Explanatory Memorandum

For

Draft Terms and Conditions for determination of Tariff

For

Rooftop PV and other Small Solar Systems (< 1 MW)

May 2010

CENTRAL ELECTRICITY REGULATORY COMMISSION
NEW DELHI

Table of Contents

1 INTRODUCTION 3

1.1 CONTEXT 3
1.2 NEED FOR GUIDELINES FOR ROOFTOP PV & SMALL SOLAR SYSTEMS 3
1.3 APPROACH FOR DEVELOPMENT OF NORMS FOR ROOFTOP PV AND SMALL SOLAR SYSTEMS 6

2 BENCHMARK CAPITAL COST FOR SMALL SOLAR PROJECTS 8

2.1 INTRODUCTION 8
2.2 DEVELOPMENT OF ROOFTOP PV & OTHER SMALL SOLAR PROJECTS IN INDIA 9
2.3 SOLAR PV MODULES 12
2.4 NON-MODULE COST COMPONENT 13
2.5 LAND 14
2.6 POWER CONDITIONING UNIT OR INVERTER 15
2.7 MODULE SUPPORTING STRUCTURE 22
2.8 CABLING 24
2.9 CIVIL WORKS, GENERAL WORKS 25
2.10 PRELIMINARY/PRE-OPERATING EXPENSES AND FINANCING COST 26
2.11 CAPITAL COST SUMMARY 27

3 CAPACITY UTILIZATION FACTOR (CUF) 28

3.1 VARIATION IN PERFORMANCE (WITH OR WITHOUT TRACKING) 28

4 OPERATION AND MAINTENANCE EXPENSE 33

5 COST OF GENERATION AND APPLICABLE TARIFF 33

5.1 COST OF GENERATION FOR SMALL SOLAR SYSTEMS 33
5.2 APPLICABLE TARIFF (PROPOSED): 35

6 ANNEXURE-1: TECHNICAL REQUIREMENTS FOR SMALL SOLAR SYSTMS 36

6.1 TECHNICAL SPECIFICATIONS FOR PV MODULES AND INVERTER SYSTEMS 36
6.2 ELIGIBLE PROJECT CAPACITY 37
6.3 GRID CONNECTIVITY 37
6.4 METERING ARRANGEMENT 37
6.5 COMMUNICATION INTERFACE AND DATA ACQUISITION SYSTEM 38
6.6 POWER QUALITY REQUIREMENTS 38
6.7 SCHEDULE: PROPOSED METERING SCHEME 40

1 INTRODUCTION

1.1 Context

The **Jawaharlal Nehru National Solar Mission (JNNSM)** announced by Central Government during November 2009, seeks to promote development of rooftop PV and other small solar power plants connected at distribution network at voltage levels at LT/11 kV voltage level to replace conventional power and diesel-based generators. During Phase-I of the Mission, it is envisaged that around 100 MW of solar power project capacity could be added through such rooftop PV and other small solar generation systems.

The operators of such systems will also be eligible to receive the feed-in tariff fixed by the CERC, both on the solar power consumed by the operator and the solar power fed into the grid. Utilities will debit/credit the operator for the net saving on conventional power consumed and the solar power fed into the grid, as applicable. A Generation Based Incentive will be payable to the utility to cover the difference between the solar tariff determined by CERC, less the base price of Rs. 5.50/kWh with 3% p.a. escalation. The metering and billing arrangements between the utility and the rooftop PV operator, will be as per guidelines/regulations of the Appropriate Commission.

Thus, it is necessary that uniform principles for applicable tariff, standard guidelines for metering/billing/energy accounting are adopted; to the extent feasible, across States to facilitate smoother implementation of the Programme.

1.2 Need for Guidelines for Rooftop PV & Small Solar Systems

The Act provides for policy formulation by the Government of India and mandates State Electricity Regulatory Commissions to take steps to promote renewable sources of energy within their area of jurisdiction. Section 3 of the Act, clearly mandates that formulation of National Electricity Policy, National Tariff Policy and Plan thereof for development of power systems shall be based on optimal utilization of all resources including renewable sources of energy.

Grid connected large solar systems (> 1 MWp or MWe)

The Act has also mandated the Central Electricity Regulatory Commission (herein after referred as the Commission) to deal with aspects involving inter-

State generating stations and generating stations set up by the Central Government owned Companies. The Section 79 of the Act empowers the Commission to regulate the tariff for generating stations owned and controlled by the Central Government and also to regulate the tariff of generating companies other than those owned and controlled by the Central Government, if such generating stations enter into or otherwise have a composite scheme for generation and sale of electricity to more than one state. Therefore, in accordance with the provisions of the Act, the renewable energy power plants set up by the Central Government owned companies and other inter-state generating stations also needs to be regulated by the Central Commission.

Accordingly, the Central Commission has notified CERC (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2009 (hereinafter referred to as CERC RE Tariff Regulations) on September 16, 2009. Subsequently, the Central Commission has notified first amendment to CERC RE tariff regulations and also stipulated the benchmark capital cost norms for solar PV and solar thermal project vide its Order dated February 25, 2010. Such benchmark capital costs are valid for solar PV projects to be commissioned upto March 31, 2012 and valid for solar thermal projects to be commissioned upto March 31, 2013 subject to fulfilment of certain conditions.

Rooftop PV & Small Solar Systems

The rooftop PV and small solar power projects are likely to be connected to distribution network at voltage level below 33 kV (embedded) and likely to have capacity limits in the range of kW to few MW either on rooftop or ground mounted installations. Such project schemes and configurations are mainly designed to meet local load requirement or to substitute the local fossil fuel based generation applications.

There would be significant difference between in characteristic features of the rooftop PV and small solar systems vis-a-vis large solar power systems, although both would be grid connected. Some of the features that would result in distinct implications in terms of capital cost, operating cost parameters and performance parameters are as under:

- Design and operation philosophy of system
- Location and citing conditions (ground mounted/rooftop)
- Land requirement

- Mounting structures – fixed axis with tilt angle (without tracking systems)
- Grid connectivity (voltage level and evacuation arrangement)
- Metering arrangements (generation and consumption parameters)
- Power conditioning systems and its integration with standby/battery back-up systems etc.

It is preferred that standard sets of guidelines are evolved for such small solar systems which could facilitate the smother implementation of the national level programme such as Generation Based Incentive scheme announced as part of JNNSM.

In this context, it may be noted that, Para 6.4 (3) of National Tariff Policy's empowers the Central Electricity Regulatory Commission to determine the guidelines for pricing of non-firm power. Para 6.4 provides as under,

> *"(3)The Central Commission should lay down guidelines for pricing non-firm power, especially from non–conventional sources, to be followed in cases where such procurement is not through competitive bidding".*

Further, Section 61 (h) of the Act requires the Appropriate Commission to specify the terms and conditions for the determination of tariff and in terms of Section 61(a), the norms specified by Central Commission shall act as guiding principle while developing such norms. The relevant clause is reproduced below:

Section 61 (Tariff regulations):

The Appropriate Commission shall, subject to the provisions of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the following, namely:-

……

(h) the promotion of co-generation and generation of electricity from renewable sources of energy;

In view of above and in exercise of powers conferred under Sections 61 read with Section 178(2)(s) of the Electricity Act, 2003 (36 of 2003) and all other powers enabling it in this behalf, and in pursuance of Clause 6.4(3) of the National Tariff Policy notified by the Central Government, the Central Electricity Regulatory Commission shall notify following **Tariff Guidelines**, namely; "**Central Electricity**

Regulatory Commission (Determination of tariff for procurement of power from Rooftop PV and other Small Solar Power Projects) Guidelines, 2010".

