Working Committee Report on Formulation of Regulatory Framework for Exploring Grid Connectivity of Solar Generators 1 MW & below capacity

Report submitted to:

Maharashtra Electricity Regulatory Commission

13th Floor, World Trade Centre, Centre No. 1, Cuffe Parade, Mumbai – 400 005

Working Committee Report on Formulation of Regulatory Framework for Exploring Grid Connectivity of Solar Generators 1 MW & below capacity

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Note: ' * ' denotes recommendations made by the Committee Members through their mail

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1 Background

Shri Sudhir Budhay filed a Petition with the Hon'ble Commission on 1 July, 2013, seeking formulation of guidelines for connectivity to solar generators below 1 MW within Maharashtra. Under the said Petition, various relaxations were also sought such as waiver of transmission charges, cross subsidy surcharge and provision of 24 hrs banking facility by the licensees, etc., for the power so generated from such solar generators.

The Hon'ble Commission vide its Order dated 25 November, 2013 ruled as under:

> *"In view of the complexities involved in the matter and the far-reaching implications that it would have on the distribution companies and LT level consumers, the Commission has decided to study the issues involved in the matter in detail. Thus, the Commission directs formation of a Working Committee under Director (EE), MERC along with the representatives from all impleaded parties (MSEDCL, TPC-D, RInfra-D, BEST, MSETCL, STU & MSLDC), including the Petitioner and Prayas Energy Group to study issues involved in the matter. The Working Committee is further directed to prepare a draft Terms of Reference (ToR) and submit it to the Commission for approval. The Committee shall submit its report to the Commission within period of six months from the date of issuance of this Order, which shall form the basis for formulation of appropriate regulatory framework for exploring grid connectivity of solar generators below 1 MW."*

In view of above, the Working Committee was formed under Director (EE), MERC along with the representatives from the following organization/ Associations;

Nominated members for Working Committee:

1) Shri Prafulla Varhade, MERC
2) Shri Sudhir Budhay, the Petitioner in Case No. 86 of 2013
3) Shri S S Paratkar, MSEDCL
4) Shri A. S. Ghogare, MSEDCL
5) Shri Rahul Ranade, TPC-D
6) Shri Suhas Dhapare, TPC-D
7) Shri N. V. Bhandari, BEST
8) Shri M. M. Davare, BEST
9) Dr. J V Torane, MEDA
10) Shri Satish Bhirud, RInfra-D
11) Shri Abaji Naralkar, RInfra-D
12) Shri Jayant Kulkarni, MSLDC
13) Shri Anil Rewagad, MSLDC
14) Shri B N Khasale, STU & MSETCL

15) Shri Ashwin Gambhir, Prayas Energy Group
16) Shri Ajit Pandit, Idam Infrastructure Advisory Pvt. Ltd.
17) Shri Amit Mittal, ICRA Management Consulting Services Ltd. (Special Invitee)

2 Terms of Reference (ToR) of Working Committee

The approved ToR for the Working Committee is as under:

a) Examine technical feasibility of grid/Utilities' network connectivity of solar roof-top PV projects and other small solar PV generations at different voltage level, as follows:

Sr. No.	Capacity of Solar roof-top PV project	Connectivity at voltage level
a)	Below 1 MW and up to & including 100 kW	Below 33 kV/22 kV/11 kV
b)	Below 100 kW and up & including 10 kW	at 11 kV or 415 V
c)	Below 10 kW	at 415 V or 230 V

Technical feasibility study should address the following aspects:

A. Project capacity conditions (Min/Max) for type of consumer connection –The capacity considered in (1) (a) (b) & (c) should be as per prevailing SOP Regulations and Supply Code Regulations of distribution licensee.

B. Limits on Aggregate Capacity limits (Min/Max): LT feeder level/Distribution Transformer level –The maximum capacity allowed for solar roof top projects as proportion of KVA rating of distribution transformer/feeder for concerned distribution licensee in a staged manner.

C. Requirements for earthing, safety measures and protection systems within consumer premises: – Consideration of the protection & safety measures *w.r.t* DC injection into grid, effects of Harmonics, Voltage variation, Fuses of adequate rating, manual disconnection switches. Earthing, safety measures and protection systems should be in line with CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 and CEA measures of electrical safety and electricity supply Regulations, 2010 and amendments there-under.

D. Grid safety and islanding requirements with utility interface – The grid safety and islanding issues should be as per present practices adopted by the distribution utilities and in line with CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 and CEA measures of electrical safety and electricity supply Regulations, 2010 and amendments there-under.

E. Installation, certification and third party verification mechanism, as applicable, prior to synchronization –The protocol for monitoring and third party verification for installation shall be in line with provisions of E.A.2003, and CEA measures of

electrical safety and electricity supply Regulations, 2010 and amendments there-under and may be as per the prevailing SOP Regulations and Supply Code Regulations of distribution licensee.

b) Review of FOR model guidelines and experience in other Countries/States with regard to technical aspects of connectivity of solar roof-top PV projects and other small scale solar PV projects.

c) Defining roles and responsibilities of parties (i.e. DISCOMs, solar generator etc.) and devising the information protocols for connectivity of solar roof-top PV projects and other small scale solar PV projects for the capacities as mentioned in point (i) (a)(b) & (c) above, to the grid at appropriate voltage level in line with CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013.

d) Devising the appropriate protocols for metering and energy accounting of grid interactive solar roof-top PV projects below 1 MW in line with CEA (Installation and Operation of Meters) Amendment Regulations, 2013, which is in draft stage: The Metering protocol should cover following aspects for each type of installation:

a) Type of meter, b)Accuracy of meter, c) Location of meter, d) Ownership of meters, e) Energy accounting (Meter reading) f) Feasibility option on phase wise implementation of net metering facility.

CEA Smart Grid Meter specifications should also be studied.

e) Suggest broad outline/contours of Model connection Agreement and suggest terms and conditions for connections for solar PV installations below 1 MW.

f) Feasibility study for stage wise implementation of intra-distribution and inter-distribution open access and issues of banking facility and other related issues for solar PV installation below 1 MW.

g) Recommendation on modifications or relaxation of existing Regulations and/or formulation of new Regulatory framework for grid connectivity of solar roof-top PV projects and other small solar PV generators.

3 Proceedings of the Working Committee

The first meeting of working committee for the formulation of regulatory framework for exploring grid connectivity of solar generators 1 MW and below capacity, was conveyed on 17 January, 2014 at 12.30 hrs. Shri Prafulla Varhade, Director (EE), MERC chaired the meeting. The official of the Hon'ble Commission made a presentation on agenda of first meeting of working committee and point wise discussion was made on proposed draft Terms of Reference (ToR). The proposed draft ToR was also made available to all the members of the working committee for ready reference and for their suggestions. All the members of working committee suggested inviting MEDA as a special invitee of the working committee.

The second meeting of the Working Committee was held on 10 February, 2014 at MSLDC Office, Airoli, Navi Mumbai. During the meeting, the official of the Hon'ble Commission made a presentation and point wise discussion was made on revised draft Terms of Reference (ToR) w.r.t., the suggestions given by the members of working committee during the first meeting of working committee.

The third meeting of the Working Committee was held on 7 March, 2014 at MERC Office, Mumbai. During the meeting, the members of working committee suggested few more points on proposed draft ToR. After incorporating the suggestions/recommendations given by the members of working committee, the proposed broad ToR for the formulation of Regulatory Framework for exploring Grid connectivity of solar generators 1 MW and below capacity has been finalized.

The fourth meeting of the Working Committee was held on 23 May, 2014 at Tata Power Company Ltd. Office, Carnac Bunder, Mumbai. During meeting Shri. Amit Mittal, IMaCS (Special Invitee) made presentation on key issues and probable way ahead on various issues regarding connectivity of Solar rooftop PV. The members of the Working Committee were requested to submit the comments on the same. The members of Working Committee visited the Solar rooftop Project installed at Tata Power Company Ltd.'s office at Carnac Bunder.

The minutes of the meetings held are attached are annexed in Annexure 1.

Based on the discussion during the various meeting of the Working Committee, the draft Report prepared in this matter was circulated to all Committee Members for their comments/suggestions. After incorporating the suggestion given by the Committee Members, the Report in this matter has been finalized and discussed in subsequent section.

4 Review of Existing Framework

4.1 Review of Existing Regulations and reports at Central level

4.1.1 Central Electricity Authority Regulations:

The Committee noted that Central Electricity Authority (CEA) has notified the CEA (Technical Standards for connectivity of the Distributed Generation Resources) Regulations, 2013 on 30 September, 2013. The Committee has reviewed the provisions of the Regulations and summarized in the following table:

Sr. No.	Particulars	CEA Regulations
1.	Applicant	A generating company or person owning distributed generation resource
2.	Connectivity	Applicant seeking connectivity at voltage level below 33 KV for its distributed generation resources
3.	Standards, Code and Practices	Industry best practices and as per BS, BIS, IEC Standards or Standards issued by ANSI or any other equivalent International Standards.
4.	Safety	As per CEA (Measures relating to Safety and Electric Supply) Regulations, 2010
5.	Sub-station grounding	As per IS 3043 -1987 – Indian Standard for Code of Practice for Earthing
6.	Metering	As per CEA (Installation and Operation of Meters) Regulations, 2006 and subsequent amendments
7.	Harmonic Current Injection	Annual measurement in presence of Party as indicated in Connection Agreement. Within the limits specified in IEE 519
8.	DC injection	Annual measurement in presence of Party as indicated in Connection Agreement. DC current injection shall not be greater than 0.5% of full rated output at interconnection point.
9.	Flicker	Annual measurement in presence of Party as indicated in Connection Agreement. Within the limits specified in IEC 61000
10.	Inspection, test and calibration	Inspections Test to be finalized by the Applicant in consultation with Distribution Licensee or Generating company.

Sr. No.	Particulars	CEA Regulations
11.	Protection requirements for Parallel Operation	It shall have following protective functions: Overvoltage and undervoltage trip functions if voltage reaches above 110% and below 80% with clearing time upto 2 seconds Over and under frequency trip functions if frequency reaches 50.5 Hz and below 47.5 Hz with clearing time upto 0.2 seconds Voltage and frequency sensing and time delay function to prevent energizing and reconnecting of distributed generation with system for at least sixty seconds Function to prevent distributed generation from contributing to formation of an unintended island and cease to energize system within 2 seconds of the formation of unintended island.
12.	Equipment requirement	Equipments shall be capable of withstanding 220% of the nominal voltage at interconnection point. Capable of interrupting the maximum available fault current expected
13.	Synchronization	Voltage fluctuations shall not be greater than ±5% at point of connection
14.	System Isolation	Manual switch for separation of distributed generation and system Visible verifications and indicators to clearly show open and closed positions Manual switch shall be easily accessible and located at height of at least 2.44m above the ground level Manual switch be capable of being locked in Open Position Manual switch may not be rated for load break or for over current protection
15.	Access to connection site	Reasonable access and other required facilities to licensee for inspection and maintenance of equipment
16.	Site responsibility schedule	Site responsibility schedule shall be prepared by licensee It shall include schedule of electrical apparatus

Sr. No.	Particulars	CEA Regulations
		services and supplies, telecommunication and measurement apparatus and safety rules applicable. It shall include the equipment information for ownership, responsibility and control, responsibility for operation & maintenance, manager at site and responsibility of all matters relating to safety of persons and equipment at site.

Further, the Committee also noted that CEA has notified the amendment in CEA (Installation and Operation of Meters) Regulations, 2006 on 10 June, 2010. In the said Regulations, CEA has revised the specifications of meters Standard Reference Voltage, Voltage Range, Standard Frequency, Standard Basic Current, Accuracy Class, Starting current and maximum current, etc.

As regards the electrical safety, the Committee referred the CEA (Measures relating to Safety and Electric Supply) Regulations, 2010 and CEA (Safety requirements for Construction, Operation and Maintenance of Electrical Plants and Electric Lines) Regulations, 2011.

The Committee also referred the technical standards Regulations notified by CEA for installation of Solar rooftop PV and allied equipments and lines i.e., CEA (Technical Standards of Construction of Electric Plants and Electric Lines) Regulations, 2010.

As regards the connectivity to grid, the Committee referred CEA (Grid Standards) Regulations, 2010 and CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007. The Hon'ble Commission noted that Grid Standards have specified the standards and limits for steady state voltage, temporary overvoltage, voltage unbalance, power quality in terms of harmonic distortion, etc.

4.1.2 Forum of Regulator Report on Net metering

Forum of Regulator (FOR) has recognised the issue of penetration of solar rooftop and formed the Working group for evolving Net metering model Regulations. The Committee noted that the report recommends that the penetration levels be introduced in a phased manner so that the utilities have sufficient time to undertake technical studies. Until that time the FoR recommends that the penetration level be fixed at 15% of peak capacity to avoid any technical issues in the initial phase. As regards the net metering, the report states that a grid connected net-metering arrangement requires a well-defined regulatory and

commercial framework to address issues related to third party owned systems, provisions under the open access regulations, provision related to banking of energy, etc.

The report has discussed the two distinct ownership based net metering business models as under:

a) Self-owned arrangement wherein rooftop owner also owns the PV system
b) Third party ownership in which a developer owns the PV system and also enters into a lease/commercial arrangement with the rooftop owner.

