall remain connected to the grid. If the voltage during the disturbance reduces below the aforesaid voltage profile, the solar PV plant shall trip.

#### 5.1 POWER QUALITY

The power quality depends on the interaction between the grid and solar PV plant. Power quality in terms of voltage and frequency should be maintained as per given IEC standards.

## 5.2 Harmonics

The harmonics and inter harmonics are as defined in IEC 61000-4-7 and amendment 1. For solar PV system power electronic converter, the emission of inter harmonic current during continuous operation should be specified. These are to be specified for frequencies up to 50 times the fundamental grid frequency, as well as the total harmonic distortion and emission of the individual harmonics. The relevant emission limits as per IEC 61800-3 are given below. Further the total harmonic distortion (THD) to be less than 5% of the fundamental rated current.

Harmonic order	Odd harmonic Current (% of $I_{rated}$ )	Even harmonic current (% of $I_{rated}$ )
$n < 11$	4.0	1.0
$11 \leq n < 17$	2.0	0.5
$17 \leq n < 23$	1.5	0.4
$23 \leq n < 35$	0.6	0.2
$35 \leq n \leq 50$	0.3	0.1
THD $\leq$ 5%		

## 5.3 Flicker

Flicker emission for continuous operation and switching operation should be within the limits given in the relevant IEC standards. The applicable IEC Standard are IEC 61000-4-15 and IEC 61000-3-7.

### 6.1 Requirements for commissioning tests and inspection.

The commissioning tests and inspection shall be carried out as per the IEC 62446.