1.3 Approach for development of Norms for Rooftop PV and Small Solar Systems

The project scheme and configuration of the Rooftop PV and Small solar systems essentially differ from the large grid connected systems in terms of grid connectivity features, mounting arrangements, power conditioning units, layout arrangement and associated civil/erection costs etc. There is hardly any difference between large solar systems or small solar systems in terms of Solar PV modules/arrays. However, due to consideration of space requirements and fixed axis (without tracking systems), the small solar systems predominantly uses crystalline PV modules. A comparison of key features of the large solar systems (> 1 MW) and small solar systems (< 1 MW) are presented below:

Sr. No.	Item Description	Large Solar PV Generators	Rooftop PV & Other Small Solar	
			< 100 kW	> 100 kW - 1 MW
A	**Project Scheme**			
A1	Project Developer/User	Generating Company	Domestic/ Commercial	industrial / tail end generation
A2	Grid connection (voltage level)	33 kV at Transmission N/W	LT - 1ph LT - 3ph at distribution n/w	11 / 22 / 33kV (HT) at distribution n/w
A3	typical system size	> 5000 kW	25 - 50 kW	100 - 500 kW
A4	Interface Utility	Transmission Utility	Distribution Utility	
B	**Configuration / Design features**			
B1	Land/Site location	Arid/barren/ proximity to Transmission Grid S/S	At premises of consumer or proximity to load centre or distribution s/s	
B2	PV Modules	Crystalline / Thin film	Crystalline / thin film (limited)	
B3	Mounting structures	Ground Mounted	Rooftop/Ground mounted	
B4	Tracking system	Single axis / double axis tracking features	Fixed Axis (typical)	
B5	Typical Evacuation arrangement	33 kV transformer/ cables /pooling s/s	11 kV transformer/ cables	

The capital cost norms, operating norms and performance norms for the large solar (> 1 MW) have been notified by the Commission upon extensive consultation process. Hence, it would be appropriate to undertake comparative analysis of following key parameters for its incremental/decremental impact on cost components and performance parameters vis-à-vis norms stipulated for large solar systems. The key parameters for comparative analysis include:

- Capital Cost components
    - Power conditioning units (Inverter/with or without battery back-up)
    - Mounting structure (fixed axis /without tracking systems)

  - Grid connectivity and evacuation arrangement

- Capacity Utilization Factor (fixed axis /without tracking systems)
- Operations & Maintenance Cost

Norms for small solar systems can be specified upon detailed comparative analysis vis-à-vis large solar systems upon adjusting for factors corresponding to economies of scale.

2 Benchmark Capital Cost for Small Solar Projects

2.1 Introduction

The capital cost of the Grid connected Rooftop PV and other Small Solar Power Projects can be broadly classified into two components, namely, (a) Solar PV Module component and (b) Non-Module component. The non-module component comprises following sub-components, viz. (i) Land (ii) Inverter (iii) Module Supporting structures & Works related to the installation of the structures (iv)Electrical Works including power evacuation facilities (v) Preliminary and pre-operative expenses including financing cost. Following paragraphs cover detailed analysis of various cost components and cost drivers for Grid connected Rooftop PV and other Small Solar Power Projects in Indian context.

The grid interactive roof top solar PV system generally comprises the following equipment.

a) Solar PV Power Source (PV Modules)

b) Inverter

c) Charge Controller (only with system with batteries)

d) Grid Charger(only with system with batteries)

e) Batteries(Optional)

f) Mounting Structure

g) Power and control Cables

h) Earthing equipment /material

i) Junction Boxes or combiners

j) Instruments and protection equipments

The functions of inverter, Charge controller and Grid charger can be built in one unit called power conditioning unit (PCU). Similarly inverter and charger can also be built in one unit. All control logics are built in inverter or PCU.

2.2 Development of Rooftop PV & other Small Solar Projects in India

Significant developer interest for grid connected Solar PV power development in India was generated pursuant to announcement of generation based incentive scheme by MNRE for pilot/demonstration power projects. The capital cost information for the relevant small size (< 1 MWp) proposed solar power installations from the detailed project reports (DPRs) or the petitions filed before regulatory commissions or from MNRE/Industry players have been summarized in the following Chart.

Table 2. 1: Details of Reference Installations (Small scale - < 1 MW)

#	Name of the company	Installed capacity	Estimated annual Generation	Eligible CFA	Fund released to company	Place	Land
1	Karnataka Power Corporation Limited, Bangalore	1 MWp	1.5 million units (est. CUF of 17.12%)	9.955 Crore	2.489 Crore	Raichur district Andhra Pradesh	15 Acres
2	M/s North Delhi Power Limited (NDPL), Delhi	54 kWp	87512 units (est. CUF of 18.49%)	0.50 Crore	0.3245 Crore	Pooth Khurd Gride, Bawana, in Delhi	850 sqm
3	M/s North Delhi Power Limited (NDPL), Delhi	43 kWp	69500 units (est. CUF of 18.45%)	0.398 Crore	0.0995 Crore	A-7 Grid, Narela Delhi	700 sqm
4	M/s North Delhi Power Limited (NDPL), Delhi	45 kWp	78,200 units (est. CUF of 19.83%)	0.385 Crore	0.09625 Crore	Clear Water Grid, Bawana, Delhi	682 sqm

Table below highlights the features of Rooftop Solar PV Project by PEDA for the city of Sas Nagar, Mohali. The capital cost for each grid connected 1kWp Rooftop Solar PV plant is estimated approximately at Rs. 2.5 Lakh/kWp (or Rs 25 Cr/MWp). This cost includes a battery bank adequately sized for 5 hours backup.

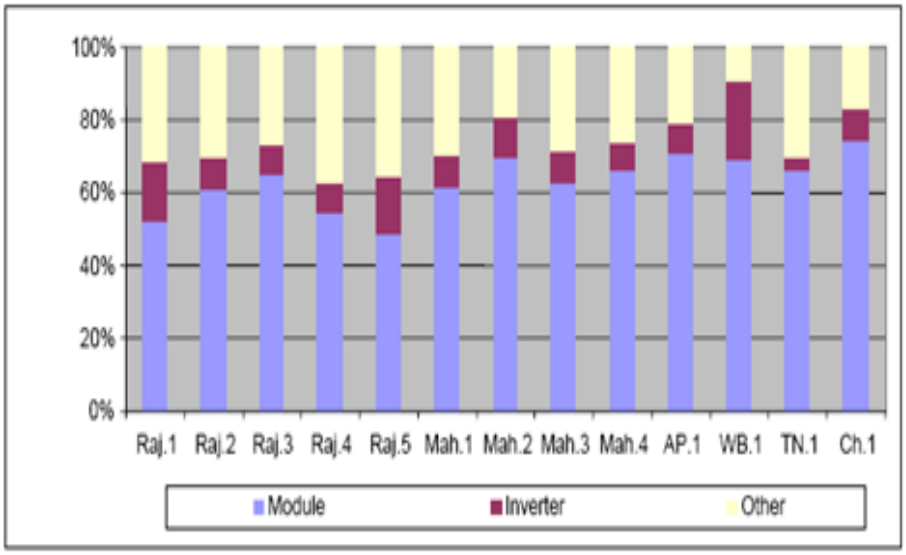
Table 2.2: Rooftop Solar PV Project for the City of Sas Nagar, Mohali, Punjab

Sr No.	PEDA Rooftop Solar PV Project (Mohali)	
	Description	Details
1	No. of rooftops under the project	5000
2	Each rooftop solar PV Capacity	1 kWp
3	Connected load for each house	5-8 kWp
4	Capital Cost for each System (With Battery Bank)	Rs. 2.5 Lakh
5	Solar PV Panels	1 kWp
6	Power Conditioning Unit	1.5 kVA
7	Battery Bank	5 Hours Backup
8	Bi-directional Energy Meter	0.5 Class
9	Grid Connection	LT - 415 V

Source: PEDA, Solar Energy Conclave

While detailed component-wise cost break up of various proposed installation is not readily available, an attempt has been made to compare the module and non-module cost of the small solar systems (< 1 MW) vis-à-vis large solar systems (> 1 MW). Chart below also shows the percentage composition of the costs of modules, inverter & balance of the system of the total capital cost **for large capacity size plants (> 1 MW).**

Chart 2.1: Costs of modules, inverters & other costs by PV project Developers



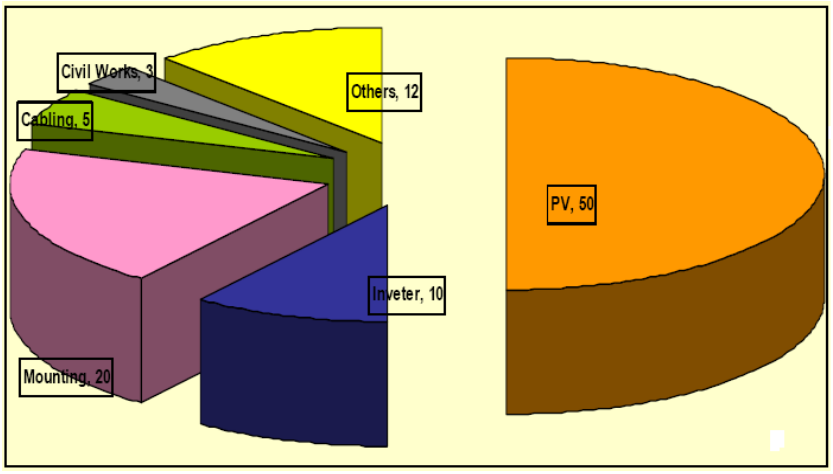
(Source: MNRE and ABPS Infra Research)

(Others include Expenditure towards Land, Civil and General Works, Structures, Cable and Transformers, Installation and Commissioning, Project Management, IDC and Financing Charges)

The information submitted by the various developers in their DPR/industry players suggests that solar PV module alone forms significant portion of the total capital cost and contribute to around 60% to 65% of the total capital cost. However, in fewer cases the cost towards solar module has found to be around 70% to 75% of the entire capital cost requirement for setting up solar PV power project.