The report also described about the energy accounting, interconnection arrangements, metering schemes, etc. The report also depicted comprehensive comparison of net metering and gross metering arrangements as under:

Sl No.	Parameter	Gross Metering	Net Metering
1	Objective	Electricity sale to utility	Self-consumption of electricity
2	Contractual arrangement	Power Purchase Agreement (PPA) with the utility. Price determined by Regulator or based on Competitive Bidding	Arrangement between utility and consumer in case the excess electricity sale is allowed
3	Metering Requirement	Compliance with the specifications of generation meter	Metering arrangement to measure generation as well as respective consumption
4	Energy Accounting	Accounting for the solar generation	Accounting for the net power consumption by the consumer as well as solar generation (in case it is linked to any benefits/ incentives)
5	Beneficiary	Enables the utility to meet its Solar RPO compliance	Enables the consumer in reducing the electricity consumption form the grid
6	Utility's Concern	Not keen on signing PPA with small rooftop projects	Loss of revenue for utility
7	Developer's Concern	Grid unavailability to impact revenue	Low level of incentive may impact viability of project for certain consumer segments

4.2 Review of framework in other States

The Committee noted that many States have released Solar rooftop policy or net metering policy to promote the solar rooftop technology as an alternative mechanism for providing power at local level. The Committee has analysed the enabling framework for Solar rooftop as under:

Sr. No	Parameters	TAMILNADU	ANDRA PRADESH	KERALA
1	**Policy Details**	Order No. 3 of 2013 dated 13.11.2013 Order on LT Connectivity and Net-metering, in regard to Tamil Nadu Solar Energy Policy 2012	Net Metering for solar grid interactive Rooftop and small SPV Power plants in the state vide G.O.Ms.No.22, dated 25.03.2013	KERC (Grid Interactive Distributed Solar Energy Systems) Regulations, 2014
2	**Issuing Authority**	TNERC	APEPDCL	KSERC
3	**Type of Scheme**	Net Metering	Net Metering	Grid Connected SPP, inc. Roof top (Net Metering at APPC)
4	**Subsidy**	Not Mentioned	30% subsidy on the project cost is available from Ministry of New and Renewable Energy, Govt. of India.	Not Mentioned
5	**Eligible Categories of Consumers**	HT tariff II-A, HT tariff III, LT tariff I-A, LT tariff I-C, LT tariff II-A, LT tariff II-B (1), LT tariff V	Applicable to consumers only with a 3 Phase Supply Connection	All consumers in the area of supply of the Distribution licensee are eligible
6	**Voltage Level**			

Sr. No	Parameters	TAMILNADU	ANDRA PRADESH	KERALA
	1. Upto 4Kw	Single phase or 415V – three phase at the option of the consumer.	All three phase consumers at LT & HT Voltages.	The capacity of the solar energy system shall be in conformity with the provisions relating to the connected load or contract demand permissible at each voltage level as specified in the Kerala Electricity Supply Code, 2014.
	2. Above 4kw and upto 112 kw	415V – three phase		
	3. Above 112 kw	At HT/EHT level		
7	**Capping on Electricity Generated**	Capped commercially at 90% of the electricity consumption. Excess energy generated beyond the 90% cap shall be treated as lapsed.	1. Capped commercially at 100% of the electricity consumption. 2. Excess energy generated beyond the 100% cap shall be treated as inadvertent	Provided that the capacity of the solar energy system shall be in conformity with the provisions relating to the connected load or contract demand permissible at each voltage level as specified in the Kerala Electricity Supply Code, 2014.
8	**Technically Maximum Installed Capacity Allowed**	Connectivity restricted to **30%** of the Distribution transformer capacity on the basis of first come first served.	-	1. The cumulative capacity of solar energy systems connected to the Distribution system under a particular Distribution transformer does not exceed 50% of the capacity of the transformer. 2. If the capacity of solar system increase beyond 50%, the licensee shall within 2 months, replace the transformer with higher capacity.
9	**Program Capacity**	Maximum cumulative capacity shall be limited to the extent prescribed in the Solar Policy and Linked with RPO.	-	3MW

Sr. No	Parameters	TAMILNADU	ANDRA PRADESH	KERALA
10	**Settlement Period**	Yearly (August – July); No carry forward of energy to next settlement period.	Monthly	Billing Period & Yearly
11	**Meters Installed**	Solar Generation Meter +Bi directional Meter +Solar Check Meters (above 20 kw Installations)	0.2 class accuracy, tri-vector based energy meter, non ABT having the MRI downloading facility along with related accessories shall have to be installed by the SPV generator as per the specifications of APTRANSCO/APDISCOMS.	MRI Compatible Solar meter + Net meter + Check meter *(solar energy system having capacity more than 20kW)*,
12	**Cost of Metering Installations and other allied costs**	Cost of Metering equipments and testing, Installation charges to be borne by consumer. Consumer shall pay the costs of Modification and upgrades to the service line, if any.	All Installation and Metering costs are borne by the Consumer.	The consumer shall have the option to purchase the net metering system as provided in the Act and in the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.
13	**REC (RPO) Eligibility**	Net metering Injection is not eligible for REC. It qualifies as deemed RPO for Distribution Licensee	Deemed injection into grid for in-house/ co-located solar generation will also be eligible for REC benefits subject to applicable CERC/ APERC guidelines[1]	Accounting towards REC is allowed, If consumer is an eligible obligated entity under Renewable Purchase Obligation (RPO).
14	**Penalty for payment delays**	Not mentioned in the Order	Not mentioned in the Order	Not Mentioned
15	**Minimum Monthly Charges**	NA	*Rs. 5 Lakh Insurance Coverage charges + Meter Rental* + The M*inimum Monthly Charges* as prescribed in the retail supply tariff and as	*Not Mentioned*

[1] http://mnre.gov.in/file-manager/UserFiles/guidelines_sbd_tariff_gridconnected_res/Amendment%20to%20AP%20Solar%20Power%20Policy%202012.pdf

Sr. No	Parameters	TAMILNADU	ANDRA PRADESH	KERALA
			per the general terms and conditions of supply .	
16	**Special Incentive/Facilities**	New Meter cards to be installed in consumer meters to transfer GBI[2] benefits directly by TEDA. Target 50 MW; GBI Rs 2/unit for first 2 years, Rs 1/unit for next 2 years, Rs 0.5/unit for next 2 years for all solar and wind solar hybrid plants installed before Match 31, 2014.		1. The eligible consumer shall pay wheeling charges at the rate of five percent of the energy wheeled for use in other premises owned by him. 2. Exemption from Banking and cross subsidy surcharge. 3. The banking facility shall be limited to the target capacity of the solar energy purchase obligation of the licensee, fixed by the Commission. 4. The eligible consumer in time of the day (ToD) billing system shall be entitled to use the quantum of electricity banked by him, first in the corresponding normal period in which the electricity was generated and injected into the system and the balance in the peak period and in the off peak period in succession, while not ToD consumer can use it irrespective of the normal, peak or Off-Peak Periods.

[2] http://mnre.gov.in/file-manager/UserFiles/october_month_2012_rerf.pdf

Sr. No	Parameters	PUNJAB	DELHI	UTTARAKHAND
1	**Policy Details**	"Guidelines on net metering for Grid Interactive Roof-Top SPV Power Plants" O.M. No. 10/174/2013/STE(3)/-----. The --th AUGUST, 2013	DERC proposal on net metering & connectivity in respect of rooftop solar pv projects	Scheme for Grid Interactive Roof top and small SPV Power Plants
2	**Issuing Authority**	Gov of Punjab (Department of Non Conventional Energy Sources)	DERC	UREDA
3	**Type of Scheme**	Net Metering	Net Metering	Net Metering with Feed in Tariff
4	**Subsidy**	Applicable MNRE and GOI grant, As per prevailing Instructions/Guidelines.	NA	MNRE may provide one time subsidy upto 30% of the benchmark cost of the project as follows (current rate)
5	**Eligible Categories of Consumers**	Individual households, industries, offices, commercial establishments, institutions, residential complexes etc. will be eligible with project capacity from minimum 1 KW upto 500 KW with/ without battery back-up support.	Consumer categories like residential, commercial and industrial consumers	All the individuals, residential/commercial/Institutional/Govt. building owners, Industrial units are eligible to set up Solar Power Plant
6	**Voltage Level**			
1.	Upto 7Kw	Single phase LT 230V	Upto 10 kw – 240 V Single Phase or 415v – three phase at the option of the consumer	Load Upto 4kw:Low voltage Single Phase supply
2.	Above 7kw and upto 25 kw	400V – three phase	Above 10kw and upto 100kw – 415 V-Three Phase	Load >4 kW and upto 75 kW: low voltage three phase supply

Sr. No	Parameters	PUNJAB	DELHI	UTTARAKHAND
	3. Above 25 kw and upto 100 kw	400V – three phase	Above 100kw – AT HT/EHT Level	Load >75 kW and upto 1.5 MW: at 11 kV
	4. More than 100kw	At HT/EHT level		Load >1.5 MW and upto 3 MW: at 11/33 kV or as per site condition
7	**Capping on Electricity Generated**	1. Capped commercially at 90% of the electricity consumption.	1. The capacity of an individual Rooftop PV system would be the available capacity of the service line connection, i.e. the sanctioned load of the consumer. 2. If higher capacity than the sanctioned load of the consumer in installed then the consumer would pay SLD charges as prescribed in the DERC supply code & Performance standards. 3. Electricity generated from a solar Rooftop system shall be capped cumulatively at 90% of the electricity consumption by the eligible consumer at the end of settlement period which shall be the relevant financial year. In case of COD during the year, the 90% capping shall be on the energy drawl by the consumer from the date of COD to the end of the financial year. 4. Any excess generation (above 90 per cent) at the end of the financial year would be considered as free energy and not offset against the consumer's consumption. There shall be no carry	Eligible Capacity of generation is as under : . Project capacity with battery backup – 300 Watt to 100 KW . Project capacity without battery backup – upto 500 KW.

Sr. No	Parameters	PUNJAB	DELHI	UTTARAKHAND
			forward to next financial year.	
8	**Technically Maximum Installed Capacity Allowed**	The maximum capacity of the Roof Top Solar PV system shall not be more than 80% of the Sanctioned Connected Load/Contract Demand (in KVA converted to KW at normative Power Factor of 0.95) of the consumer on AC side at the output of inverter based on rated inverter capacity and the minimum capacity shall not be less than 1 KW.	The Distribution licensee shall provide net metering arrangement to all eligible consumers as long as the cumulative Capacity to be allowed for a particular Distribution transformer shall not exceed 15% of the capacity of the Distribution transformer.	Not Mentioned
9	**Program Capacity**	NA	Subject to Point No. 8	The projects of total capacity 5 MW is proposed for 2013-15, this scheme announced by MNRE vide No. 5/23/2009-P&C dated 8th July, 2010
10	**Settlement Period**	Yearly.	Yearly (Financial Year)	
11	**Meters Installed**	Bidirectional energy meter with CTs and PT as per CEA metering regulations/ State Grid code	Two meters would have to be installed by the solar power generator. One is for measuring solar generation and the other is for Import/Export measurement. These meters should be MRI and AMR compliant.	Export Import meters/two way meters shall be installed with the facility of net metering. Two way meters can also be used as they are cheaper and give better idea about power exported. The meter may also be finalized in consultation with the DISCOM.
12	**Cost of Metering Installations and other allied costs**	PSPCL shall supply and install/seal tested bidirectional energy meters for small and domestic Solar PV projects of 20 KW Capacity. Meters Installed	The cost of these meters shall be borne by the consumer	The cost of these meters shall be borne by the consumer

Sr. No	Parameters	PUNJAB	DELHI	UTTARAKHAND
		at the cost of SPV plant owner till the point of Interconnection.		
13	**REC (RPO) Eligibility**	Not Mentioned	Net-metering injection is not eligible for REC	Not mentioned
14	**Penalty for payment delays**	Any delay in payment shall attract surcharge at the agreed rate.	NA	Not Mentioned
15	**Minimum Monthly Charges**	NA	NA	NA
16	**Special Incentives/facilities**	If the Net energy is exported to the grid, then such quantum will be treated as energy banked by the consumer with PSPCL in the current billing cycle.	In order to promote the third party owned systems and avoid complexities around evaluation and monitoring of wheeling/banking/open access charges, the net metering Rooftop solar arrangements are specifically exempted from these charges.	UPCL/PTCUL will inform wheeling charges uniformly applicable to all producers would be announced in advance. UPCL would extend the facility of Banking to the Developers at mutually agreed terms. For evacuating energy from the generation site, requisite network of transmission/ Distribution lines would be provided by UPCL/PTCUL.[3]

Sr. No	Parameters	UTTARPRADESH	WEST BENGAL	KARNATAKA
1	**Policy Details**	Draft U.P Rooftop Solar PV Power Plant Policy	Policy on Co-generation and Generation of Electricity from Renewable Sources of Energy.	Determination of Tariff for grid interactive solar power plants including Rooftop and small solar Photo voltaic power plants *(Order dated 10 October*

[3] Policy for Harnessing Renewable energy sources in Uttarakhand with private sector/community participation

Sr. No	Parameters	UTTARPRADESH	WEST BENGAL	KARNATAKA
				2013)
2	**Issuing Authority**	UPNEDA	WBREDA	KERC
3	**Type of Scheme**	Net Metering/Billing Mechanism	Net Metering/ Billing Mechanism	Net Metering/ Preferential Tariff @ Rs. 9.56/unit and @ Rs. 7.20/unit *(for plants availing capital subsidy benefits)*
4	**Subsidy**	*No state level subsidy -* State Nodal Agency shall facilitate in availing Government of India subsidy, if available for implementation of such plants, to both Public and Private Institutions / organizations	Applicable as per the central level policies	30% Capital subsidy can be availed; Control Period (1 April 2013 to 31 March 2015)
5	**Eligible Categories of Consumers**	1. Any person, which shall include any company or body corporate or association or body of individuals, whether incorporated or not, shall be eligible to set up Rooftop solar Photovoltaic power plant and approach nodal agency for implementation of such power plants. 2. Plants are to be set up for the purpose of captive use/self-consumption of electricity and such plants comply with the technical standards and specifications.	1. It shall be mandatory for all the public buildings to have solar devices to meet electricity requirements and other applications. All existing and upcoming commercial and business establishments having more than 1.5 MW of contract demand will be required to install solar Rooftop systems to meet at least 2% of their total electrical load. 2. All the existing and upcoming schools and colleges, hospitals, large housing societies and Government establishments having a total contract demand of more than 500 KW will be required to install solar Rooftop systems to	

