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Training on

Grid Connected Rooftop PV Systems Technical & Economic Fundamentals

2018-Ahmadabad, Jammu, Shimla, Dehradun

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Indian Grid Code and Commissioning Test Procedure

Large SPV Power Projects

IEC – 62446 - Grid connected photovoltaic systems

- ❖ IEC 62446 standard consists of two parts
- ❖ System documentation requirements:
 - ❖ Details the information that has to be provided, as a minimum, within the documentation provided to the customer following the installation of a grid connected PV system
- ❖ Verification
 - ❖ Provides the information expected to be provided following initial (or periodic) verification of an installed system. It includes requirements for inspection and testing.

IEC – 62446 - System documentation requirements

- ❖ Single wiring diagram
 - Array general specifications
 - PV string information
 - Array electrical details
 - Earthing and overvoltage protection
 - AC system
- ❖ Module datasheet for all types of modules used in the system –
to the requirements of IEC 61730-1 Verification
- ❖ Inverter datasheet for all types of inverters used in the system
- ❖ Datasheet for array mounting system

IEC – 62446 - System verification

- ❖ DC system inspection
 - ❖ Protection against overvoltage/electric shock
 - ❖ AC system
 - ❖ Labeling and identification
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- ❖ All these may not be applicable for Rooftop Solar
 - ❖ They are more relevant to commercial projects
 - ❖ However, basic principles are same

Rooftop Solar Power Projects

(Guideline by respective SERCs)

Documentation Checking

- ❖ Whether proper site survey has been done?
 - ❖ Check site feasibility report.
 - ❖ Check technical pre-feasibility report e.g. PVSyst etc.
- ❖ Whether the materials fulfill the IEC, IS or MNRE specifications?
- ❖ Check module IEC certificates.
- ❖ Check mounting structure certifications.
- ❖ Check all electrical items certifications.
- ❖ Check on-site monitoring and remote monitoring system specifications.

Pre-commissioning tests of all electrical equipments

- ❖ Specific points to be considered during commissioning are:
 - Continuity checking and insulation resistance measurement of cables.
 - Proper crimping, lugging and glanding of cables before final terminations.
 - Checking of all electrical terminations for any loose contacts.
 - Proper earthing of electric equipment & solar array to be ensured.
 - At junction box in solar array, voltage levels to be checked (between positive & negative terminal, positive to earth and negative to earth) in consultation with inverter OEM.
 - Inverter to be checked in testing mode and after No Fault indication is displayed on LCD it is to be connected to grid/battery.

State Electricity Regulatory Commissions: Guidelines

- ❖ 23 states and 6 UTs issued rooftop net metering orders
- ❖ Points common to all:
 - DISCOMs to permit on a nondiscriminatory and 'first come, first serve' basis
 - All residential, commercial and industrial consumers are eligible
 - MNRE/State subsidy if available may be availed
 - SPV plant as per MNRE tech spec
 - Energy Injection Voltage Restriction: As per SERC**
 - Interconnection as per CEA Tech Spec**
 - No banking, wheeling and cross subsidy charges
 - Tariff as per SERC in a given year
 - Interconnection agreement for 20-25 yrs
 - RPO to be claimed by utility

Energy Injection Voltage Restriction: Example Uttarakhand

UTTARAKHAND ELECTRICITY REGULATORY COMMISSION

Vidyut Niyamak Bhawan, Near I.S.B.T., P.O.-Majra, Dehradun-248171

Shri Subhash Kumar

Chairman

Shri C. S. Sharma

Member

“42. Connectivity and Metering arrangement for grid interactive roof top and small solar PV plants

(1) Roof-top Solar PV sources shall be allowed connectivity at the following voltage level in the distribution system of the licensee:

(i) Load upto 4 kW: low voltage single phase supply

(ii) Load >4 kW and upto 75 kW: low voltage three phase supply

(iii) Load >75 kW and upto 500 kW: at 11 kV

Every State has its own regulation

Energy injection voltage restriction: Example HP

THE HIMACHAL PRADESH ELECTRICITY REGULATORY COMMISSION, SHIMLA

In the matter of draft Regulations of the Himachal Pradesh Electricity Regulatory Commission (Rooftop Solar PV Grid Interactive System based on Net Metering) Regulations, 2015.

Place: Shimla
Date: 31.07.2015.

Sd/-
(Subhash C. Negi)
Chairman

These limits shall be included as under:

Sr. No.	Voltage at which consumer getting supply	Maximum Capacity of rooftop solar PV system
1	LT (1 ϕ)	5 kWp
2	LT (3 ϕ)	15kWp
3	HT/EHT	1 MWp

Every State has its own regulation

Applicable standards & regulations for grid connectivity

- ❖ Central Electricity Authority (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations 2013
- ❖ IEEE 1547 – Standard for Interconnecting Distributed Resources with Electric Power System, 2011
- ❖ Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations, 2010
- ❖ Central Electricity Authority (Technical Standards for Connectivity to the grid) Regulations 2007
- ❖ IEEE 519: Recommended Practice and Requirements for Harmonic Control in Electric Power Systems, 2014

Consumer Meter and Net-Meter (RE meter)

Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 and Amendment, 2014

- ❖ **Amended applicability** – Applicable to all grid interactive RE plants seeking connectivity with the grid at **415 V and below voltage level**
- ❖ **RE meter concept:** RE meter means a meter used for accounting and billing of electricity supplied to and from the consumer.
- ❖ **Above 415 V grid meters:** The regulation of 2006 applicable
- ❖ **Location of Meter** – Gross Meter at outgoing feeder from RE plant.
Net-meter at location of consumer meter
- ❖ **RE Plant with battery** - RE plant can supply the consumer load if grid fails. Automatic isolating mechanism is must for islanding from the grid

Interconnection technical specifications and requirements

General requirements:

- ❖ **Voltage Regulations** – The distributed resources shall not actively regulate the voltage at the point of interconnection.
- ❖ **Synchronization** – The distributed resource synchronised with electric system shall not cause a voltage fluctuations at the point of interconnection greater than $\pm 5\%$.
- ❖ **Monitoring Provision** – Each distributed resource of 250 kVA or more at a single point of interconnection shall have provisions for monitoring its connections status, real power output, reactive power output and voltages at the point of interconnection.

IEEE 1547/ CEA Regulation 2013

Interconnection technical specification and requirements

General requirements:

- ❖ **Isolation device** – there should be a manually operating isolating switch between distributed generation resource and electric system, which shall meet following requirements:
 - ❖ allow visible verification that separation has been established
 - ❖ Indicators to show clearly closed and open position
 - ❖ Be capable of readily accessible and be capable of being locked in open position
 - ❖ May not be rated for load-break nor have feature of over current protection
 - ❖ Be located at height of 2.44 m above ground level

IEEE 1547/ CEA Regulation 2013

Interconnection technical specification and requirements

General requirements:

❖ Interconnect integrity

- Interconnection system shall have the capability to withstand electromagnetic interference
- Paralleling device shall withstand 220% of interconnection system rated voltage
- Interconnection system shall have the capability to withstand voltage and current surge

IEEE 1547/ CEA Regulation 2013

Interconnection technical specification and requirements

Response to abnormal conditions :

- ❖ Voltage – Inverter must have over and under voltage trip functions if voltage reaches above 110% or below 80% respectively with clearing time up to two seconds.
- ❖ Frequency – Inverter must have over and under frequency trip functions if frequency reaches 50.5 Hz and below 47.5 Hz with a clearing time of 0.2 seconds
- ❖ Islanding – Inverter must have function to prevent formation of unintended island, and cease to energize the electricity system within 2 seconds

IEEE 1547/ CEA Regulation 2013

Interconnection technical specification and requirements

Power quality:

Limitation on DC injection – The rooftop solar and its interconnection system shall not inject dc current greater than 0.5% of the full rated output current

Limitation of flicker – The distributed resource shall not cause objectionable flicker on the electric system (IEC 61000)

Harmonics – The distributed resource shall not inject harmonic current greater than 5% at the electric system (IEEE 519)

IEEE 1547/ CEA Regulation 2013

Interconnection test specification and requirements

Interconnection installation evaluation:

Isolation device – A system design verification shall be made to ensure that the requirements have been met

Monitoring provision – A system design verification shall be made to ensure that the provisions for monitoring are in accordance with the requirements

Grid fault – A system design verification shall be made to ensure that in case of grid fault the solar inverter shall cease to energize the grid to which it is connected.

Grounding integration with grid – A system design verification shall be made to ensure that solar inverter shall not cause over voltage and shall not disrupt the coordination of the ground fault protection connected to the grid.

IEEE 1547/ CEA Regulation 2013

Commissioning tests

- ❖ All commissioning tests shall be performed based on written test procedures of equipment manufacturer/ system integrator.
- ❖ A visual inspection shall be made to ensure that the system earthing is adequate as per standard/ regulation.
- ❖ A visual inspection shall be made to confirm the presence of the isolation device as required by standard/ regulation.
- ❖ The following initial commissioning tests shall be performed on the installed solar system and grid connected inverter prior to the initial parallel connection to the grid.
 - ❖ Operability test on the isolation device
 - ❖ Unintentional-islanding functionality
 - ❖ Cease to energize functionality

IEEE 1547/ CEA Regulation 2013

Unintentional islanding functionality test

- ❖ This test must be conducted during noon time in a sunny day.
- ❖ PV system shall produce more than 20% of the rated output of the PV array or the inverter – whichever is less.
- ❖ If there is more than one inverter, tests should be carried out for each inverter.

Test 1: inverter must cease supplying power within two seconds of a loss of mains

STEP 1: Keep DC supply from the solar array connected to the inverter

STEP 2: Place the voltage probe in the inverter side of the AC main switch

STEP 3: Turn OFF the AC main switch through which inverter is connected to grid

STEP 4: Measure the time taken for the inverter to cease attempting to export power with a timing device and record.

Unintentional islanding functionality test

Test 2: inverter must not resume supplying power until mains have been present for more than 60 seconds.

STEP 1: Keep DC supply from the solar array connected to the inverter

STEP 2: Place the current probe in the inverter side of the AC main switch

STEP 3: Turn ON the AC main switch through which inverter is connected to grid

STEP 4: Measure the time taken for the inverter to re-energize and start export power with a timing device and record

Thank You