However, the average percentage cost allocation for various heads in a Grid Interactive Rooftop Solar System, as suggested by CEA, points that the cost towards modules contribute to around 50% of the total capital cost for a grid interactive rooftop solar PV system. Clearly, for small solar systems, the non-module cost component, due to inherent disadvantage of lack of economies of scale, has greater influence on the total project cost of the small solar system.

Chart 2.2: Cost Allocation of PV System (%)



Source: CEA

Thus, PV module cost forms significant component of the overall capital cost of the Solar PV based power plant. Since the Capital Cost of the Solar PV based power projects shall be greatly influenced by the PV module prices and projections of demand/supply scenario of PV modules, a comparative analysis of various industry reports covering forecast of PV module demand-supply and prices thereof during 2010-11 carried out by CERC in its Explanatory Memorandum for Solar PV and Solar Thermal Capital Norms (2010-11) has been used for reference.

2.3 Solar PV Modules

The Explanatory Memorandum for Solar PV and Solar Thermal Capital Norms (2010-11), issued by CERC for large scale solar projects suggests that the PV industry analysts have divergent views of the near-term PV supply and demand scenario. However, analysts' project reductions in module prices starting in 2009 with continued growth in PV demand.

CERC has undertaken exhaustive analysis and observation of various analysts' reports , reference projects and giving due consideration to the evolving market scenario, it has suggested that the module price shall reduce significantly and hence the capital cost requirement of the Grid Interactive Rooftop PV and other Small Solar Power Projects.

CERC, in its Suo Motu Order on Solar Capital Cost Norms for large projects has provided for Rs. 10.19 Crore/MWp (Rs. 1.019 Lakh/kWp) towards Solar PV Module

Cost and the same is proposed to be considered for Grid Interactive Rooftop PV and other Small Solar Power Projects.

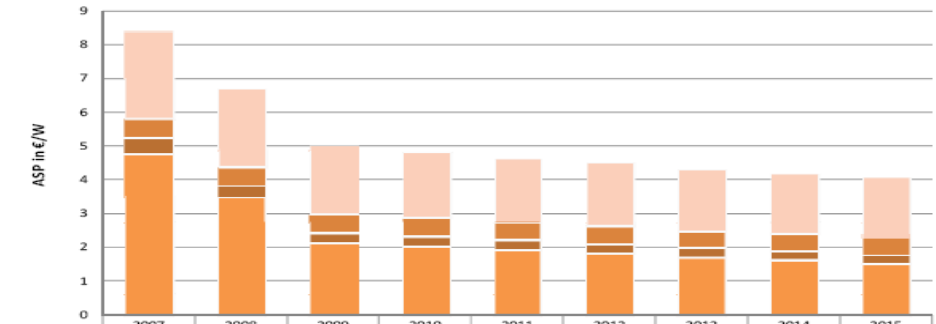
2.4 Non-Module Cost Component

The non-module cost component comprises cost towards (i) Land (ii) Inverter (iii) Module Supporting structures & Works related to the installation of the structures (iv) Electrical Works including power evacuation facilities (v)Preliminary and pre-operative expenses including financing cost. Based on the project cost information compiled from project developers, it is observed that non module component together contributes to approximately 35% - 40% of the overall capital cost requirement of solar PV based power plant. Some of the international study reports on cost of non-module/balance of system costs in case of rooftop and small solar installation also indicate that non-module cost or balance of system (BOS) costs have greater influence on overall system cost, particularly, in case of small solar system installations. Besides, such influence or percentage of BOS costs shall rise with rapid decline in the PV module costs whereas BOS costs are not declining at such rapid rate. Findings of some of the international studies for rooftop PV and small solar installations are presented below:

2.4.1 Yole Development

Yole Development has projected the breakup of the Average Selling Prices of the solar systems for residential installations as give in below chart:

Chart 2.3: ASP Breakdown Evolution in Residential Installations



	2007	2008	2009	2010	2011	2012	2013	2014	2015
Installation	2,62	2,27	2	1,895	1,88	1,85	1,81	1,77	1,76
Rest of BOS	0,52	0,53	0,54	0,55	0,54	0,54	0,52	0,52	0,51
Inverter	0,48	0,374	0,345	0,325	0,305	0,29	0,275	0,26	0,25
Module	4,8	3,5	2,1	2,01	1,9	1,805	1,7	1,62	1,55

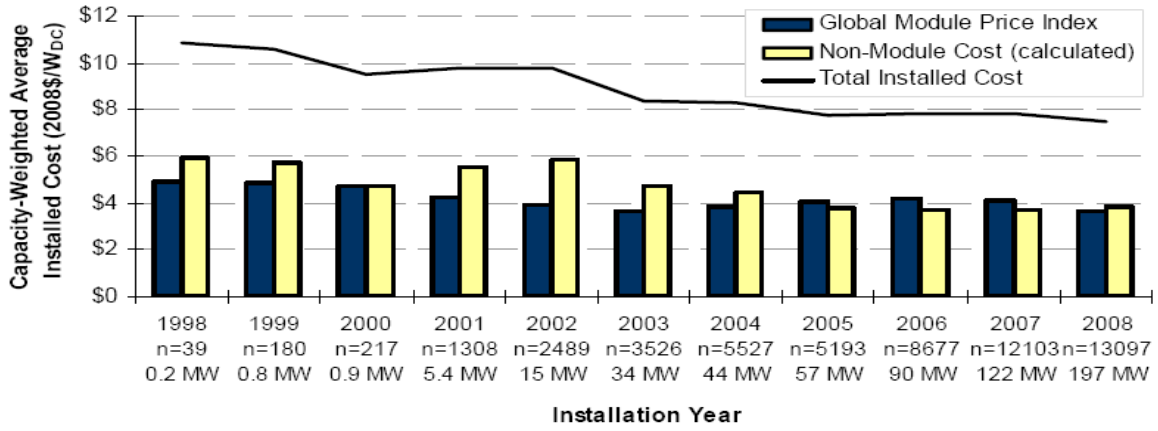
Source : Yole Development 2009

It suggests that the while cost of PV modules have been declining over the period, the cost of average prices towards Balance of System (BOS) and other cost of

installation for rooftop/small solar installations, has not followed such declining trend over the years and is expected to be same in the near future.

2.4.2 Lawrence Berkeley National Laboratory (LBNL)

Chart 2.4: Module & Non-Module Cost Trend over Time



Note: Non-module costs are calculated as the reported total installed costs minus the global module price index.

Source: Lawrence Berkeley National Laboratory, 2009

Lawrence Berkeley National Laboratory conducted a study on "The Installed Cost of Photovoltaic in the U.S from 1998-2008" and reported that, from 1998 to 2008, non-module costs fell by $2.1/W, from approximately $5.9/W in 1998 to $3.8/W in 2008. However, the major decline towards non-module component has been until 2005 and has been stable since then till 2008.

2.5 Land

The requirement of area for setting up solar power project largely depends upon the technology employed (i.e. crystalline technology or thin film) and the solar radiation incident in the respective area. According to a Report by CEA's Subgroup – I on Grid Interactive Rooftop Solar PV Systems, the roof top solar PV modules will cover a maximum area in the range of 8 sq. m – 18 sq m per kWp depending on the type of technology used and also depending upon the space available.

Report on "Solar PV Industry : Global and Indian Scenario" by India Semiconductor Association also suggests that approximately 10-20 Sq. m/kWp of land shall be required for setting up Grid Interactive Rooftop and other small solar power project in India.

CERC, in its Suo Motu Order on Solar Capital Cost Norms for large scale projects has provided for Rs. 0.15 Crores/MWp towards the Cost of Land based on requirement for solar PV project at 5 acre/MW and at estimated cost of Rs 3 lakh/acre.

The area acquired for setting up rooftop solar PV power projects is mostly unutilized roof area over buildings. However, opportunity cost of Rs. 0.015 Lakhs/kWp (Rs. 0.15 Crores/MWp) towards land may be considered for such projects.

2.6 Power Conditioning Unit or Inverter

In a grid interactive system AC power is fed to the grid at 11 KV three phase systems or to a 415V three phases or 220/240 V single phase system line depending on the system installed at institution/commercial establishment or residential complex or single house consumer and load requirement. Power generated from the solar system during the daytime is utilized fully by powering the captive loads and feeding excess power to the grid as long as grid is available. In cases, where solar power is not sufficient due to cloud cover etc. the captive loads are served by drawing power from the grid. The inverter should always give preference to the Solar Power and will use Grid/DG power only when the Solar Power is insufficient to meet the load requirement.