Sr. No	Parameters	UTTARPRADESH	WEST BENGAL	KARNATAKA
			meet at least 1.5% of their total electrical load.	
6	**Voltage Level**	1. At 415 V and above voltage level consumer should set up evacuation Infrastructure. 2. At 415 V and below, service line of consumer will be utilized.	Rooftop solar PV sources of capacity ranging between 100 kW – 2 MW shall be allowed connectivity at LV or MV or 6 kV or 11 kV of the Distribution system of the licensee as considered technically and Financially suitable by the licensee and the developer.	1. 1kw to 5kw @ 1- Phase, 230 V 2. 5kw to 50 kw @ 3-Phase, 415V 3. >50kw at 11kv Distribution system.
7	**Capping on Electricity Generated**	Not Mentioned	Not Mentioned	Not Mentioned
8	**Technically Maximum Installed Capacity Allowed**	All consumers having contracted load of not less than 1kW shall be eligible. The cumulative capacity to be allowed at a particular Distribution transformer shall not exceed 15% of the peak capacity of that Distribution transformer.	100kw to 2MW connectivity mentioned, but not mentioned anything about capacities more or less than these.	1. The maximum installed capacity of solar Rooftop PV plant at any single location shall be limited upto 1 MW, for the purpose of applying the solar Rooftop PV tariff. 2. Governed by , CEA (Technical Standards for Connectivity to the Grid) Regulations 2007, CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations 2012 to be notified by CEA and KERC grid code as amended from time to time
9	**Program Capacity**	Rooftop Solar Photovoltaic Power Plants are proposed to be promoted under Net Energy Metering Mechanism	The Policy envisages a target of 16 MW of Rooftop and small PV installations by the	Not Mentioned

Sr. No	Parameters	UTTARPRADESH	WEST BENGAL	KARNATAKA
		up to 50 kW and Net Energy Billing Mechanism above 50 kW.	year 2017	
10	**Settlement Period**	Yearly.	Monthly/ Yearly	Monthly/Yearly
11	**Meters Installed**	Bidirectional energy meter with CTs and PT as per CEA metering regulations/ State Grid code and a unidirectional Solar main and check meter.	Bidirectional energy meter with CTs and PT as per CEA metering regulations/ State Grid code and a unidirectional Solar main meter.	Metering shall be in compliance with the CEA (Installation and Operation of Meters) Regulations 2006 as amended from time to time
12	**Cost of Metering Installations and other allied costs**	Procurement, testing, installation of new meter and replacement of existing meter with new and/or additional meter shall be undertaken by the host Distribution Licensee and shall recover the charges from the eligible consumer as approved from the Commission.	Charges as Approved by the Commission	Charges as Approved by the Commission, to be borne by consumer
13	**REC (RPO) Eligibility**	The quantum of electricity consumed by eligible consumer, who is not defined as obligated entity, from the solar Photovoltaic power plant shall qualify as deemed Renewable Purchase Obligation (RPO) for the Distribution Licensee.	1. The RPO will be as per the West Bengal Electricity Regulatory Commission (Co-generation and Generation of Electricity from Renewable Sources of Energy) Regulations, 2010 or the subsequent amendment of the same. 2. The Commission may consider inclusion of captive consumers and open access consumers under the purview of the obligated entity	RPO benefits can be claimed by the Consumer by selling the electricity to ESCOM's
14	**Penalty for**	Any delay in payment shall attract	As per the penalty terms mentioned in the	Not Mentioned

Sr. No	Parameters	UTTARPRADESH	WEST BENGAL	KARNATAKA
	payment delays	surcharge at the agreed rate.	agreement.	
15	**Minimum Monthly Charges**	NA	Not mentioned	Not Mentioned
16	**Special Incentives/facilities**	1. In Net Energy Metering Mechanism, the effective billing rate for Non-Domestic category of consumers is Rs.7.70, Rs. 7.97/Unit for Public Institution and Rs. 8.23/Unit for Private Institution. 2. 100% banking of energy allowed. Withdrawal of energy not allowed during peak hours i.e. 17:00 to 22:00 hrs. 3. The withdrawal of banked energy shall be allowed subject to deduction of 2% of the banked energy, in each month, as banking charges payable to the Distribution Licensee in kind. 4. The unutilized banked energy on the expiry of the year would be treated as free energy to the Distribution Licensee and no commercial settlement shall be made. 5. Nil wheeling charges for Power. These charges would be nil during 1st control period or when the total capacity reaches 20 MW. 6. Nil Cross subsidy Surcharge	1. As per the West Bengal Municipal Act, 1993, it is mandatory for all buildings 14.5 meters in height or higher (about four-storied high); need to install solar panels on their roofs. Even, KMC Act, 1980, has declared that all buildings 15.5 meters (about five-storied high) in height or higher need to have solar panels on the roofs. 2. Exemption of demand cut to the extent of 50% of the installed capacity assigned for captive use purpose will be allowed subject to the Regulations of the Commission.	1. All grid connected solar power plants inclusive of Kw scale Rooftop plants and small solar plants shall be considered as 'Must Run' and shall not be subjected to Merit Order Dispatch principles. 2. The Commission decides not to levy any Wheeling and Banking charges, or Cross-Subsidy Surcharge on the solar generators who sell electricity on open access within the State. 3. In cases of projects availing capital subsidy of 30% the tariff with 30% reduction in capital cost as determined in this Order will be applicable.

Sr. No	Parameters	UTTARPRADESH	WEST BENGAL	KARNATAKA
		It shall be nil during the first control period or when the total capacity 20 MW for Rooftop solar power plant is being installed, whichever is earlier.		

Sr. No	Parameters	GUJARAT	GOA, UT'S	CHATTISGARH
1	**Policy Details**	Determination of tariff for Procurement by the Distribution Licensees and others from Solar Energy (Order 1 of 2012)	Determination of Preferential Tariff under net metering for Rooftop solar Photovoltaic Power Projects of Chandigarh Renewal Energy and Science & Technology Promotion Society (CREST) and for sale of such power to the Electricity Department of UT of Chandigarh	These Regulations may be called the "Chhattisgarh State Electricity Regulatory Commission (Determination of tariff for procurement of power from Rooftop PV Solar Power Projects by Distribution licensees of State) Regulations, 2013; Dated 14 August 2014
2	**Issuing Authority**	GERC	JERC	CSERC
3	**Type of Scheme**	Feed in Tariff *"The Commission has decided that there shall be a flat levelized tariff for 25 years for the kilowatt-scale Photovoltaic Power Projects"* *1.* The levelized tariff for kilowatt-scale solar Photovoltaic Power Projects availing accelerated depreciation is finalized at Rs. 11.14 per kWh, while the tariff for	Feed in Tariff/ Sale to Grid *(MNRE scheme' Roof Top PV & Small Solar Power Generation Programme (RPSSGP).* Tariff of Rs. 1.13/Unit is applicable to Rooftop solar PV Power developer implemented under central financial assistance, entering into power purchase agreements (PPA) with the Electricity Department, U.T. of Chandigarh.	Net Metering/ Feed in Tariff. 1. Applicable tariff for new project will be 50% of the generic levellised tariff determined for Solar PV based Power Projects for relevant year as per provisions of the Chapter 7 of the Chhattisgarh State Regulatory Commission (Terms and conditions for determination of generation tariff and related matters for electricity generated by plants based renewable energy

Sr. No	Parameters	GUJARAT	GOA, UT'S	CHATTISGARH
		similar projects not availing accelerated depreciation is finalized at Rs.12.44 per kWh. 2. 7% decline in tariff for 1 April, 2013 to 31 March, 2014, and a further 7% decline for 1 April, 2014 to 31 March, 2015.		sources) Regulations, 2012.
4	**Subsidy**	Not Mentioned	As applicable in MNRE *(RPSSGP)scheme*	Not Mentioned
5	**Eligible Categories of Consumers**	Consumer of Distribution Utility	The net metering facility shall be allowed only for three phase service consumers.	
6	**Voltage Level**	1. 1kw to 6 kw – 1-Phase @ 230v 2. 6kw to 100kw – 3-Phase@ 415 v 3. 100kw to 1 MW – 3-Phase@ 11KV	1. The evacuation from 1 kW up to 5 kW installed capacity of solar Rooftop PV shall be at 3-phase 415 volts. 2. The evacuation from 5 kW up to 50 kW installed capacity shall be at 3 phase 415 volts level. 3. 50 kW and above shall be connected at 11 kV Distribution systems.	50KW -100KW , 3 – Phase , 415 V 100KV – 1000KW, 3 – Phase , 11kV
7	**Capping on Electricity Generated**	Not Mentioned	1. Electricity generated from a solar Rooftop system shall be capped cumulatively at 90% of the electricity consumption by the eligible consumer at the end of the relevant financial year. 2. The excess energy generation shall be settlement on monthly basis and above capping shall apply therein to allow for seasonality in generation. 3. Any excess generation (above 90 per cent) at the end of the financial year	Annual energy injection by the projects to the Distribution system shall not be more than **49%** of the annual net generation. No payment shall be made for any excess energy supplied to licensee.

Sr. No	Parameters	GUJARAT	GOA, UT'S	CHATTISGARH
			would be considered as free energy and not offset against the consumer's consumption.	
8	**Technically Maximum Installed Capacity Allowed**	Not Mentioned	The maximum installed capacity of solar Rooftop PV plant at any single location shall be limited up to 1 MW.	NA
9	**Program Capacity**	Not Mentioned	Not Mentioned	NA
10	**Settlement Period**	Yearly.	Monthly/Yearly	Monthly/Yearly
11	**Meters Installed**	Bidirectional energy meter with CTs and PT as per CEA metering regulations/ State Grid code and a unidirectional Solar main and check meter.	Bidirectional energy meter with 0.2 Accuracy class, tri-vector based energy meter, with download facility along with related accessories, and Meters must comply Time of Day (ToD) requirements.	The Grid Meter (GM) and Solar Meter (SM) shall be interface type as envisaged in the CEA metering regulations. These meters may also comply the Time of Day (ToD) requirements.
12	**Cost of Metering Installations and other allied costs**	Procurement, testing, installation of new meter and replacement of existing meter with new and/or additional meter shall be undertaken by the host Distribution Licensee and shall recover the charges from the eligible consumer as approved from the Commission.	The SPV generator shall bear the entire cost of metering arrangement provided including its accessories.	1. Adequate metering equipments shall be installed by Distribution licensee for and at the cost of project developer. 2. Rather than adopting billing for net energy, it is proposed that retail supply billing to the consumers shall be done as a normal consumers and billing for power purchase shall be carried out separately.
13	**REC (RPO)**	The (RPO) is applicable to all Distribution Licensees as well as	The RPO is applicable	Power procured by Distribution licensee from such projects shall qualify for their renewable

Sr. No	Parameters	GUJARAT	GOA, UT'S	CHATTISGARH
	Eligibility	any other person consuming electricity.		purchase obligation.
14	**Penalty for payment delays**	Delay penalties for payment included in the PPA	NA	1. Delayed Payments by a Distribution licensee beyond a period of 30 days from the date of billing will attract a late payment surcharge at the rate of 1.25% per month. 2. Late payment surcharge for the retail consumer shall be recoverable as per the provisions of relevant tariff order.
15	**Minimum Monthly Charges**	NA	NA	NA
16	**Special Incentives/facilities**	1. Roof top SPP with 100 kW and 1 MW capacity can wheel electricity at 66kv with charges applicable to normal open access consumer and transmission and wheeling loss at 7% of energy fed. 2. Wheeling at 11kv and above is allowed on payment (in kind) of Distribution loss @ 3% of the energy fed in to the grid. 3. For Rooftop solar installations of capacity between 1 kW and 5 kW feeding at 220 V, 1φ; and Rooftop solar installations of capacity between 5 kW and 100 kW feeding at 415 V, 3φ, No wheeling charges shall apply for	1. Commission is of the view that the wheeling, banking charges and cross-subsidy charges are not applicable for such projects	1. Communication interface and data acquisition system to be provided by the consumer. 2. The project developer must install all the required hardware to have this web based Supervisory Control an Data Acquisition (SCADA) operational such that the system can be monitored via the web from Distribution company office.

Sr. No	Parameters	GUJARAT	GOA, UT'S	CHATTISGARH
		wheeling of power generated by such projects, to the desired locations(s). 4. There is no cross-subsidy surcharges shall be levied in case of third-party sale. 5. BG of 50Lakh /MW at the time of signing PPA		

Sr. No	Parameters	RAJASTHAN	ORISSA
1	**Policy Details**	Notification Dated 19 April 2011 In order to promote generation of power from Solar Energy, the State Government hereby makes the Rajasthan Solar Energy Policy, 2011.	Determination and Declaration of Tariff for Power Procurement by the Distribution licensee/GRIDCO in State of Orissa from Grid Interactive Solar Photovoltaic Power Projects under Rooftop PV and Small Solar Generation Programmes (RPSSGP) announced by MNRE, GOI, on 16th June, 2010
2	**Issuing Authority**	Govt. of Rajasthan , Energy Department	OERC
3	**Type of Scheme**	PPA Sale to grid, Net Metering Proposed	Sale to grid, PPA
4	**Subsidy**	As available with MNRE	MNRE
5	**Eligible Categories of Consumers**	Under this scheme, the Power Purchase Agreement shall be executed between the concerned Discom of Rajasthan and the operator of small solar power plant as per guidelines of MNRE/IREDA and tariff orders of RERC.	1. As per the Guidelines for Rooftop and Other Small Solar Power Plants issued by MNRE. 2. Draft Tariff Guidelines for Rooftop PV and other Small Solar Power Plants issued by CERC on 9th June, 2010.