Inverter shall have the software and controls capable of operating the complete system for safe and efficient operation and includes the Islanding protection, Over voltage/ under voltage protection, Ground fault /short circuit protection system, communication equipment such as modems, web box etc, DC reverse polarity protection, Grid monitoring of all the phases & pole sensitive residual current monitoring unit, protection against voltage fluctuations in the grid & protection against internal faults in the power conditioner, operational errors and switching transients etc.

Based on the analysis, it was observed that the expense towards the inverter for the Grid Interactive rooftop & other solar PV plants comprises approximately 10% - 20% of the total capital cost requirement on an average basis. The submission made by various developers for large scale projects also suggests the same. The views of few industry players are summarized in the following paragraphs.

2.6.1 GTM Research

GTM Research conducted a study on the Solar PV inverter industry (September 2009) and pointed that Solar panel pricing has dropped 10 percent to 25 percent per

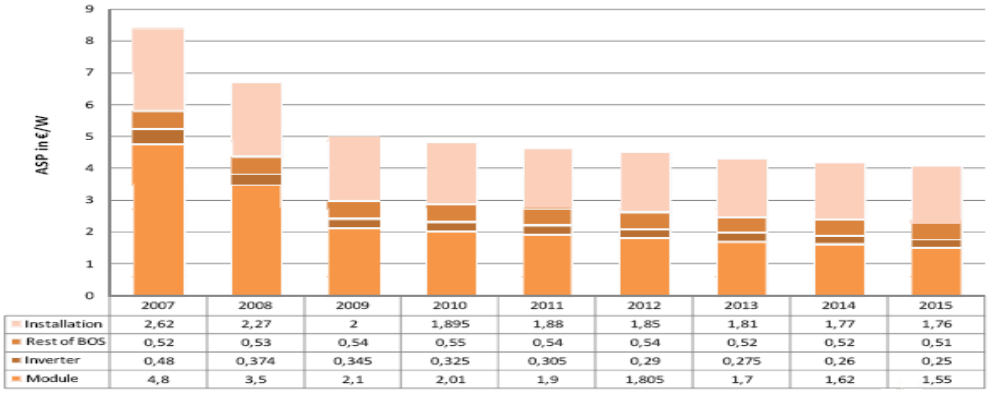
quarter over the last four quarters and that trend is expected to continue through the first half of 2010 with prices expected to stabilize by third quarter of 2010. Demand for panels has seen a rising trend up but there are still inventory issues.

It, also points that inverter pricing has remained relatively stable over the last few quarters. **Small-size inverter pricing (below 5 kW) has consistently been in the $0.80 to $1.00 per Watt range. Large-size inverter pricing is about half that price.**

2.6.2 Yole Development

Yole Development has projected the breakup of the Average Selling Prices of the solar systems for residential installations as give in below chart:

Chart 2.5: ASP Breakdown Evolution in Residential Installations



	2007	2008	2009	2010	2011	2012	2013	2014	2015
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Inverter	0,48	0,374	0,345	0,325	0,305	0,29	0,275	0,26	0,25
Module	4,8	3,5	2,1	2,01	1,9	1,805	1,7	1,62	1,55

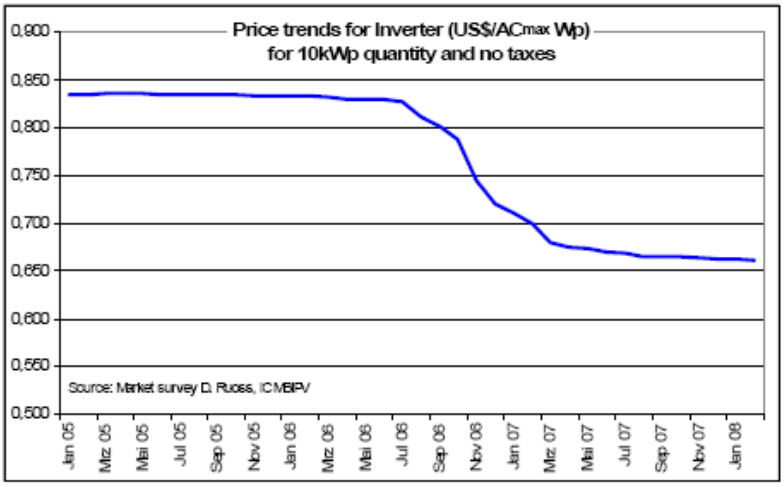
Source: Yole Development 2009

It suggests that the trend in average prices of inverters witness nominal decrease since 2007 and is projected to be around $ 0.43/ Wp (€ 0.325 /Wp) in 2010.

2.6.3 The Malaysia Building Integrated Photovoltaic (BIPV) Technology Application Project (MBIPV)

MBIPV report (May 2009) suggests that a central inverter costs slightly less than the same capacity of string inverters, but shows higher cost in the installation, due to the involved components like wiring and junction box. However string inverters need a better monitoring concept compared to a central inverter. Both concepts have their pros and cons, and need to be applied considering the site-conditions, e.g. shading or obstacles and the resulting total cost of the installation.

Chart 2.6: Price Trends for inverter (US $/Wp)



Source: MBIPV, 2008

The above chart suggests a declining trend in the inverter prices over the years. However, the prices underwent slight decrease during 2007-08

Table 2.3: Inverter Cost Overview

Inverter Concept	Cost (USD/WpAC)	Dimension	Weight	Efficiency	Installation
Central	0.5 to 0.85	A0 size	>200kg	93% to 96%	Junction box, more wiring, higher effort
String	0.6 to 0.90	A3 size	Between 5 to 20 kg	93% to 98%	Easy wiring & fast installation

Source: MBIPV, 2009

For smaller PV systems up to 100 kWp string inverters are preferable choices, and for PV system larger 100 kWp installers tend to apply central inverters. Thus the above reports the pricing of the small inverter in the range of $ 0.60/Wp - $ 0.90/Wp.

2.6.4 Signet Solar

Signet Solar (2009), a thin film silicon PV module manufacturer, has suggested the cost of inverters for its smaller area solar modules to be around $ 0.33/Wp.

2.6.5 CRN Network

CRN Network reported (12 August, 2009) that after recent acquisition of Phoenixtec Power Company, Eaton Corporation has plans to launch photovoltaic inverters in India. The solar-powered inverters will be primarily targeted at telecom and FMCG companies who have substantial presence in rural markets where availability of power is a big issue. It further stated that the range of inverters will be available at a starting price of Rs 45,000, excluding the solar panel for a 2kWp inverter.

2.6.6 Solarbuzz

Solar buzz in its "Inverter Price Highlights: April 2010" reported that April result broke five months trend, but only just. April is the first month where the number of price increases exceeded the number of decreases since October. It suggested that during April, there were 18 price increases closely outpacing 17 increases. The prior month there were 82 decreases and 12 increases. The number of price reductions left the US index unchanged at $0.716 per continuous watt.

Table 2.4.: All Inverter Price Index

All Inverter Price Index		
Month/ Year	**US $ per Continuous Watt**	**Euro € per Continuous Watt**
Apr2010	0.716	0.530
Mar 2010	0.716	0.523
Feb 2010	0.718	0.510
Jan 2010	0.718	0.503
Dec 2009	0.719	0.474
Nov2009	0.719	0.489
Oct 2009	0.719	0.489

Sep 2009	0.719	0.503
Aug 2009	0.720	0.504
Jul 2009	0.721	0.512
Jun 2009	0.721	0.519
May 2009	0.721	0.548
Apr 2009	0.720	0.547
Mar 2009	0.720	0.569
Feb 2009	0.720	0.562
Jan 2009	0.720	0.518
Dec 2008	0.719	0.561
Nov 2008	0.719	0.568

Source: Solarbuzz, 2010

The All Inverter Index includes the full basket of Inverters on the worldwide survey represented in US dollars and European, Euros. The Price Index is based on Prices per Continuous Watt - which is a measure of the output power of Inverters. Here the methodology involved is that all global inverter prices were aggregated in to a single Index. Those aggregated products were then simply translated from the local currency in to either US dollars or European Euros. This month, the dollar strengthened against the euro over the month. As a consequence, the euro index was up to €0.530 per continuous watt.

2.6.7 Renewable Energy World

Renewable Energy World (11 March, 2010), referring to a new report from French industry analysis firm Yole Development, reported that the current market leader, Germany-based SMA with a 34% share has seen its revenues grow. In its latest figures to 30 September 2009, SMA reported total sales increased to €560 million

($767 million) in the first nine months while sold inverter output rose from 0.2 GWp in the first quarter to 1.2 GWp in the third. The Company claimed that the specific price was reduced to € 0.25/Wp in the third quarter of 2009 and as a result of these improved figures; the group estimated that it has increased its market share to between 45% and 50% during the year.

2.6.8 Solarfeeds

Solarfeeds (17 December, 2009), in its article on "Solar Inverter Industry Review & Trend Watch" reported that in the third quarter of 2009, SMA increased its 2009 revenue guidance for the second time and revealed a record 1.2-gigawatt sales quarter at an improved margin even as the inverter price dropped to $ 0.365 per watt.

2.6.9 ABC Solar

ABC Solar, one of California's most experienced solar electric and hybrid solar pumping contractors, mentioned in its "A step by step Guide- Government, Not- for –Profit, Commercial & Residential Solar Energy Systems" presented during "South Bay Energy Fair 2006",cost towards in inverter for a 60 kWp Grid –Tie Commercial System as $ 38,940 ($ 0.649/Wp).

2.6.10 University of California Energy Institute

The Centre for the study of Energy Markets (CSEM), University of California Energy Institute (UCEI) conducted a study on "The Market Value & Cost of Solar Photovoltaic Electricity Production, January 2008" and reported the inverter cost for a 10 kWp system to be in the range of $ 8,000 in 2008. However it suggested a decline in inverter costs by 2% per year (approx. $ 0.77 in 2010) in real terms, consistent with a study by Navigant consulting (2006) for National Renewable Energy Laboratory.

2.6.11 University of Illinois at Urbana - Champaign

The College of Engineering, University of Illinois at Urbana- Champaign in its study on "Power Electronics needs & performance analysis for achieving grid parity Solar Energy Costs" also indicated the inverter price to be around $ 0.722/Wp plus installation during 2008-09.

2.6.12 BEW Engineering

BEW Engineering (February, 2006) prepared "Consumer Confidence Guidelines for the Comprehensive Small PV System Comparison" for California Energy Commission which reflected the culmination of over four years of program design, site and system selection, installation, and monitored operation for three residential style systems at the Davis, CA former PVUSA site. The report also indicated that the cost for the inverter shall be around $ 0.75/Wp.

2.6.13 Punjab Energy Development Agency (PEDA)

PEDA has submitted a proposal to establish 1 MWp solar PV power plant, to be developed as a tail end grid connected system under demonstration programme of the Ministry. As per the detailed project report, the project cost is estimated to be around Rs. 1800 Lakh whereas the cost of inverter is given as Rs. 170 Lakh ($ 0.38/Wp).

Table 2.5.: Summary of Inverter prices for Small Solar systems

Sr	Inverter Price Details	Price Considered ($/Wp)
1	**GTM Research (Sep 2009):**	
	Small inverters (<5kWp) : $ 0.8- $ 1.0 (per Wp)	
	Large Inverters: $ 0.4- $ 0.5 (per Wp)	**0.9**
2	**Yole Development (2009) :**	
	Inverters for Residential systems : € 0.325 (per Wp)	0.43
3	**MBIPV (May,2009) :**	
	Small inverters (upto 100 kWp) : $ 0.6 - $ 0.9(per Wp)	
	Large Inverters (>100 kWp) : $ 0.5- $ 0.85 (per Wp)	0.75
4	**Signet Solar (2009)**	
	Small Area Modules : $0.33 (per Wp)	0.33
5	**CRN Network (2009)**	
	2kWp Inverter: Rs. 45000	0.5
6	**Solar Buzz (April 2010)**	
	Inverter (including all categories): $ 0.716 (per Wp)	0.716
7	**Renewable Energy World (2010):**	
	SMA inverter(2009) : € 0.25 (per Wp)	0.33
8	**Solarfeeds (2010) :**	0.365

	SMA inverter(2009) : $ 0.365(per Wp)	
9	**PEDA (1 MWp plant):**	
	Inverter : Rs. 170 Lakh	0.37
10	**ABC Solar (2006):**	
	Inverter for 60 kWp Grid Tie Commercial System : $38,940	0.65
11	**University of California Energy Institute (2008):**	
	Inverter for 10 kWp system : $ 8,000 (2% decline per year)	0.77
12	**University of Illinois at Urbana- Champaign(2008-09):**	
	Inverter Price : $0.722(per Wp) plus installation	0.722
13	**BEW Engineering (2006)**	
	BIPV Inverter Price : $ 0.75 (per Wp)	0.75
14	**Average Inverter Price**	**0.58**

Accordingly, on the basis of inputs it is proposed that expenditure towards Power Conditioning Unit or Inverter may be considered as Rs. 0.262 Lakh/kWp ($ 0.58/Wp).

2.7 Module Supporting Structure

The PV module support structures have significant role in power generation. In order to get the maximum power, PV modules need maximum exposure to direct sunlight for the longest time. Any shading shall reduce module output considerably. The material used to prepare the structure can be aluminium, angle iron, stainless steel etc. Further, it has been observed that MS Structure contributes to around 6-10% of the total capital cost requirement on average.

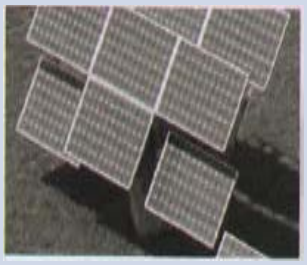
The mounting structure requirement is mainly influenced by the selection of technology viz. crystalline silicon or thin film and deployment of tracking system (fixed axis or with tracking). The solar to electricity conversion efficiency of crystalline silicon technology is more compared to the thin film technology which translates to employing less number of modules compared with the latter to generate

same units of electricity. The per Watt cost of thin film modules are less compared to the crystalline silicon module. Hence, employing thin film technology will require less cost towards modules however in order to achieve the specified CUF, due to lower solar to electricity conversion efficiency, large number of modules shall need to be employed which will increase cost towards the mounting structure.

CERC, in its Suo Motu Order on Solar Capital Cost Norms for large projects has provided for Rs. 1 Crore/MWp towards the cost for module mounting structures. The specified cost is inclusive of the tracking system. However, most of the small scale projects considered have proposed the usage of mounting structures without tracking arrangement.

Industry Sources suggest a cost difference of 10%-20% between fixed installations and installations with tracking arrangements.

Table 2.6: Fixed v/s Tracking

Installation	Fixed	Single-Axis	Double-Axis
Demo			
Cost	100%	10%-15% higher than fixed installation	15%-20% higher than fixed installation

Source: Rimlife Green Technologies

Lawrence Berkeley National Laboratory conducted a study on "The Installed Cost of Photovoltaic in the U.S from 1998-2008" and reported that in the solar capacity range of 10kWp-100kWp, tracking systems had average installed costs 6% higher than their fixed axis counterparts

Whereas, a Cost & Environmental Impact Comparison of Grid-Connected Rooftop & Ground-based PV system presented at the 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, 4-8 September 2006 reported that although large

ground-based systems use larger weights of mounting structures than small roof-top systems and occupy land, they have considerably lower prices than small-scale roof-top systems **due to efficient installation and bulk purchasing.** This effect will be in future lower as it scales mainly with the (falling) module prices.

Table 2.7.: Summary of Mounting structure costs for Small Solar systems

Sr	Mounting Structure Price Details	Price Considered ($/Wp)
1	**21st European Photovoltaic Solar Energy Conference, Dresden, Germany, 4-8 September 2006**	
	Small on – roof solar systems in Europe : $ 0.52 (per Wp)	0.52
2	**ABC Solar (2006):**	
	For 60 kWp Grid Tie Commercial System : $29,086	0.485
3	**PEDA (1 MWp plant):**	
	Mounting Structure : Rs. 195 Lakh	0.43
4	**BEW Engineering (2006)**	
	BIPV Mounting Structure Cost : $ 0.5 (per Wp)	0.5
5	**Average Mounting Structure Price**	**0.485**

Accordingly, on the basis of inputs it is proposed that expenditure towards Mounting Structures without tracking arrangement may be considered as Rs. 0.218 Lakh/kWp ($ 0.485/Wp).

2.8 Cabling

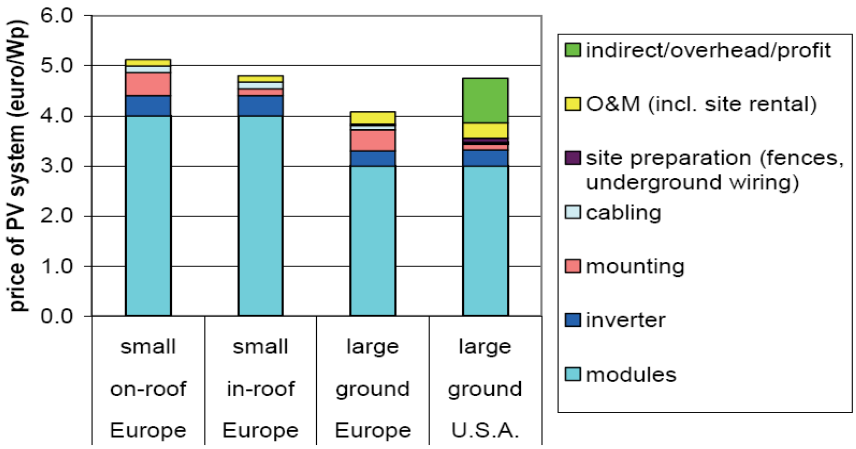
It has been observed from analyzing the inputs forwarded, that the expense towards DC Cabling including labor as well as additional installation material such as cable connectors etc. comprises approximately 4-6% of the total capital cost requirement on an average basis.