Sr. No	Parameters	RAJASTHAN	ORISSA
6	**Voltage Level**	11KV ; Discoms of Rajasthan shall allow interconnections of solar power plants connected to LT voltage level as per standard /norms fixed by Central Electricity Authority/ guidelines of MNRE/ relevant RERC order.	Projects shall be connected at the HT level of Distribution network at voltage levels below 33 KV i.e. at 11 KV in Orissa.
7	**Capping on Electricity Generated**	NA	NA
8	**Technically Maximum Installed Capacity Allowed**	NA	NA
9	**Program Capacity**	The Rajasthan State will promote deployment of Roof Top and Other Small Solar Power Plants connected to LT/11kV Grid as per guidelines of MNRE under Rooftop PV & Small Solar Generation Programme (RPSSGP) of NSM and orders of appropriate Regulatory Commission.	IREDA has been designated as 'Programme Administrator' by the MNRE for administering the generation based incentive programme for rooftop PV and other small solar power plants. It is proposed to develop solar capacity of 100 MW under these guidelines.
10	**Settlement Period**	As per the T&C of PPA	As per the T&C of PPA
11	**Meters Installed**	Metering arrangement shall be made as per Central Electricity Authority (Installation & Operation of Meters) Regulations, 2006, the grid code, the metering code and other relevant regulations issued by RERC/CERC in this regard.	Both Grid interface meters and Solar meters would be installed. The SPV shall be connected normally to the 11 KV bus of the nearest 33/11 KV bus of DISCOM's Substation. With the consent of DISCOM in the specific cases the RPSSGP may also be

Sr. No	Parameters	RAJASTHAN	ORISSA
			connected to the nearest 11 KV line through LILO arrangement.
12	**Cost of Metering Installations and other allied costs**	Till the point of interconnection with grid, all costs to be borne by the customer.	All the DISCOMs submitted that the connectivity cost upto DISCOM interconnection point should be borne by the Project Developers. The necessary interconnecting line shall be constructed by DISCOM and the cost of such interconnection shall be reimbursed by the project proponent to the DISCOM.
13	**REC (RPO) Eligibility**	Allowed	NA
14	**Penalty for payment delays**	NA	In case the payment of any bill for charges payable under these Guidelines is delayed beyond a period of 60 days from the date of billing, a late payment surcharge at the rate of 1.25% per month shall be levied by the generating company.
15	**Minimum Monthly Charges**	NA	NA
16	**Special Incentives/facilities**	1. In case of third party sale/captive use/sale to other States, the Power Purchase Agreement will be executed between the Power Producer and the procurer on mutually agreed rates. 2. Open access will be granted to any Solar Power Producer or beneficiary. They shall have to pay the applicable open access charges and losses as approved by RERC/ CERC from time to time. 3. A separate agreement will be executed for Wheeling and banking of power with Discoms of	1. Any developer availing accelerated depreciation, the same shall be internalized in the tariff and accordingly the tariff per kWh shall be reduced to the extent of Rs.3.13 per kWh. This means the effective tariff for developers availing accelerated depreciation shall be Rs.18.52 minus Rs.3.13 which equals to Rs.15.39 per kWh on a levellised basis. 2.

Sr. No	Parameters	RAJASTHAN	ORISSA
		Rajasthan for such banking. 4. A generation-based incentive will be admissible to the Discoms of Rajasthan to cover the difference between the solar tariff and base price as per the guidelines issued by MNRE and orders of appropriate Commission.	

5 Technical Feasibility

In the Terms of Reference of the Working Committee, it is required to carry out the technical feasibility study in view of the connectivity of the Solar rooftop PV projects. The Committee limits its scope for the technical feasibility for connectivity of Solar rooftop PV projects to distribution system as the projects below 1MW are required to connect to distribution system.

In this report, the Committee has deliberated on the issues related to connectivity of the rooftop Solar PV projects for 1 MW and below capacity. . The Committee firstly analysed the possible impacts and benefits of grid interconnection by reviewing existing studies and concerned technical measures to eliminate such impact.

5.1 Technical Impacts of Solar rooftop PV

The Committee has analysed technical possible impact of solar rooftop PV projects for connecting to grid as under:

5.1.1 Overvoltage/ Under voltage

In general, electricity current flows from a higher voltage point to a lower voltage point. Further, the voltage of electricity decreases as it is consumed. The line voltage decreases relative to the distance the measurement is taken from the voltage source, as well as the types of loads encountered. However, the voltage must be kept in a certain range as specified in Standards of Performance of Regulations as applicable, for the purposes of appliances and machinery operating properly. In order to control the voltage within the range, Distribution Licensee has to apply various technology countermeasures.

On the other hand, when the power generated by Solar PV projects is more than the energy consumed at the point of use, the surplus electricity will flow back to the grid. In this case, the electricity current flow reverses direction and the voltage rises as it goes to the end. This is not a significant issue in case of high grid impedance and limited PV capacity. However, as PV penetration increases or currently when a number of PV systems are installed with lower impedance, the voltage could exceed the upper limit.

Both overvoltage and under voltage would have a negative impact on stable operation of the supply-side devices including generators and Distribution Transformers. Additionally, there would also be an impact on the demand-side equipment. Overvoltage might shorten the lifetime of the equipment and under voltage could constrict the normal performance of electric equipment. Such voltage rise can be mitigated by reactive power management

from the system. Both distribution licensee and consumer can take appropriate measures for reactive power control to maintain the voltages within the specified limits.

5.1.2 Instantaneous voltage change

When faults such as lightning occur on the grid, the voltage around the fault point drops until the protective relay detects the fault and isolates the fault from the main grid by means of breakers. This is the typical case for instantaneous voltage change. The duration of the voltage drop is dependent on the operational time of protective relays and breakers.

Instantaneous voltage change may also happen when distributed AC generators are connected to the grid under certain conditions. In the case of synchronous generators, considerable inrush current will flow if the generators are not properly synchronized in the grid connection processes. However, Solar rooftop PV have little impact on instantaneous voltage change since fluctuations in the power output are relatively slow. One possibility for instantaneous voltage change occurrence by Solar rooftop PV system is simultaneous disconnection of PVs by an islanding function. Household appliances, computers, office equipment are vulnerable to instantaneous voltage change.

5.1.3 Short Circuit capacity

Short-circuit capacity can be used as a measure of grid strength and is an indicator representing the level of electric current when a short-circuit fault occurs. If a number of distributed generators are connected to a distribution line, the short-circuit current might exceed the rated amount. If the short-circuit current is higher than the capacity of the breaker, the breaker cannot block the current and the grid devices will be damaged. In the case of Solar rooftop PV systems, the impact is not as crucial compared with that of synchronous generators. The use of inverters in solar rooftop PV consists of very fast switching elements and contribute negligible over currents during the faults. If the short-circuit current exceeds either the short-circuit capacity of the breakers or the limit for instantaneous current of the underground cables, it can damage those devices.

The Committee further discussed the counter measure for the above said technical impacts. The following measures are suggested by the Committee to minimize the technical impacts:

Sr. No	Impact	Grid Side	Consumer Side	Rooftop Solar PV Side
1	Overvoltage/ Under voltage	Shunt capacitor, Shunt reactor, Step voltage regulator	Shunt capacitor, Shunt reactor	Voltage control by Power Conditioner Systems, Electric Storage devices
2	Instantaneous	TVR, SVC,	DVR, Electric	Electric Storage

Sr. No	Impact	Grid Side	Consumer Side	Rooftop Solar PV Side
	Voltage Change	STATCOM	Storage devices	devices
3	Short circuit capacity			Advanced Power Conditioner System

Further, the Committee also suggests that the installation of such measures shall be guided by the standards and norms specified in CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013.

5.2 Eligible type of Consumers

The Committee noted that ideally, distribution system is balanced and single phase loads are evenly distributed between the three phases. However, in practical, any difference will cause a phase voltage unbalance in the three phase distribution system. The voltage unbalance is the ratio of the maximum voltage deviation of the phase voltage from the average phase voltage to the average phase voltage of the three phases. CEA (Grid Standards) Regulations, 2010 also recognize the voltage unbalance as undesirable.

Further, the Committee noted that directly connected three phase generator will normally serve to reduce any existing voltage unbalance. If the single phase generator is connected to the three phase distribution system, it may cause the voltage unbalance in the distribution system. In order to avoid such voltage unbalance in the system either the loads on all three phases has to be made balance or only three phase generator may be allowed to be connected. The impact of voltage unbalance is variation in voltage. However, it is noted that for voltage unbalance in the system, the single phase generation cannot be the only reason and irrespective of such voltage unbalance in the system. Considering single phase consumer base in State of Maharashtra, restriction on single phase consumers is not feasible for promoting the implementation of Solar rooftop PV projects.

Hence, to start with the implementation of Solar rooftop PV projects, the Committee recommends that single phase and three phase consumers may be allowed to install to Solar rooftop PV projects. Distribution licensees require taking appropriate steps/measures to keep distribution system in balance mode, which is desirable.

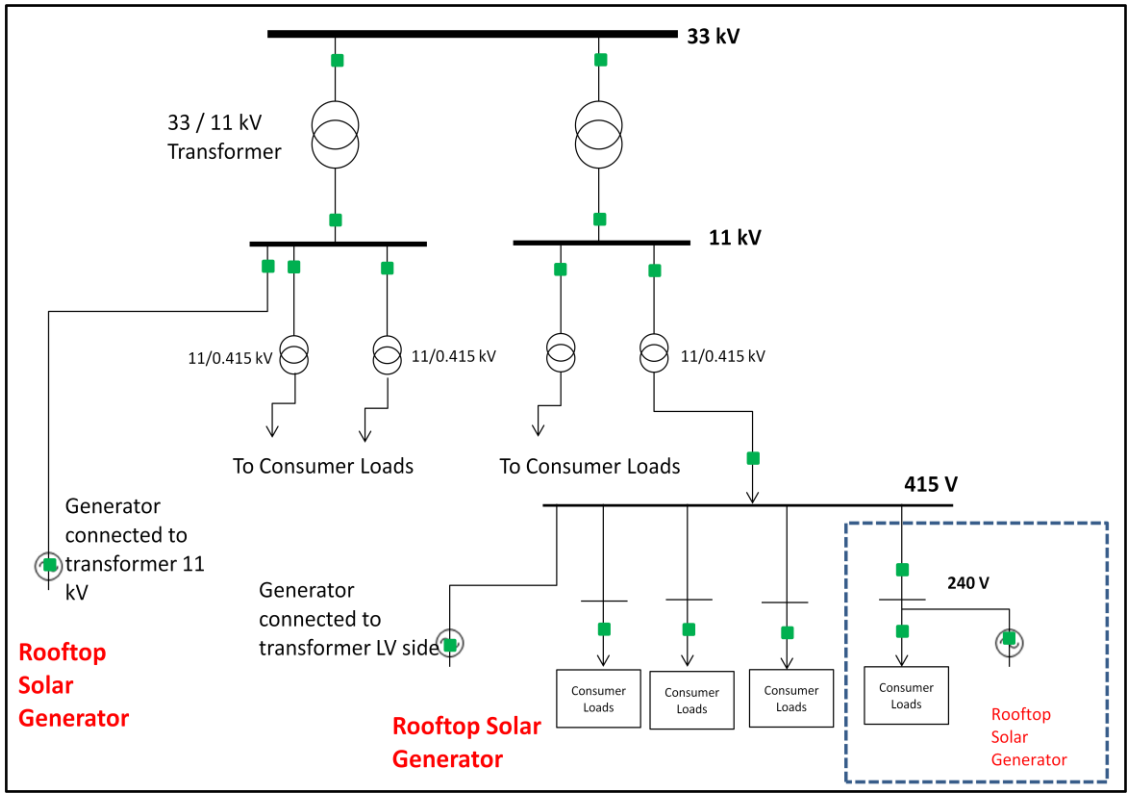
5.3 Capacity Conditions and Capacity Limits

The existing distribution systems are designed to accept the bulk power at interconnection point with the transmission system and to distribute it further to consumers. The flow of

both real power and reactive power is always from higher to lower voltages. With the significant penetration of Solar rooftop PV, the power flow may become reverse. In such situation, the distribution system will become an active system with power flows and voltages determined by the generation as well as loads. The power flows through the distribution system will be in either direction depending on the relative magnitude of the real and reactive loads compared to generator output and any losses in the distribution system.

5.3.1 Capacity conditions and limits at voltage level

The Committee deliberated on issues related to the connectivity of the Solar rooftop PV projects. The basic requirement of connecting any generator to system is that it must not adversely affect the quality of the electricity supplied to the consumer. Hence, it is required to identify the connecting voltages for solar rooftop PV project. In the distribution system, the connecting voltages available are 230/ 240 V (1 Φ), 400/415 V (3 Φ), 11 kV, 22 kV and 33 kV The various options for connecting the Solar rooftop PV to distribution system is depicted in following diagram:



The Solar rooftop PV projects may be connected at different voltage levels. The Capacity limits for connecting such projects are required to be defined to control the penetration at each level. The consumer installation at each voltage level is classified in the Standards of Performance Regulations notified by the Hon'ble Commission. The Committee noted connecting voltages wise consumer installations in Regulation 5.3 of MERC (Standards of

Performance of Distribution Licensees, Period of giving Supply and Determination of Compensation) Regulation, 2014 as under:

Sr. No.	Voltage level	Contract demand
1	240 V	Less than 40 A
2	415 V	Less than 80kW/100 kVA Less than 150kW/187 kVA (Municipal Corporation areas)
3	11kV	Up to 3000 kVA Up to 5000 kVA (MMR* Region)
4	22kV	More than 3000 kVA up to 7000 kVA More than 5000 kVA up to 10,000 kVA (MMR* Region)
5	33 kV	Up to 10,000 kVA Up to 20,000 kVA (MMR* Region)

**MMR – Mumbai Metropolitan Region*

The Committee observed that the higher capacity limits for each voltage level are specified in the Standards of Performance Regulations. Also, special provisions have been specified for the Mumbai Metropolitan Regions (MMR) considering the anticipated future growth in the area. The Committee further noted that distribution system has to be planned after considering such limits for consumer installations specified in the Standards of Performance Regulations.

The Committee noted that the various States have defined the various guidelines for connecting the solar rooftop PV projects. Further, the scope of the study is limited to the projects having capacity 1MW and below. The Committee further noted that the solar rooftop PV projects are feasible for connectivity at LT level.