2.8.1 Signet Solar

Signet Solar (2009), a thin film silicon PV module manufacturer, has suggested the cost towards DC Cabling for its smaller area solar modules & larger area modules to be around $ 0.14/Wp & $ 0.11/Wp respectively.

2.8.2 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, 4-8 September 2006

Chart 2.7: System Price Overview



Source: 21st European Photovoltaic Solar Energy Conference, Dresden, Germany

A Cost & Environmental Impact Comparison of Grid-Connected Rooftop & Ground-based PV system presented at the 21st European Photovoltaic Solar Energy Conference, Dresden, Germany, 4-8 September 2006 suggested that the cost towards cabling for small on – roof solar systems in Europe were around € 0.1/Wp ($ 0.13 /Wp).

2.8.3 BEW Engineering

BEW Engineering (February, 2006) also included in its "Consumer Confidence Guidelines for the Comprehensive Small PV System Comparison" for California Energy Commission, (which reflected the culmination of over four years of program design, site and system selection, installation, and monitored operation for three residential style systems at the Davis, CA former PVUSA site), the costs towards cabling works to be around $ 0.20/Wp.

Accordingly, on the basis of inputs it is proposed that expenditure to approximately Rs 0.071 Lakh/kWp ($ 0.16/Wp) may be considered as the cost towards cabling for projects getting commissioned in FY 2010-11.

2.9 Civil Works, General Works

It has been observed from analyzing the inputs forwarded by the industry sources, that the expense towards civil works & general works, related to the installation of the structures such as testing of the site area, leveling works (if required, especially in case of other small solar PV systems) for setting up structures, fencing requirements (if required, especially in case of other small solar PV systems), development of foundation for solar arrays, laying cables etc. along with general works include security of the plant, installing lighting arrestor and earthing kit, street lighting etc. comprises approximately 2-3% of the total capital cost

requirement on an average basis which is equivalent to approximately Rs 0.054 Lakh/kWp may be considered for projects getting commissioned in FY 2010-11.

2.10 Preliminary/Pre-operating Expenses and Financing Cost

Preliminary and pre-operative expenses contribute to approximately 7-9% to the total capital cost on an average basis. The preliminary and pre-operative expenses essentially include services related to installation related to installation and commissioning, project management, expenditure incurred in transportation of equipments, insurance, contingency, taxes and duties, IDC and finance charges etc. For the solar PV projects to be commissioned during FY 2010-11 Rs 1.00 Cr/MWp (Rs. 0.10 Lakh/kWp, $ 0.22/Wp) as Preliminary and Pre-operative expenses and financing cost may be considered.

Keeping the above facts into consideration, the expenditure towards Non-Module component together forms around Rs 7.21 Cr/MWp (Rs. 0.721 Lakh/kWp) for Grid connected Small Solar projects.

The table below presents the break of the capital cost for such small solar projects.

Table 2.8: Summary of Capital Cost

S.No	Particulars	Capital Cost (Rs. Cr./MWp)
1	PV Modules	10.19
2	Inverter	2.62
3	Module Mounting Structures (Without Tracking Arrangement)	2.18
4	Cables & Transformers	0.71
5	Civil & General Works	0.54
6	Preliminary & Pre-Operative Expenses	1.00
7	Land	0.15
8	**Total**	**17.40**

2.11 Capital Cost Summary

A comparison of Capital Cost summary for Large Solar (> 1 MW) and Small solar System (< 1 MW) is presented below:

Table 2.9: Comparison on Capital Cost (large and small solar systems)

Item Description	Large scale Grid Connected(Rs.Cr/MW)	%	Rooftop PV and Small Solar (Rs.Cr/MW)	%
Land	0.15	1%	0.15	0.9%
Civil & General Works	0.9	5%	0.54	3%
PV Modules	10.19	60%	10.19	59%
Module mounting structures	1.00	6%	2.18	13%
Power Conditioning Unit (Including Inverter)	2.00	12%	2.62	15%
Cables and Transformers (Including Power Evacuation)	0.85	5%	0.71	4%
Preliminary & Pre-operative expenses	1.81	11%	1.00	6%
Total Capital Cost	**16.90**	**100%**	**17.40**	**100%**

Based on detailed analysis of module costs and non-module cost components as well as comparison of cost for several projects, it is proposed that the Benchmark Capital Cost Norm for Rooftop Solar & Other small PV power projects to be commissioned during FY 2010-11 may be considered as Rs 1740 Lakh per MWp (1.74 Lakh/kWp).

3 CAPACITY UTILIZATION FACTOR (CUF)

CERC, in its Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2009 has provided CUF of 19% for large scale Grid Connected Solar PV projects. The large solar systems tend to use tracking systems (single axis or double axis) which increases the potential of solar generation at a given site, albeit, with cost implications. However, most of the small scale projects considered have proposed the usage of mounting structures without tracking arrangement. Hence, the CUF shall decrease in absence of tracking. Some of the international studies have highlighted the influence of the tracking system (single axis or double axis) on the overall plant performance as reflected in energy generation or capacity utilization factor as presented below:

3.1 Variation in performance (with or without tracking)

3.1.1 Rimlife Green Technologies

Rimlife Green Technologies, a company promoting green products in USA and China suggested an increase of 20%-40% in CUF after deployment of tracking arrangement.

Table 3.1: Fixed v/s Tracking

Installation	Fixed	Single-Axis	Double-Axis
Demo			
Electricity Production	100%	Increases 20%-30% relative to fixed installation	Increases 30%-40% relative to fixed installation

Source: Rimlife Green Technologies

The following chart shows comparison for double axis tracker and fixed angle installation

Chart 3.1: Fixed v/s Tracking

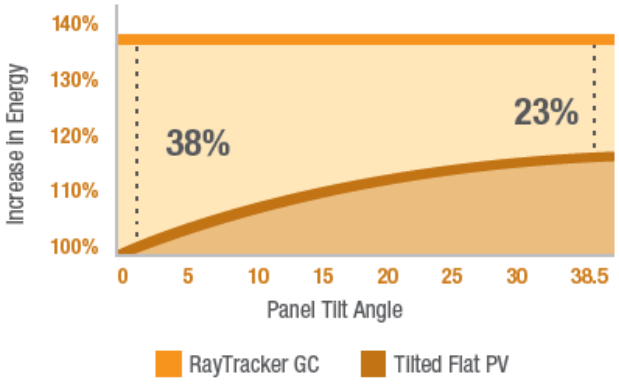
Source: Rimlife Green Technologies

3.1.2 Raytracker

Raytracker, a leading single axis tracking system provider, suggested that fixed photovoltaic systems usually have modules tilted toward the arc the sun makes in order to increase the kWh energy production. There is an optimal tilt angle for each location to maximize the annual energy production. While fixed tilt increases energy production, there is more energy available to capture if the modules track the sun throughout the day. Single-axis trackers, provide a significant energy increase while being low cost and simple.

The following chart shows that for Sacramento, CA modeled with PV Watts, a single axis tracker gives a 38% increase in energy production over non-tilted PV panels, and a 23% increase over flat panels tilted at latitude.

Chart 3.2: Energy Production: Fixed v/s Tracking



Source: Raytracker

3.1.3 Solar Electric Solutions

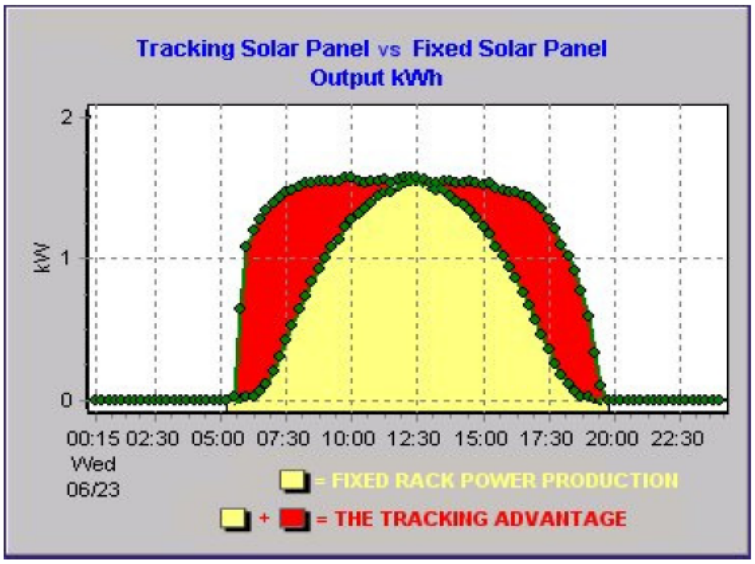
Solar Electric Solutions, a developer of Solar PV projects, also suggested that a single-axis sun tracking PV system shall generate up to 30% more electricity than fixed, rooftop –mounted PV system.

3.1.4 Watsun Solar Trackers

Watsun Solar Trackers also reports that the tracked array increases the delivered power by 40%.

The graph below is a combination of the power curves for two identical arrays. One array is fixed and the other is on a Dual-Axis Tracker. The power curves are typical of a clear, cloudless summer day. The yellow area under the smaller bell curve represents the delivered energy by the fixed rack. The area under the larger curve (red plus the area in yellow) is the power delivered by the tracked array. The tracked array increases the delivered power by 40%. The fixed array would have to be 40% larger to match the output of the tracker.

Chart 3.3: Energy Production: Fixed v/s Tracking

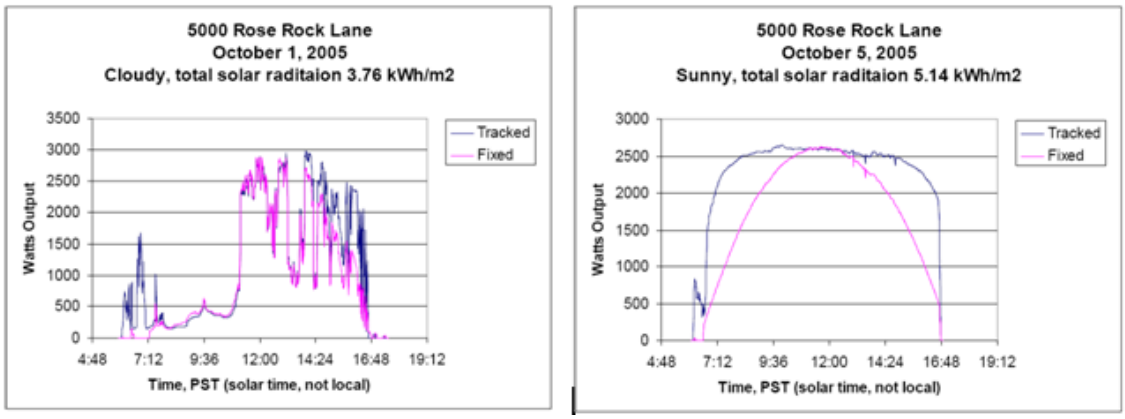


Data collected for June 23, 2004. Springfield, MO. Merge of two graphs.

Source: Watsun Solar Trackers

Chart below shows a comparison between tracked & fixed mounts for two different days of a week. On October 1, there was significant cloud cover and total radiation totaled 3.76 kWh/m$^{2.}$ In contrast, October 5 was sunny with 5.14 kWh/m^{2}.

Chart 3.4: Comparative: Fixed v/s Tracking



Source: Watsun Solar Trackers

On October 1, the benefit of tracking was measured to be around 18% whereas a 30% benefit was measured on October 5. Over the entire weekend, the benefit from tracking was around 27%.

3.1.5 National Renewable Energy Laboratory (NREL)

An analysis for few major Indian cities was carried out for a 120 kWp Solar PV Plant using PVWatts ,an internet accessible tool developed by the National Renewable Energy Laboratory that calculates electrical energy produced by a grid-connected photovoltaic (PV) system.

Table 3.2: Fixed v/s Tracking

kWh for 120 kW Solar PV system			
Tracking	**Fixed**	**1-Axis**	**2-Axis**
Ahmedabad	175138	209948	218177
% Increase	-	20%	4%
Chennai	162313	191298	196985
% Increase	-	18%	3%
Goa	174592	208398	216090
% Increase	-	19%	4%

kWh for 120 kW Solar PV system			
Tracking	**Fixed**	**1-Axis**	**2-Axis**
Kolkatta	144887	163470	167929
% Increase	-	13%	3%
Mumbai	155945	178608	183998
% Increase	-	15%	3%
Nagpur	162316	189832	196247
% Increase	-	17%	3%
New Delhi	177458	213221	221668
% Increase	-	20%	4%

Source: PV Watts, NREL

The above study suggested that the single axis tracking has an advantage of 13%-20% over fixed systems whereas the double axis tracking has an advantage of 3%-4% over single axis tracking. Further roof mounted arrays operate at a higher temperature and can suffer up to a 5% loss of power in the summer. The rooftop of an existing building might not have optimum orientation. The topography, trees and views might also override the ability to provide practical electric generation.

In view of above, it is proposed that lower CUF of 18% be considered for Grid connected Rooftop PV and other Small Solar Power Plants as against 19% considered for large grid connected solar systems.

4 OPERATION AND MAINTENANCE EXPENSE

As per CERC RE Tariff Regulations 2009, Operation and maintenance expense including insurance for large solar systems have been specified as Rs 9 Lakh/MW for FY 2009-10 which amounts to approx. 0.52% of the capital cost. In case of small solar systems due to lack of economies of scale, O&M expense as % of capital cost would be higher. Accordingly, it is proposed to consider O&M expense for small solar system at Rs 11 Lakh/MW equivalent to 0.63% of normative Capital cost for small solar systems.

5 COST OF GENERATION AND APPLICABLE TARIFF

5.1 Cost of Generation for Small Solar Systems

Apart from normative assumptions for capital cost, capacity utilization factor and operation & maintenance expense as elaborated in earlier paragraphs, all other assumptions and norms for parameters for small solar systems (< 1 MW) have been proposed to be similar as that applicable for large solar systems (> 1 MW).

Summary of various parameter assumptions for the purpose of determination of year-to-year cost of generation and levellised tariff thereof, is presented under following table:

Table 5.1: Summary of Parameter assumptions

Parameters	Unit	Value	Remarks
Plant Capacity	MW	1	
Capital Cost	Rs Lakh/ MW	1740	
Useful life	years	25	
Tariff Period	years	25	
Debt : Equity	D:E	70 : 30	
Debt component	Rs Lakh/MW	1218	
Equity component	Rs Lakh/MW	522	

Parameters	Unit	Value	Remarks
Interest Rate	% p.a.	13.37%	SBAR (11.87%) + 150 basis points, (based on wt. avg. SBAR of 12.25% and 11.75% for the applicable period)
Loan tenure	years	10	
Depreciation	% p.a.	7% for first 10 years and 1.33% for remaining period of useful life	
Return on equity	% p.a.	19% for initial 10 years and 24% for subsequent period	Pre-tax return on equity
Discount rate	%	15.96%	Equivalent to WACC
Interest on working capital	% p.a.	12.87%	SBAR (11.87%) + 100 basis points, (based on wt. avg. SBAR of 12.25% and 11.75% for the applicable period)
Working Capital requirement		1 mth O&M expense 15% of O&M expense as maintenance spares and receivables of 2 months	
Capacity Utilisation Factor	% p.a.	18%	
Operation and Maintenance expense	Rs L/MW	11	For FY 2010-11

Parameters	Unit	Value	Remarks
Escalation factor for O&M expense	% p.a.	5.72%	

The Levellised Cost of Generation for rooftop PV and other small solar power projects, in accordance with the assumptions outlined above work out to **Rs 19.57 /kWh.**

5.2 Applicable Tariff (Proposed):

Accordingly, it is proposed that Tariff for Small Solar Systems (< 1 MW) may be determined as **Rs 19.57/kWh** to be valid for period of 25 years from the date of commissioning provided that such small solar projects (<1 MW) are commissioned on or prior to March 31, 2012 in case of small solar PV and on or prior to March 31, 2013 in case of small solar thermal power projects.

Other technical features, grid connectivity conditions, metering arrangements and power quality requirements for Small Solar Systems have been enclosed as Annexure-1.

6 ANNEXURE-1: TECHNICAL REQUIREMENTS FOR SMALL SOLAR SYSTMS

6.1 Technical Specifications for PV Modules and Inverter Systems

(1) The Rooftop PV and Other Small Solar Power Projects deploying PV modules and Inverter systems complying with relevant IEC/BIS standards and/or compliant with applicable standards as specified by Central Electricity Authority shall alone be considered to be technically qualified.

(2) The quality of equipment to be deployed should meet the guidelines for engineering design included in the standards and codes listed in the relevant ISI and other standards, such as :

i. IEEE 928: Recommended Criteria for Terrestrial PV power systems.

ii. IEEE 929 Recommended practice for utility interface of residential and intermediate PV systems.

iii. IEEE 519 Guide for harmonic control and reactive compensation of Static Power Controllers.

iv. National Electrical NFPA 70-1990 (USA) or equipment national standard.

v. National Electrical Safety Code ANSI C2 (USA) or equipment national standard.

vi. IEC : 61215 (2005)- Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval

vii. IEC: 61730 -1, -2 Photovoltaic (PV) module safety qualification Part 2: Requirements for testing

viii. IEC: 60904-1(2006) Photovoltaic Devices- Part-I: Measurement of Photovoltaic current-Voltage Characteristic

ix. IS 9000 Basic environmental testing procedure for Electronic and electrical items.