As regards the capacity conditions and limits, the Committee observed that the consumer installations and connections are made as per prevailing Standards of Performance Regulations. Solar rooftop PV is intended to connect at consumer premises and any changes in the capacity limits may require change the network configuration. Hence, to start with the promotion of Solar rooftop PV projects, the Committee recommends the Capacity Limits as defined in Regulation 5.3 of MERC (Standards of Performance of Distribution Licensees, Period of giving Supply and Determination of Compensation) Regulation, 2014 as under:

Sr. No.	Voltage level	Capacity of Solar rooftop PV project
1	230/240 V (1 Φ) or 400/415 V (3 Φ)	Less than 8 KW/40 A
2	400/415 V	Less than 80kW/100 kVA Less than 150kW/187 kVA (Municipal Corporation areas)
3	11kV and above	Up to 1000 kVA Up to 1000 kVA (MMR Region)

As the present ToR deals with Solar PV projects of less than 1 MW, the Committee considered capacity limits for the projects having capacity 1 MW and below.

The Committee further suggests that distribution licensee may, if required, carry out technical studies for deciding the capacity limits for Solar rooftop PV projects at each voltage level.

5.3.2 Capacity limits on individual projects

After the connecting Solar rooftop PV projects, the power flow will be reverse in the distribution system. Solar rooftop PV projects are intended to be connected at individual premises subject their connection with distribution licensee. Hence, the capacity limits has to be considered for solar rooftop PV projects at individual consumer level and LT feeder or Distribution Transformer level.

The existing distribution system has been planned for the individual premises considering their contract demand/connected load (in case contract demand not available). While deciding the capacity of the project, this aspect needs to be considered. As discussed earlier, some of the States has limited the capacity with the annual consumption. The Committee opined that the approach of the deciding the capacity limits based on annual consumption is based on the commercial aspects. Further, the Committee noted that inherent nature of the solar rooftop PV makes the output power infirm and entire distribution system is planned and designed based on Contract Demand (Sanctioned load of Consumers) and hence same should be considered. The Committee recommends that such capacity of the projects to be connected at individual premises may be limited up to the contract demand or sanctioned load of the consumer For example: If consumer has sanctioned load of 4 kW with the distribution licensee, the maximum capacity of the Solar rooftop PV project allowable to be connected will be 4 kW.

5.3.3 Capacity limits at Distribution Transformer level

Further, the Committee noted that the penetration of the solar rooftop PV projects is required to be controlled at the feeder level or Distribution Transformer (DT) level. One of the likely impacts of the connecting the solar rooftop PV projects in the distribution

system are variation in the voltages. However, the Distribution licensee has to control the voltage levels within the prescribed limits as specified in MERC (Standards of Performance of Distribution Licensees, Period of giving Supply and Determination of Compensation) Regulation, 2014. The Committee further noted that connection of projects on all LT feeders is more critical instead of allowing single feeder for connection. For minimizing the voltage variation impact, the option of allowing only particular feeder for connecting solar projects is not feasible. The Committee noted that issue of voltage rise at LV side of DT will occur in light loaded conditions. If the level of solar penetration is more than the minimum load of the particular DT, then the voltage at LV side of DT may rise. Also, Distribution Transformer is not available with the feature automatic tap changer to control such voltage variation. The Committee recommends that the level of solar penetration at DT level may not be more than its minimum load during the day time (i.e., 10 am to 6 pm). The Committee further noted that many other States have put the limit on Solar penetration at DT level in terms of the % of the DT capacity. The Committee also looked out this option. The Committee to start with this option recommends that solar penetration may be less than 40% of DT capacity.

The Committee further recommends that distribution licensee should allow the penetration on First-Come-First-Serve basis up to the threshold level. Further, such limit should not be interpreted as a fixed upper limit, but as the first checkpoint for additional screening and technical studies. At present, Regulation 4 (6) of CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 mandates that licensee should undertake an inter-connection study to determine maximum net capacity of Distributed Generation at a particular location. Such studies are to be taken up only after the first check-point of capacity limit at DT level is reached. Once the Capacity limit at DT level is reached, distribution licensees can perform some preliminary screening checks based on ratios such as minimum load to generation ratio, stiffness factor, fault ratio factor, ground source impedance ratio, etc. to ascertain if the system effects of the distributed PV have become significant enough to warrant additional detailed technical studies. A larger penetration may be allowed, based upon DT capacity and on studies which assess anti-islanding ability, ground fault over-voltages (if generation is not effectively grounded), over-current device co-ordination and voltage regulation. Detailed loading, voltage profile and fault studies may need to be conducted based on the preliminary screening checks to further understand the impacts of Solar PV projects on the distribution system and its hosting capacity.

The Committee further observed that in many cases, studies conducted for medium-high penetrations may reveal that no system changes (equipment or protection settings) are needed to allow for higher distributed generation deployment. In some cases, it may be that only protection settings and/or protection equipment needs modification. The

Committee also noted that to further increase the hosting capacity of the distribution network, several options exist. A detailed study on such technical solutions was carried out under the project PVGRID[4]. Some of the important solutions are noted below which may be considered in future after the penetration of Solar PV project achieved at substantial level.

1) Distribution Grid Adaptations:
   a) Network reinforcement and increasing cable and transformer capacity, thereby directly increasing the system's PV hosting capability
   b) Voltage control through On Load Tap Changer for MV/LV transformer and booster transformers along long feeders
   c) Reactive power support though Static VAR Compensators (SVC)
2) Consumer Side Adaptations:
   a) Additional inverter functions (LHVRT, LHFRT, power-frequency droop characteristics, reactive power support as a function of local voltage, etc.) supporting integration of distributed solar and providing support to system.
   b) Reducing injection of solar PV power into distribution system to overcome voltage and congestion issues through increased self-consumption of PV, curtailment of power injected at PCC by limiting it to a fixed value storage during periods of peak solar generation load shifting through tariff incentives or demand response
3) Interactive Adaptations:
   a) A communication protocol and platform[5] between Distribution Licensees/SLDC and solar systems. This allows SLDC to directly control PV generation in emergency situations by sending appropriate signals. Similarly, reactive power support can also be initiated in response to utility signals rather than as a part of a pre-set function. Such communication is also helpful in changing any operational set points.

Hence, as regards the capacity limits at DT level, to start with the Committee recommends that the solar penetration level may be limited to minimum of either day time minimum load of the Distribution Transformer or 40% of its installed capacity. The Committee further suggests that such limit at the DT level may be relaxed subject to consent of distribution licensee in the initial phases to promote the solar rooftop PV projects.

[4] The PVGRID project publications: bit.ly/UnxXwm

[5] In Germany, according to §6 of the German renewable energy act (EEG), PV systems with an installed capacity of more than 100 kW must participate in feed-in and grid security management. The BDEW stipulates this for all plants feeding in at the medium voltage level. The grid security management requirements in Germany are: remote-control reduction of feed-in capacity in grid overload situations via a radio ripple control receiver, limitation of feed-in power in up to ten adjustable levels (for example, 0%, 30%, 60%, 100% of the agreed installed active power), setting of the required target value in less than one minute and gradual increase of power at a maximum rate of 10% per minute.

5.4 Power Quality and harmonics

The Committee noted that there are two aspects of power quality i.e., transient voltage variations and harmonics distortion of the voltage. Depending upon the circumstances, the distributed generator can increase or decrease the quality of voltage received by consumers.

The transient voltage variation occurs because of large current changes during the connection and disconnection of the generator. Further, the harmonic of a wave is defined as a component frequency of the signal that is an integer multiple of the fundamental frequency. A common source of harmonics is widespread use of cheaper power supplies in Computer, Television, power electronics devices and other appliances. Such devices can generate harmonics which may distort the grid voltages and current.

Inverters of the PV system convert DC current to AC current through a semiconductor switching circuit, but the AC wave obtained from the devices will not be a perfect sinusoidal wave. The latest model inverters generate little harmonics, but an older poor-quality inverter may generate severe harmonics when converting Solar rooftop PV output to AC.

The Committee noted that it is utmost important to control the harmonics at interconnection point in case of Solar rooftop PV as it is source of harmonics. The CEA (Grid Standards) Regulations, 2010 requires to ensure that voltage wave form quality is maintained at all point in grid and prescribed the desirable harmonic distortion for various voltage level. MERC (Standards of Performance of Distribution Licensees, Period of giving Supply and Determination of Compensation) Regulations, 2014 also recognizes the harmonics control in accordance with IEEE STD 519-1992, namely "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

The Committee noted that Standards of Performance Regulations in the State do not set any targets regarding the harmonic distortion but obligated the distribution licensee to follow the IEEE 519 which is IEEE standards for harmonics control. The Committee opined that in the initial phase it is difficult to set any target of harmonic distortion for distribution voltage level without carrying out any practical study. The Committee recommends that, in line with Standards of Performance Regulations, IEEE STD 519-1992 may be followed by consumer for controlling the harmonics at interconnection point. The consumer shall ensure the quality of supply at interconnection point of Solar rooftop PV Project and distribution licensee at all other point of supply in the distribution system.

5.5 Grid Safety and Islanding mode of operation

As Solar rooftop PV is connected to grid, it has to adhere grid discipline and ensure grid safety in the operation of the system. The Consumer as owner of generator has to abide by the CEA (Grid Standards) Regulations, 2010 and prevailing Grid Code Regulations notified for the State.

The current operating frequency range as per Indian Electricity Grid Code, 2010 is 49.95 to 50.05 Hz. The impact of solar rooftop PV in controlling the frequency will be significant as the penetration level of solar rooftop PV increases. The Committee noted that as rooftop PV system is interfaced with the grids through power electronic devices and as no mechanical inertia is involved, the speed of response to increase or decrease in power flow is fast indeed. The Solar radiation varies more slowly than other infirm sources such as wind and hence it can be fairly predictable. The Committee noted that at low penetration level, Solar roof top PV system cannot be able to provide frequency response services. The Committee suggests that this may be considered in future when the quantum of rooftop PV will increase substantial.

Further, the Committee noted that islanding is the continued operation of a grid-coupled inverter (or generator in general) in cases where the intra-state grid has been switched off, cut off or the distribution system have been damaged so that no electric energy is delivered from the distribution system. In such a situation the safety of persons and/or the safety of equipment might no longer be guaranteed. In case of rooftop PV system Islanding operation can only be possible when the following three conditions happen at simultaneously:

a) The power supply from the main grid stops for some reasons;
b) The power generated from the PV systems accidentally matches load; and
c) Islanding protection functions in the PCS failed to detect the islanding conditions

Islanding can be dangerous where it may not realize that a circuit is still powered when working on repairs or maintenance. For that reason, the inverter in the PV systems must detect islanding and stop supplying power if the grid is down. The Committee noted that CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 does not have the provisions related to anti-islanding for rooftop solar PV system. In view of the above, the Committee in such case recommends that the anti-islanding features may be adopted in PV system. Also, IEEE 1547 - IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems is recommended to be followed in such case, where the provisions are not available in the existing regulations. Further, the features may be designed such a way that it may have visible isolation facility

for Solar rooftop PV system from with grid and licensee reserves right to check such facility as and when required. The Committee also recommends that to ensure the anti-islanding features, consumer and distribution licensee may jointly verify and test the functioning of system in case of grid fault or outages. Further, after testing and verification, the distribution licensee may certify the anti-islanding features adopted.

5.6 Safety and Earthing measures

The safety of human being and electrical equipment is utmost important during the operation of the power system. As regards the safety measures, the consumer and distribution licensee has to comply with safety measures as specified in the CEA (Measures Relating to Safety and Electric Supply) Regulations, 2010. The Committee also recommends that the said regulations have to be followed for solar rooftop PV projects installations.

As regards the earthing of the system, it is mentioned that IS 3043 has to be followed for the earthing. This Indian Standard 3043 deals with earthing requirements at consumer installation, substation premises. The Committee recommends that earthing is the basic requirement for the system installations and hence, the standards have to be followed. The Committee recommends that the same standards IS 3043 has to be followed for earthing.

5.7 Protection requirements

5.7.1 Ground Fault Protection

Ground-fault currents are defined as currents flowing in other than the normally designated current-carrying conductors. The magnitude of ground-fault current depends on the impedance of the fault path and the potential difference across the fault. Ground faults are typically localised and not distributed since they are normally caused by damaged insulation, Solar rooftop PV projects breakage, localised corrosion or fallen objects that strike and damage insulation in the system. Solar rooftop PV projects can develop leakage currents as they age, especially in wet conditions. The leakage comes from internal module current paths to the outside frame or surface of the module through the edge seal or through other deteriorated insulating membranes. Ground faults can evolve from continuous leakage when carbon or metal is released or deposited by the leakage current. Module junction boxes can accumulate moisture, either from condensation or rain, and this water, coupled with airborne debris or corrosion products, creates leakage paths within a junction box. Hence, the Committee recommends that the Solar rooftop PV system may be grounded solidly to avoid the fault and the consumer must be aware of the grounding methods and the ground-fault detection methods. In addition to the above, the

Committee recommends that protection requirements as specified in the CEA (Technical Standards for connectivity of the Distributed Generation Resources) Regulations, 2013 may also be implemented.

5.7.2 Over voltage Protection

Solar rooftop PV projects have a large exposure to the open sky and are subjected to atmospheric influences. A lightning strike is one of the most severe atmospheric influences. The Committee noted that to protect a PV system for a direct lightning strike is very difficult, if not impossible. The energy in a direct lightning strike is extremely high. This will simply destroy materials by thermal overloading, damage to the insulation and/or deform materials due to the pressure of expanding air. Adequate protection of Solar rooftop PV systems for direct lightning strikes can only be established by using arrestor poles and/or a grid of grounded wires above the modules. Also, the transient voltages occur from switching action has to be withstand by the PV system.

Further, the Committee recommends that in order to protect a PV system for indirect lightning strikes, it is advised to connect all metal enclosures and/or support structures to a ground wire.

In addition to the above, the Committee recommends that protection requirements as specified in the CEA (Technical Standards for connectivity of the Distributed Generation Resources) Regulations, 2013 may also be implemented.

5.8 Installation, Verification and Certification Mechanism

The substandard equipment such as inverters and isolation equipment by the consumers will grave risk to the licensee staff/ public at large /and the consumer himself. Hence, Committee suggests ensuring good quality and standard equipment with inbuilt safety features is of utmost importance and should be appropriately addressed.

The Committee further views that considering the new technology and to ensure the quality of the equipments of the Solar rooftop PV systems, the certificate of manufacture complying the Indian Standards or relevant standards, CEA Regulations may be asked from the consumer/applicant by distribution licensee at the time of approving the connectivity of the project.

The responsibility of the installation of PV system lies with consumer. The distribution licensee and consumer may jointly verify and test the installation and connection requirements of Solar rooftop PV system. The distribution licensee upon satisfaction of such requirements may grant the connectivity to the consumers for Solar rooftop PV

projects. For the installations above 650V, the approval of electrical inspector is required as per CEA Regulations. However, for lower installation, test report of licensed electrical contractor may be asked from the consumer. The distribution licensee may also verify, test and self certify the installation of PV system.

Also, as regards the verification and testing of features, the consumer and distribution licensee may be mutually agreed on routine testing and verification of such installation and functioning of PV system.

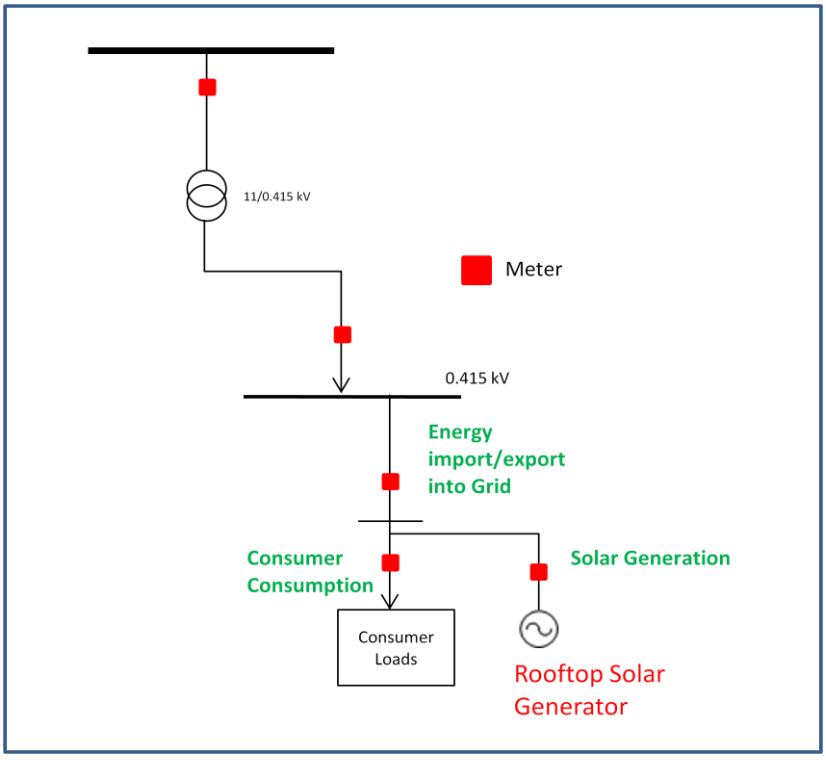
6 Metering and Communications

6.1 Metering scheme

The adequate metering and communications requirements are required for Solar rooftop PV systems. The Committee noted that in case of Solar rooftop PV connection, the metering is required to measure the following energy transaction in addition to the measurement of current and voltage parameters of the system:

a) Solar rooftop PV generation on continuous basis
b) Consumer consumption
c) Export of energy from Solar rooftop PV to grid
d) Import of energy from the grid

The metering scheme for measuring above energy transaction is depicted in the following figure which considers the Solar generator connected in consumer premises:



The metering arrangement and requirement shall be done according to the commercial philosophy adopted in the relevant Policy/Regulations. The Committee noted that there are two philosophies which are Net metering and Gross metering (Feed in tariff Metering). Section 4.3.2 of this report comprehensively has compared the features of Gross and Net metering.

The Committee recommends that for the metering requirements shall be complied with CEA (Installation and Operation of Meters) Regulations, 2006 as amended from time to time. Further, a draft amendment was released in 2013 to include renewable energy meters for distributed solar generation. In the said draft Regulations, the location of renewable energy meter is proposed based on metering arrangement as under:

Sl. No.	Metering Arrangement	Location of Renewable Energy Meter
1	Feed in tariff	Outgoing feeder from Renewable Energy Plant
2	Net Metering	In case of first installation for the purpose of Renewable Energy Metering, the 'Renewable Energy (RE) Meter' shall be installed at the location specified for consumer meter and in case of existing consumers, the consumer meter shall be replaced with 'Renewable Energy (RE) Meter

Hence, the Committee recommends that location of the metering may be considered in accordance with above mentioned draft amendment based on metering arrangement.

The Committee further noted that the CEA in its amendment of the CEA (Installation and Operation of meters) Regulations, 2010 specified specifications of meters which includes the Standard reference voltage, Voltage range, Standard frequency, Standard basic current, Staring Current, Maximum Current, Power Factor, AC Voltage test, Impulse Voltage test. All such specifications are required to be as per Indian Standards for different class of meters. The accuracy class for different voltage levels as under:

Sl. No.	Voltage level	Accuracy Class
1	Up to 650 V	1.0 or better
2	Above 650 V and up to 33 kV	0.5S or better
3	Above 33 kV	0.2S or better

Further, the Committee noted that the CEA minimum accuracy class requirement for consumer meters in the distribution network is either class 1 or class 0.5 S. Hence, the same may be adopted for Solar rooftop PV projects.

The Committee further noted that although the CEA mandates metering requirements throughout the country, several State Electricity Regulatory Commissions have specified divergent requirements. Several State solar policies mention metering requirements that are not in line with the CEA requirements.

	Gujarat	AP	Uttarakhand	Tamil Nadu	Delhi	Kerala	Punjab
Technical standards	CEA	CEA	CEA	CEA	CEA	CEA	CEA
No of meters	2	2	1	3	3	2	1
Type of meter	Not specified	Tri vector	Not specified	Not specified	Not specified	Not specified	Not specified
Metering arrangement	Feed in tariff	Net metering	Net metering	Net metering with GBI	Net metering	Net metering	Net metering
Accuracy class (minimum requirement)	Not specified	0.2	Not specified	CEA	Solar meter- 0.2 S Bidirectional meter- 1.0	CEA	Not specified
Check meter requirement	Not specified	Not specified	Not specified	Mandatory above 20 kW	Mandatory above 20 kW	Mandatory	Not specified

Further, the Committee suggests that the distribution licensee may be responsible for specifications, installation, testing and maintenance of the metering arrangement. Further, the number of meters required and location of meter shall be decided based on the commercial arrangement as Feed in tariff or Net metering. In case of net metering arrangement, the Committee recommends the two meters including one bi directional meter. The location of the bidirectional meter shall be before the node points the consumer installations and Solar rooftop PV. The Committee also looked into possibility of check meter. The Committee recommends that check meter shall be required for the Solar rooftop having capacity 20 kW and above, however, it may be optional to Solar rooftop PV generator for capacity lower than 20 KW. Further, the Committee suggests that the check meter may not have the communication support however, it should record the desired energy transactions.

The Committee recommends that metering scheme for Solar rooftop PV system have the following features:

1) Meter to measure Solar generation on continuous basis and register the energy based on daily, monthly generation.
2) Meter to record voltage, current and power factor on daily and monthly basis.
3) Meter to display on instantaneous, AC system voltages and currents, frequency, reactive power with sign, Total harmonics current and voltage distortion etc.
4) Specification of meters shall be in accordance with CEA (Installation and Operation of Meters) Regulations, 2006 as amended from time to time.

5) Metering arrangement shall comply with CEA (Installation and operation of Meters) Regulations, 2006 as amended from time to time and as per provisions of draft CEA (Installation and operation of Meters) Regulations, 2013.

6.2 Communication facilities

Further, Committee suggests that the Communication port of Meters must support real time data logging, event logging and supervisory control. Data logger system must record parameters for study of effect of various environmental & grid parameters on energy generated by the solar system and various analysis would be required to be provided. The Committee further suggests that the importance of the data acquisition will be significant in case the penetration level is high. However, these communication facilities may be considered in phases as the penetration level increases.

7 Roles and Responsibilities of Parties

The Committee noted that CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 defines the roles and responsibilities of parties as below:

"Role of Applicant:

- *The Applicant shall be responsible for the planning, design, construction, reliability, protection and safe operation of its own equipment subject to the regulations for construction operation and maintenance and connectivity and other statutory provisions.*

- *The Applicant and user shall furnish data as prescribed by the appropriate licensee in a non-discriminatory manner.*
- *The Applicant and user shall provide necessary facilities for communication and storage of data and parameters as may be stipulated by the appropriate licensee in a non-discriminatory manner*
- *The Applicant and user shall coordinate with the appropriate licensee on the issues including but not limited to protection, safety, and metering.*

Role of Distribution Licensee:

The appropriate licensee shall carry out the inter-connection study to determine:-

- *The point of inter-connection, required interconnection facilities and modifications required on the existing electricity system, if any, to accommodate the interconnection,*
- *the maximum net capacity of the distributed generation resource at a particular location for single-phase generators connected to a shared single-phase system, based on the configuration of the electricity system and imbalance in the power flows that distributed generation resource may cause,*
- *likely impact, if any, on the quality of service to consumers connected to the electricity system and measures to mitigate the same,*
- *additional measures to ensure safety of the equipment and personnel*

(7) Every connection of a requester's system to the electricity system shall be covered by a connection agreement between the applicant and appropriate licensee, which shall contain general and specific technical conditions, applicable to that connection.

(8) The appropriate licensee shall inform the concern State Transmission Utility within thirty days of acceptance of application for connectivity of a generating station to electricity system operating at voltage level below 33 kV. The concern State Transmission Utility in turn inform the state load dispatch centre with details of installed capacity, generator capabilities, connectivity, connectivity and likely date of commissioning or date of commercial operations."

Accordingly, the Committee suggested that the provisions of CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 may be considered for allocating the roles and responsibilities to the Parties. The Commission may consider the following recommendations as regards with the responsibilities to Parties:

Responsibilities of Consumer/Applicant

1) Consumer/Applicant shall be responsible for the planning, design, construction, reliability, protection and safe operation of its own equipment subject to the Regulations for construction operation and maintenance, connectivity, safety and other statutory provisions.
2) Consumer/Applicant shall adhere the capacity conditions and capacity limits for connectivity of the Solar rooftop PV projects.
3) Consumer/Applicant shall bind by the existing Regulations specified by Hon'ble Commission, such as Standards of Performance, Supply Code, State Grid Code, etc.
4) Consumer/Applicant shall provide the necessary information to distribution licensee and system operator in non-discriminatory manner.
5) Consumer shall coordinate with distribution licensee for resolving technical as well as commercial issues.
6) Consumer shall provide necessary facilities for real time communication to system operator/distribution licensee and storage of data for parameters as prescribed by concern policy/ Regulations
7) Consumer shall sign an connection agreement with distribution licensee for use of the distribution system and shall be bind by the terms and conditions made therein.
8) The Consumer shall undertake that the facility will be maintained with prudent O& M practices & annual report/certificate shall be submitted to distribution licensee annually. Further if any event occurs on account of the Consumer/applicant installation which will have adverse impact on distribution system, consumer shall be solely responsible for the same & shall be subject to the Legal / Regulatory enquiry / proceedings as per the law.
9) Consumer/Applicant shall bear the cost of meter and its installation in accordance with Supply Code Regulations and applicable Schedule of Charges.

Responsibilities of Distribution Licensee

1) Distribution licensee shall carry out the necessary interconnection study and grant the connectivity to Solar rooftop PV project to the distribution system at voltage level specified in concern policy/ Regulations.
2) Distribution licensee shall be bound by existing Regulations and concern Policy/ Regulations specified regarding to Solar rooftop PV connectivity.

3) Distribution licensee shall verify, test and certify the installations and technical features of Solar rooftop PV system before granting the connectivity.
4) Distribution licensee shall be responsible for specification, installation, testing and maintenance of metering arrangement and shall carry out billing on monthly basis.
5) Distribution licensee shall be bound by terms and conditions of connection agreement signed with consumer/applicant for connectivity of Solar rooftop PV projects.

8 Connection Agreement

The Committee noted that after establishing the connectivity with the distribution system, the applicant/consumer has to enter into connection agreement with the distribution licensee. The distribution licensee also ensures that such grant of connectivity and signing of connection agreement is done after considering all approval, due verification, testing and certification of installation.

The connection agreement shall be governed by the basic technical terms and conditions. The Connection agreement also serves as an agreement that clarifies the roles, responsibilities and liabilities of the two parties and it must cover aspects related to the safety of the grid and PV system, connection cost, termination clauses etc. The Committee opines that the Connection agreement may be limited to only technical aspects; however, the commercial aspects may be covered separately in Supply agreement with the consumer/applicant.

The Committee considers that option of implementation of Solar rooftop PV projects is open consumers of different categories (i.e. LT, HT, etc.) at various voltage level as specified in earlier Section of this report. The Committee recommends that connection agreement may be made applicable for each and every installation of Solar rooftop PV projects to enable distribution licensee to maintain technical and commercial information in one document for smooth operations. However, the Committee recommends that in case of Solar PV capacity installed and connected to voltage level below 400/415 V, process of signing of connection agreement may be kept simplified considering LT operational safety aspects.

The Committee deliberated on the terms and conditions require in the connection agreement and further suggest that the following terms and conditions shall include in the connection agreement:

1) Conditions requiring both parties, consumer/applicant and Distribution licensee to comply with existing regulations such as State Grid Code, Open Access Regulations, etc. and concern Solar Policy/Regulations.
2) Satisfaction of eligibility conditions of consumer based on capacity conditions and capacity limits
3) Roles and responsibility of both Parties, i.e, Consumer/applicant and distribution licensee
4) Details of connection and technical requirements including capacity, interconnection point, name of substation, name of LT feeder, etc.
5) Details of equipments installed in Solar PV system
6) Overall standards to be followed for grid standards, equipment, safety, etc.