6.2 Eligible Project Capacity

Rooftop PV and other Small Solar Power Projects, with a capacity limit up to and including 1MW, subject to fulfilment of other technical requirements, shall alone be considered to be technically qualified.

6.3 Grid Connectivity

(1) Subject to fulfilment of other technical requirements, Rooftop PV and Other Small Solar Power Projects connected to the distribution network at voltage levels below 33kV shall alone be eligible for generic tariff determined for such projects under these Guidelines.

(2) In general the requirements specified by CEA in the CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007 would be observed.

6.4 Metering Arrangement

(1) The metering arrangements for all grid-connected Rooftop PV and Other Small Solar Power Plants shall essentially be in accordance with the metering scheme finalized by the appropriate State Electricity Regulatory Commission.

(2) Metering requirements shall be as per Regulations on "Installation and Operation of Meters".

(3) The Metering is required to measure the solar gross generation, consumer load consumption, export of energy to the grid and import of energy from the grid besides measurement of AC system voltages and currents, frequency etc.

(4) Necessary changes in the proposed metering scheme to accommodate for required DG sets and/or battery inverter etc., as per need of solar developer may be adopted without affecting the security and sealing of complete metering system besides all cabling and switchgear from solar panel to the solar meter(SM).

(5) The Grid Meter (GM) and Solar Meter (SM) shall be interface type as envisaged in the metering regulations. These meters may also comply with the Time of Day (ToD) requirements so as to accommodate this type of metering in future course of time. Also the SM would record net solar energy export reading indicated as SE(N).

6.5 Communication interface and Data Acquisition system

(1) The communication must be able to support Real time data logging, Event logging, Supervisory control, Operational modes and Set point editing. The parameters to be measured and displayed continuously include Solar system temperature, Ambient temperature, Solar irradiation/isolation, DC current and Voltages, AC injection into the grid (one time measurement at the time of installation), Efficiency of the inverter, Solar system efficiency, Display of I-V curve of the solar system, any other parameter considered necessary by supplier of the solar PV system based on prudent practice. Data logger system must record these parameters for study of effect of various environmental & grid parameters on energy generated by the solar system and various analyses would be required to be provided through bar charts, curves, tables, which shall be finalized during approval of drawings.

(2) The communication interface shall be an integral part of inverter and shall be suitable to be connected to local computer and also remotely via the Web using *either* a standard modem or a GSM / WiFi modem. The project developer must install all the required hardware to have this web based Supervisory Control and Data Acquisition (SCADA) operational such that the system can be monitored via the web from distribution company office. Also, full fledged SCADA is required to be installed by the developer.

6.6 Power Quality Requirements

(1) **DC Injection into the grid**: The injection of DC power into the grid shall be avoided by using an isolation transformer at the output of the inverter. It is proposed to limit DC injection within 1% of the rated current of the inverter as per IEC 61727.

(2) **Harmonics on AC side**: The limits for Harmonics on AC side would be as stipulated under CEA Grid Connectivity Regulations, as under:

a) Total Voltage Harmonic Distortion…….. 5%

b) Individual Voltage Harmonics Distortion……3%

c) Total Current Harmonic Distortion……..……..8%

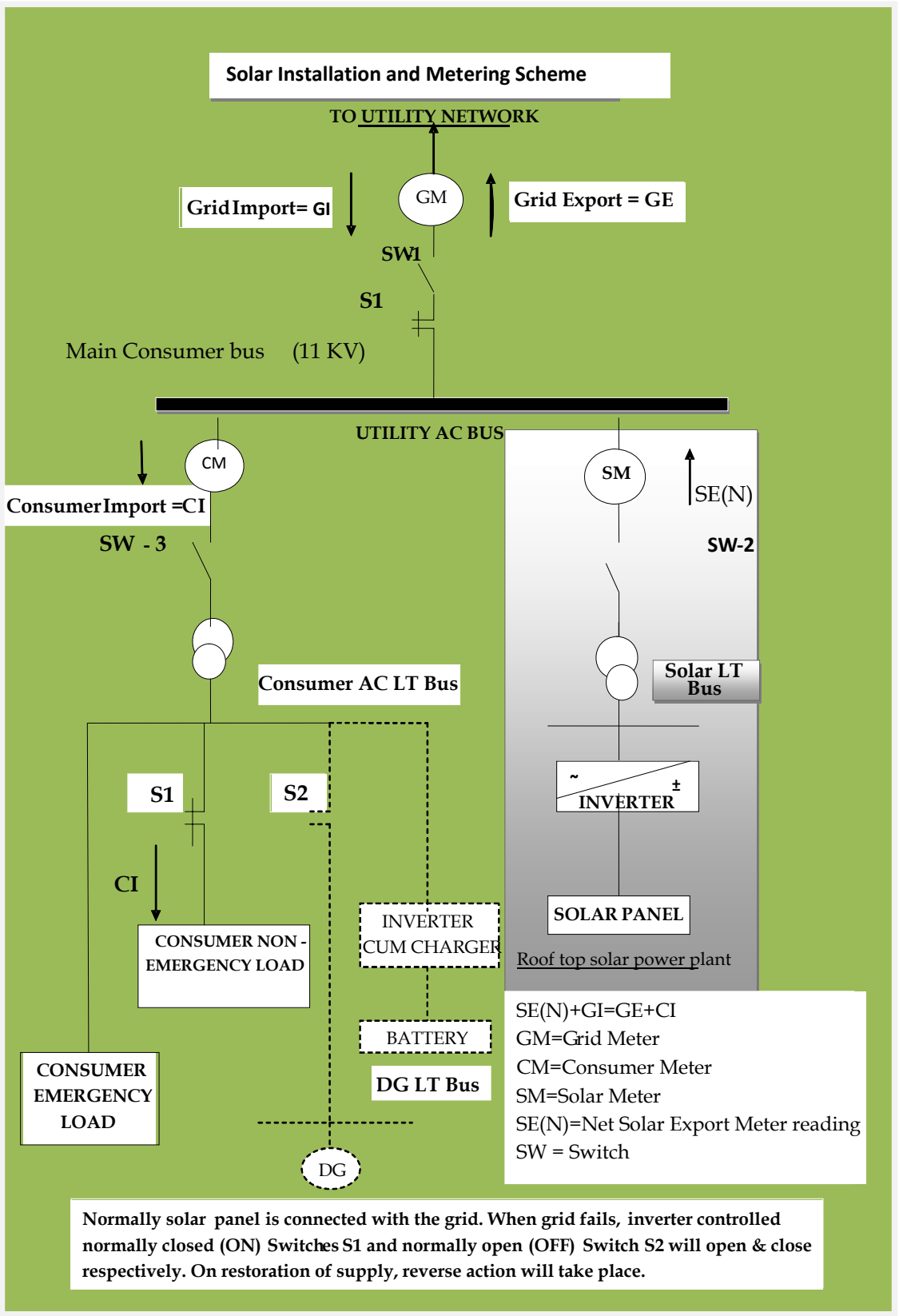
(3) **Voltage variation**: The voltage unbalance at HV side shall not exceed 3.0%. The permissible limit of voltage fluctuation for step changes which may occur repetitively is 1.5%.For occasional fluctuations other than step changes the maximum permissible limits is 3%.

(4) In addition to disconnection from the grid on no supply, under and over voltage conditions, PV systems shall be provided with adequate rating fuses, fuses on inverter input side (DC) as well as output side (AC) for overload and short circuit protection and disconnecting switches to isolate the DC and AC system for maintenance.

(5) Fuses of adequate rating shall also be provided in each solar array module to protect them against short circuit.

(6) Manual Disconnection Switch: In order to avoid possibility of malfunctioning with the automatic disconnection system of the inverter, manual disconnection switch besides automatic disconnection to grid would also be provided to isolate the grid connection by Distribution Licensee's personnel and to carry out any maintenance. This switch shall be locked by the Distribution Licensee's personnel during the planned shutdown of the Distribution Licensee's feeder. Locking of the switch may be required only under shutdown.

6.7 Schedule: Proposed Metering Scheme



Whereas the GM, SM and CM shall have the meanings assigned hereunder:-

1.1.1 **'Grid Meter or GM'** means import and export meter on the basis of which energy bills shall be raised by Distribution utility;

1.1.2 **'Solar Meter or SM'** means a meter for used for accounting and billing of electricity generated by the Rooftop PV and Other Small Solar Power Generating Plant;

1.1.3 **'Consumer Meter or CM'** means a meter used for accounting and billing of electricity supplied to the consumer but excluding those consumers covered under Interface Meters;