7) Single line diagram of electrical system to be connected
8) Metering and energy accounting arrangement
9) Conditions related to Grid Safety
10) Protection and anti-islanding arrangements
11) Data and communication facilities
12) Site Responsibility Schedule
13) Access to consumer premises
14) Conditions for disconnection or termination
15) Details of connection charges and/ or usage charges, if any

9 Commercial Arrangement

As per Terms of Reference, the Committee also analysed the probable commercial aspects of Net metering and stage wise implementation of such measures. The Committee deliberated on the probable commercial arrangements required for the promotion of Solar rooftop PV System.

9.1 Capacity target

The Committee recommends that before formulation of concrete policy/Regulations for the implementation of Solar rooftop PV projects, it is require to set target and time bound action plan that can be accomplished through implementation of Solar rooftop PV projects.

The Committee noted that Ministry of New and Renewable Energy (MNRE) target for utility grid power including rooftop Solar project is 10,000 MW for period FY 2013-2017. Out of which, 500 MW target was allocated to Maharashtra Energy Development Agency (MEDA). The Committee considered that to start with the promotion of Solar rooftop PV projects, 10% of the MEDA's target may be considered. Hence, the Committee recommends that the target of 50 MW for the State of Maharashtra shall be kept in the initial stage of implementation of Solar rooftop Projects for period till FY 2016-17. Further, the Committee also recommends that Review mechanism for revision in control period or modification to net metering or gross metering framework can be built in case of accelerated deployment of rooftop PV target.

9.2 Phase Wise Implementation

The FOR in its report recommends that penetration of Solar Rooftop may be implemented in phased manner such that utilities may get sufficient time for technical studies and implementation of adequate measures. To decide upon such phase wise implementation of Solar rooftop PV projects, the Committee identified the probable implications on stakeholder of the implementation of such PV projects and depicted in following table:

Stakeholder	Probable implications
Consumer	• Cost effective alternative for supply • Improvement in reliability of grid supply • Incentives/ reduction in cost for injection of power into grid
Distribution Licensee	• High degree of penetration leads to revenue loss for licensee • Need an additional control for Solar rooftop PV system to ensure safety, operational integrity and reliability measures

Stakeholder	Probable implications
	• Bidirectional flow in distribution system leads to change in system configuration • Additional commercial measures for metering, billing, energy accounting • Requirement for additional capex for strengthening of distribution system for integration of such PV penetration
State Regulatory Commission	• High degree of penetration of PV as cost effective alternative for grid supply leads to transformation on regulatory control for distribution licensee
Generating Company	• High degree of PV penetration may create competition in market to expensive generating assets

Considering the probable implications, the Committee recommends that the distribution licensee may require sufficient time to cope with such penetration of Solar PV in their distribution system. Hence, the Committee considers that phase wise implementation may be considered for Solar PV implementation. In the initial phase, implementation process may be kept simple from energy accounting until proliferation of installations gross/net metering framework.

The Committee compared the gross metering and net metering framework (as given in Section 4.1.2 of this report) for initial phase of implementation and observed that Gross metering framework aims for sale to distribution licensee at the price determined by the Hon'ble Commission. The gross metering model has already been recognised by the Hon'ble Commission under MERC (Terms and Conditions for determination of RE Tariff) Regulations, 2010 wherein the Hon'ble Commission determines the generic tariff for Solar Rooftop PV Projects and other small solar power projects. The net metering framework aims at self consumption of electricity which in line for promotion of Solar PV having capacity less than 1 MW. The Committee noted that the distribution licensees' main concern with the net metering framework is that high end consumers will likely opt for the net metering framework rather than low end consumers. This reduction in sales of cross subsidizing consumers may further impact the revenue of the distribution licensee and cross subsidy. But, at the other end, such reduction in sales may also reduce the purchase of costly power. The Committee observed that such economic impact on revenue may be trifling in the initial phase as proposed target of 50 MW is much less that demand of State of Maharashtra.

Further, the Committee observed that MERC (Terms and Conditions for determination of RE Tariff) Regulations, 2010 have been successful in promoting solar power projects in the State of Maharashtra, but small scale rooftop solar segment remains in nascent stage.

The rooftop Solar PV projects has certain advantages that as such projects are connected to the distribution system and injection of power is into a load centre which avoids transmission and distribution losses incurred in the case of conventional power plants. In larger benefit, the Committee suggested that the implementation of such projects shall be promoted. The Committee further noted that States like Gujarat, Karnataka, etc. have adopted Gross Metering framework and States like Tamilnadu, Andhra Pradesh, etc. preferred Net metering framework. The Committee recommends that the consumer shall be given option for both Gross metering and Net metering frameworks in the initial stage of implementation. Either of the framework may be ascertained based on the review of the initial stage of implementation for promoting Solar rooftop PV projects.

As regards the Gross Metering framework, the existing framework as per MERC (Terms and Conditions for determination of RE Tariff) Regulations, 2010 may be extended for the project having capacity less than 1 MW, specifying the additional conditions discussed in earlier Sections of this report.

As regards Net metering framework, the FOR recognised two business models as Self use and Third Party sale. The Committee noted that self use model may be useful for the consumer to install Solar PV in their premises to reduce their electricity consumptions. However, third party sale business model is not feasible to introduce at this initial stage as it may lead to issues related to energy accounting, balancing and settlement, scheduling of energy, etc. The Committee views that concept of net metering framework is new to the all stakeholders. The distribution licensees and consumer will undergo on the implementation of initial phase and make themselves groom enough for further implementation which necessitates sufficient time.

In view of the above, the Committee recommends that Net metering framework may be implemented for installation of Solar rooftop PV projects in consumer premises for generation and consumption at the same location. The Committee further recommends that all such projects under this scheme shall not be covered under REC/RPO framework.

Further, the Committee recommends the other conditions for Net metering framework may be as under:

1) Metering – The metering arrangements with two meters including one bi-directional meter may be considered. Also, the check meter may be installed for capacity having capacity 20 kW and above, however, it may be optional to Solar rooftop PV generator for capacity lower than 20 KW.
2) Billing – The billing may be done on monthly basis for the consumer. Time of day tariff, if applicable for the consumer, may be considered for net energy billing. The

billing may be considered after net adjustment of energy drawal and energy injected into grid.

3) Settlement of Surplus Energy –

Surplus power after set off with Consumer's consumptions shall be purchased by the Distribution Licensee with following conditions:

(1) Credit for energy injected should be provided on the basis monthly or Time of Day block basis as may be applicable.

(2) The surplus energy after set off with Consumer's consumption shall purchased by the Distribution Licensee at the approved Average Power Purchase Cost of the Distribution Licensee by the Commission for respective year :

Explanation. --- 'Average Power Purchase Cost' means the weighted average price at which the Distribution Licensee has purchased the electricity including cost of self generation, if any, approved by the Commission in the Tariff Order or Truing Up Order or any other general or specific Order. In case of absence of any such Order, last approved 'Average Power Purchase Cost' shall be used for settlement purpose.

Further, the Committee recommends that option to enable the Distribution Licensee to meet its Renewable Purchase Obligations through purchase of such surplus energy may be examined by the Hon'ble Commission.

9.3 Implementation through existing Regulations

The Committee noted that existing MERC (Terms and Conditions for determination of RE Tariff) Regulations, 2010 recognised the Gross metering (Feed in tariff) framework for Solar Rooftop PV Projects and other small solar power projects. The said Regulations does not provide the Net metering framework for Solar PV projects.

The prevailing Open Access regulations also does not provide the connectivity conditions and provisions for implementation of Solar rooftop PV projects having capacity less than 1 MW. Further, The Committee noted that seventh proviso of Regulation 3.1 of MERC (Distribution Open Access) Regulations, 2014 empowers the Hon'ble Commission to specify the separate terms and conditions for Solar rooftop projects by general or specific Order or Regulations.

In view of the above, the Committee recommends that the Hon'ble Commission may initiate the process of formulation of Regulations for Solar Rooftop PV promotion including the connectivity conditions and commercial arrangement.

10 Recommendation of Working Committee

The Committee analysed the various issue related to connectivity of the Solar rooftop PV to distribution system. The Committee summarizes its recommendations as under:

1) The Committee to start with the implementation of Solar rooftop PV projects recommends that single phase and three phase consumers may be allowed to install to Solar rooftop PV projects.

2) The Committee recommends the Capacity Limits as defined in Regulation 5.3 of MERC (Standards of Performance of Distribution Licensees, Period of giving Supply and Determination of Compensation) Regulation, 2014 as under:

Sr. No.	Voltage level	Capacity of Solar rooftop PV project
1	230/240 V (1 Φ) or 400/415 V (3 Φ)	Less than 8 KW/40 A
2	400/415 V	Less than 80kW/100 kVA Less than 150kW/187 kVA (Municipal Corporation areas)
3	11kV and above	Up to 1000 kVA Up to 1000 kVA (MMR Region)

The Committee further suggests that distribution licensee may, if required, carry out technical studies for deciding the capacity limits for Solar rooftop PV projects at each voltage level.

3) As regards the capacity conditions and capacity limits at individual project level, the Committee recommends that such capacity of the projects to be connected at individual premises may be limited up to the contract demand or connected load of the consumer For example: If consumer has connected load of 4 kW with the distribution licensee, the maximum capacity of the Solar rooftop PV project allowable to be connected will be 4 kW. The Committee further recommends that such limit at the individual premises may be relaxed subject to consent of distribution licensee in the initial phases to promote the solar rooftop PV projects.

4) As regards the capacity limits at DT level, the Committee recommends that the solar penetration level may be limited to minimum of either day time minimum load of the Distribution Transformer or 40% of its installed capacity. The Committee further recommends that distribution licensee should allow the penetration on First-Come-First-

Serve basis up to the threshold level. The Committee further suggests that such limit at the DT level may be relaxed subject to consent of distribution licensee in the initial phases to promote the solar rooftop PV projects. A larger penetration may be allowed, based upon DT capacity and on studies which assess anti-islanding ability, ground fault over-voltages (if generation is not effectively grounded), over-current device co-ordination and voltage regulation. Detailed loading, voltage profile and fault studies may need to be conducted based on the preliminary screening checks to further understand the impacts of Solar PV projects on the distribution system and its hosting capacity.

5) As regards with harmonics and power quality, the Committee recommends that, in line with Standards of Performance Regulations, IEEE STD 519-1992 may be followed by consumer for controlling the harmonics at interconnection point. The consumer shall ensure the quality of supply at interconnection point of Solar rooftop PV Project and distribution licensee at all other point of supply in the distribution system.

6) As regards grid safety, the Committee in such case recommends that the anti-islanding features may be adopted in PV system. Also, IEEE 1547 - IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems is recommended to be followed in such case, where the provisions are not available in the existing regulations. The Committee also recommends that to ensure the anti-islanding features, consumer and distribution licensee may jointly verify and test the functioning of system in case of grid fault or outages. Further, after testing and verification, the distribution licensee may certify the anti-islanding features adopted.

7) The Committee recommends that the standards IS 3043 has to be followed for earthing. The Committee also recommends that the CEA (Measures Relating to Safety and Electric Supply) Regulations, 2010 have to be followed for safety measures for solar rooftop PV projects installations.

8) As regards the Metering arrangement, the Committee recommends that metering arrangement may be complied with CEA (Installation and Operation of Meters) Regulations, 20006 as amended from time to time based on commercial framework.

9) The Committee recommends that connection agreement may be made compulsory for each and every installation of Solar rooftop PV projects. However, the Committee recommends that in case of Solar PV capacity installed and connected to voltage level below 400/415 V, process of signing of connection agreement may be kept simplified considering LT operational safety aspects.

10) To start with the promotion of Solar rooftop PV projects, the Committee recommends that the target of 50 MW for State of Maharashtra shall be kept in the initial stage of implementation of Solar rooftop Projects for period till FY 2016-17.

11) The Committee deliberated two options available for energy measurement and settlement for solar roof top projects viz. Net Metering and Gross Metering based on merits and demerits to Consumer, Distribution Licensee's Tariffs, etc. The Cross Subsidy built in current Tariff structure is the primary factor which is making roof top solar viable in the present scenario., Therefore, if we adopt Net Metering arrangement more and more high end Consumers will opt for installation of roof top solar. This will result into loss of cross subsidy to the Distribution Licensee. However, if Gross Metering is adopted then Distribution Licensees will have to realign their power purchase from RE & non RE sources to that extent of solar energy injected by roof top solar. Under both the options, tariffs and thus some category of consumers of Distribution Licensee are likely to get impacted.

    It is therefore the Committee recommends that both the options are technically feasible and the consumer shall be given option for both, Gross metering and Net metering frameworks in the initial stage of implementation. Either of the frameworks may be ascertained based on the review of the initial stage of implementation for promoting Solar rooftop PV projects after analysing the impact on tariffs and related economical issues.

12) Further, the Committee recommends that Net metering framework may be implemented for installation of Solar rooftop PV projects in consumer premises for generation and consumption at the same location. The Committee further recommends that all such projects under this scheme shall not be covered under REC/RPO framework. Further, the Committee recommends the other conditions for initial phase Net metering framework may be as under:

    a) Metering – The metering arrangements with two meters including one bi-directional meter may be considered. Also, the check meter may be installed for capacity having capacity 20 kW and above, however, it may be optional to Solar rooftop PV generator for capacity lower than 20 KW.
    b) Billing – The billing may be done on monthly basis for the consumer. Time of day tariff, if applicable for the consumer, may be considered for net energy billing. The billing may be considered after net adjustment of energy drawal and energy injected into grid.

c) Settlement of Surplus Energy –

Surplus power after set off with Consumer's consumptions shall be purchased by the Distribution Licensee with following conditions:

(1) Credit for energy injected should be provided on the basis monthly or Time of Day block basis as may be applicable.

(2) The surplus energy after set off with Open Access Consumer's consumption shall purchased by the Distribution Licensee at the approved Average Power Purchase Cost of the Distribution Licensee by the Commission for respective year :

Explanation. --- 'Average Power Purchase Cost' means the weighted average price at which the Distribution Licensee has purchased the electricity including cost of self generation, if any, approved by the Commission in the Tariff Order or Truing Up Order or any other general or specific Order. In case of absence of any such Order, last approved 'Average Power Purchase Cost' shall be used for settlement purpose.

Further, the Committee recommends that option to enable the Distribution Licensee to meet its Renewable Purchase Obligations through purchase of such surplus energy may be examined by the Hon'ble Commission with respect to proviso of Regulation 7.2 of MERC (RPO-REC) Regulations, 2010.

13) **Based on the above finding and recommendations, the Committee recommends that the Hon'ble Commission may initiate the process of formulation of Regulations for Solar Rooftop PV promotion including the connectivity conditions and commercial arrangement.**

Annexure -1

Minutes of Working Committee Meetings

Date: 20th January, 2014

Minutes of First Meeting of Working Committee for the Formulation of Regulatory Framework for Exploring Grid Connectivity of Solar Generators below 1 MW capacity – Case No. 86 of 2013

1) The first meeting of working committee for the formulation of regulatory framework for exploring grid connectivity of solar generators below 1 MW capacity, was conveyed on 17 January, 2014 at 12.30 hrs. Shri Prafulla Varhade, Director (EE), MERC chaired the meeting. The following officials/members of working committee were present during the meeting:

- Shri Sudhir Budhay, the Petitioner in Case No. 86 of 2013
- Shri Rahul Ranade, TPC-D
- Shri T. K. Bhaskaran, TPC-D
- Shri N. V. Bhandari, BEST
- Shri M. M. Davare, BEST
- Shri Satish Bhirud, RInfra-D
- Shri B. N. Khasale, STU, MSETCL
- Shri Umesh S. Bhagat, STU, MSETCL
- Shri Ajit Pandit, Idam Infrastructure Advisory Pvt. Ltd.

2) The official of the Commission made a presentation on agenda of first meeting of working committee and point wise discussion was made on proposed draft Terms of Reference (ToR). The proposed draft ToR was also made available to all the members of the working committee for ready reference and for their suggestions.

3) Shri Sudhir Budhe, the Petitioner in Case No. 86 of 2013 suggested that the capacities considered in proposed draft ToR for solar roof top projects shall be revised as follows;

a) 999 KW to 51 KW.

b) 50 KW to 10 KW &

c) Below 9 KW.

Further, he suggested for the intra-distribution open access for domestic consumers and also for inter-distribution open access along with baking facility.

4) Shri Satish Bhirud appeared on behalf of RInfra-D, suggested to reclassify the capacity for solar roof-top projects to 75 KW below and above. Further, he suggested that capacity for solar roof-top projects shall be considered at appropriate voltage level, preferably for 3phase voltage level.

5) Shri N. V. Bhandari appeared on behalf of BEST, Shri Rahul Ranade appeared on behalf of TPC-D and Shri B. N. Khasale appeared on behalf of STU, MSETCL suggested that the issues related to energy accounting and settlement should be studied and properly addressed in proposed draft ToR. Also the responsibilities of various entities involved in this matter should also be properly addressed.

6) Shri Ajit Pandit from Idam Infrastructure Advisory Pvt. Ltd. suggested that Category of consumers to be allowed for solar rooftop installations with net-metering facility to be identified. Feasibility of phase-wise implementation of net-metering for solar rooftop installations in Maharashtra has to be studied under ToR. Further, he pointed out that the scope of TOR item "(vi)" would depend upon modification to current regulatory provisions to enable open access below 1 MW. It is not clear from Commission's ruling under Case 86 of 2013 if Working Committee's mandate covers to deal with the same. Hence, necessary clarification in this matter may be sought from Hon'ble Commission, prior to inclusion of proposed ToR item.

7) Members of working committee suggested to consider the energy accounting and settlement issue for solar roof-top projects connected at LT and HT level of distribution grid.

8) All the members of working committee suggested to invite MEDA as a special invitee of the working committee.

9) Shri Prafulla Varhade, Director (EE), MERC requested all the members of working committee to submit their comments/suggestions on proposed draft ToR in order to study and address the various issues involved in it.

Next meeting of the Working Committee is proposed to be scheduled on **Monday, 10th February, 2014 at 15.00** hrs at 12th floor, MERC Conference hall, Mumbai.

Date: 11th February, 2014

Minutes of Second Meeting of Working Committee for the Formulation of Regulatory Framework for Exploring Grid Connectivity of Solar Generators below 1 MW capacity – Case No. 86 of 2013

1) The Second meeting of working committee for the formulation of regulatory framework for exploring grid connectivity of solar generators below 1 MW capacity, was conveyed on 10 February, 2014 at 15.00 hrs. at MSLDC, Airoli, Navi Mumbai.

2) Shri Prafulla Varhade, Director (EE), MERC chaired the meeting. The following officials/members of working committee were present during the meeting:

- Shri Sudhir Budhay, the Petitioner in Case No. 86 of 2013
- Dr. J. V. Torane, MEDA
- Shri A. S. Ghogare, MSEDCL
- Shri S. S. Paratkar, MSEDCL
- Shri Ajay Potdar, TPC-D
- Shri Suhas Dhapare, TPC-D
- Shri N. V. Bhandari, BEST
- Shri M. M. Davare, BEST
- Shri Satish Bhirud, RInfra-D
- Shri Jayant Kulkarni, MSLDC
- Shri Anil Rewagad, MSLDC
- Shri D. K. Rokade, MSLDC
- Shri P. M. Buradkar, MSLDC
- Shri Ajit Pandit, Idam Infrastructure Advisory Pvt. Ltd.

3) The official of the Commission made a presentation and point wise discussion was made on revised draft Terms of Reference (ToR) *w.r.t* the suggestions given by the members of working committee during the first meeting of working committee.

4) As per the suggestions/recommendations of the working committee, the issue wise discussion made on revised proposed draft ToR are as follows;

i. **Examine technical feasibility of grid connectivity of solar roof-top PV projects and other small solar PV generations at different voltage level:** The Committee suggested the following option for the connectivity of solar roof-top projects and other small solar PV generators may be considered which would be inline with existing tariff schedule:

Sr. No.	Capacity of Solar roof-top PV project	Connectivity at voltage level
a)	Below 1 MW and up to & including 100 KW	at 33 KV or 22 KV or 11 KV
b)	Below 100 KW and up & including 10 KW	at 11 KV or 415 V
c)	Below 10 KW	at 415 V or 230 V

Technical feasibility study should address the following aspects:

A. **Project capacity conditions (Min/Max) for type of consumer connection** – The Committee suggested that the capacity considered in 4 (i) (a) (b) & (c) may be considered in two phases and it should be as per existing SOP Regulations and Supply Code Regulations of distribution licensee.

B. **Limits on Aggregate Capacity limits (Min/Max): LT feeder level / Distribution Transformer level** – The Committee suggested that the maximum capacity allowed for solar roof top projects below 1 MW capacity should not exceed the KVA rating of distribution transformer of concern distribution licensee.

C. **Requirements for earthing, safety measures and protection systems within consumer premises** – The Committee suggested that the protection & safety measures *w.r.t* DC injection into grid, effects of Harmonics, Voltage variation, Fuses of adequate rating, manual disconnection switches, may be considered. It is also suggested that earthing, safety measures and protection systems should be in line with CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 and IE Rules 1956 & 2005 and amendments therein.

D. **Grid safety and islanding requirements with utility interface** – The Committee suggested that the grid safety and islanding issues should be as per present practices adopted by the distribution utilities and in line with CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013.

E. **Installation, certification and third party verification mechanism, if necessary, prior to synchronization** – The Committee suggested that the protocol for monitoring and third party verification for installation shall be in line with provisions of E.A.2003, IE Rules 1956 and 2005 and amendments therein and may be as per the existing SOP Regulations and Supply Code Regulations of distribution licensee.

ii. **Review of FOR model guidelines and experience in other States with regard to technical aspects of connectivity of solar roof-top PV projects and other small scale solar PV projects –** The Committee recommended that FOR model guidelines for connectivity of solar roof-top project having capacity below 1 MW may be considered. Also the Orders passed by other SERCs pertaining to the connectivity of solar roof-top projects at LT level of

distribution network and model followed by Srilanka may be considered as a feasible option.

iii. **Defining roles and responsibilities of parties (i.e. DISCOM and Generating Company) and devising the information protocols for connectivity of solar roof-top PV projects and other small scale solar PV projects for the capacities as mentioned in point 4 (i) (a)(b) & (c) above, to the grid at appropriate voltage level in line with CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013** – The Committee recommended that the roles and responsibilities of distribution licensee, generating company and other entities involved in it should be addressed separately as Distribution utilities may have to update/amend the existing connection agreements and formulate a appropriate agreement which could capture all the role and responsibilities of parties.

iv. **Devising the appropriate protocols for metering and energy accounting of grid interactive solar roof-top PV projects below 1 MW in line with CEA (Installation and Operation of Meters) Amendment Regulations, 2013, which is in draft stage:** The Committee recommended that the Metering protocol should cover following aspects for each type of installation:

a. Type of meter, b) Accuracy of meter, c) Location of meter, d) Ownership of meters, e) Energy accounting (Meter reading) f) Feasibility option on phase wise implementation of net metering facility.

The Committee also observed that meter specification should be in line with Smart Grid Meter specification which is under final stage.

v. **Suggest broad outline/contours of Model Interconnection Agreement and suggest terms and conditions for inter-connections for various types of solar PV installations below 1 MW** – The Committee suggested that model interconnection agreement and terms of conditions for inter-connections should be as per present practices adopted by distribution licensees and in line with CEA (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 and in accordance with the relevant provisions under MERC (Renewable Purchase Obligation, its compliance and Implementation of REC framework) Regulations, 2010 and MERC (Terms and conditions of determination of RE Tariff) Regulations, 2010.

vi. **Recommendation on modifications or relaxation of existing Regulations and/or formulation of new Regulatory framework for grid connectivity of solar roof-top PV projects and other small solar PV generators –** The Committee recommended that necessary clarification may be sought from the Commission on consideration of open access provision for solar generator below 1 MW capacity.

Finally the meeting was ended with vote of thanks to all participants.

Date: 7th March, 2014

Minutes of Third Meeting of Working Committee for the Formulation of Regulatory Framework for Exploring Grid Connectivity of Solar Generators below 1 MW capacity – Case No. 86 of 2013

1) The third meeting of working committee for the formulation of regulatory framework for exploring grid connectivity of solar generators below 1 MW capacity, was conveyed on 7 March, 2014 at 14.30 hrs. at MERC office, Mumbai.

2) Shri Prafulla Varhade, Director (EE), MERC chaired the meeting. The following officials/members of working committee were present during the meeting:

- Shri Sudhir Budhay, the Petitioner in Case No. 86 of 2013
- Shri B. N. Khasale, MSETCL/STU
- Shri S. S. Paratkar, MSEDCL
- Shri A. V. Potdar, TPC-D
- Shri Rahul Ranade, TPC-D
- Shri V. K. Rokade, BEST
- Shri M. M. Davare, BEST
- Shri Satish Bhirud, RInfra-D
- Shri Abaji Naralkar, RInfra-D
- Shri Ashwin Gambhir, Prayas Energy Group
- Shri Krishnajith, Idam Infrastructure Advisory Pvt. Ltd.

3) The official of the Commission made a presentation and point wise discussion was made on revised draft Terms of Reference (ToR) *w.r.t* the suggestions given by the members of working committee during the second meeting of working committee, which was held on 10 February, 2014 at MSLDC office, Airoli, Navi Mumbai.

4) During the meeting, the members of working committee suggested few more points on proposed draft ToR. After incorporating the suggestions/recommendations given by the members of working committee, the proposed broad ToR for the formulation of Regulatory Framework for exploring Grid connectivity of solar generators below 1 MW capacity has been finalized.

Finally the meeting was ended with vote of thanks to all participants.

Date: 23rd May, 2014

Minutes of Fourth Meeting of Working Committee for the Formulation of Regulatory Framework for Exploring Grid Connectivity of Solar Generators below 1 MW capacity – Case No. 86 of 2013

1) The fourth meeting of working committee for the formulation of regulatory framework for exploring grid connectivity of solar generators below 1 MW capacity, was conveyed on 23rd May, 2014 at 14.00 hrs. at TPC, Carnac Receiving Station, Mumbai.

2) Shri Prafulla Varhade, Director (EE), MERC chaired the meeting. The following officials/members of working committee were present during the meeting:

- Shri Sudhir Budhay, the Petitioner in Case No. 86 of 2013
- Dr. J. V. Torane, MEDA
- Shri Anil Rewagad, MSLDC
- Shri Anil Ghogare, MSEDCL
- Shri V. H. Wagale, TPC-D
- Shri Satish Bhat, TPC-D
- Shri Suhas Dhapare, TPC-D
- Shri Rahul Ranade, TPC-D
- Shri Niteen Bhandari, BEST
- Shri M. M. Davare, BEST
- Shri Satish Bhirud, RInfra-D
- Shri Ajit Pandit, Idam Infrastructure Advisory Pvt. Ltd.
- Shri Amit Mittal, ICRA Management Consultancy Services Ltd.

3) Shri. Amit Mittal, IMaCS (Special Invitee) made a presentation on key issues and probable way ahead on various issues regarding connectivity of Solar rooftop PV projects below 1 MW capacity. The members of the Working Committee requested to submit their comments on the same.

4) The members of Working Committee visited 60.48 KW Solar Rooftop Project at Tata Power Company Ltd.'s office at Carnac Receiving Station, Mumbai.

Finally the meeting was ended with vote of thanks to all participants.