Explanatory Memorandum

For

Benchmark Capital Cost Norms for

Solar PV Power Projects

and

Solar Thermal Power Projects

To be applicable

For the year 2011-12

September 2010

CENTRAL ELECTRICITY REGULATORY COMMISSION
NEW DELHI

1. Premise for development of Benchmark Norms

Background

1.1 In exercise of the powers vested under Section 61 read with Section 178 of the Act and after previous publication, the Commission notified the Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2009, (hereinafter referred to as "the RE Tariff Regulations"). The RE Regulations provide for terms and conditions and the procedure for determination of tariff of the following categories of renewable energy generating stations:

(a) Wind Power Project;

(b) Small Hydro Projects;

(c) Biomass Power Projects;

(d) Non-fossil fuel-based co-generation Plants;

(e) Solar Photo voltaic (PV) and Solar Thermal Power Projects.

1.2 Further, the Commission has notified the first amendment to the RE Tariff Regulations 2009 vide notification dated 25.02.2010. The relevant extract of notified First Amendment of RE Tariff Regulations is as under:

> *"(2) Notwithstanding anything contained in these regulations, a) the generic tariff determined for Solar PV projects based on the capital cost and other norms applicable for the year 2010-11 shall also apply for such projects during the year 2011-12; and b) the generic tariff determined for Solar thermal projects based on the capital cost and other norms for the year 2010-11 shall also apply for such projects during the years 2011-12 and 2012-13,*
>
> *provided that (i) the Power Purchase Agreements (PPA) in respect of the Solar PV projects and Solar thermal projects as mentioned in this clause are signed on or before 31st March, 2011; and (ii) the entire capacity covered by the PPA is commissioned on or before 31st March, 2012 in respect of Solar PV projects and on or before 31st March, 2013 in respect of Solar thermal projects."*

1.3 As per first proviso under Regulation 5 of the RE Tariff Regulations, 2009, the benchmark capital cost for Solar PV and Solar thermal power projects is to be reviewed annually. The Commission, for FY 2009-10, specified the normative capital cost for Solar PV and Solar Thermal Power Projects as Rs1700Lakh/MW and Rs1300Lakh/MW respectively.

1.4 Subsequently, as per Regulation 5, Commission had reviewed, vide the Order dated 25.02.2010 in Petition no. 13/2010, benchmark capital cost for Solar PV power projects at Rs.1690 Lakh/MW for the FY 10-11.

1.5 It has been observed that after the benchmark capital cost norms were reviewed vide order dated 25.02.2010 in Petition no. 13/2010, there has been significant change in the global market conditions for solar industry which is still evolving and certain development at national level such as announcement of Jawaharlal Nehru National Solar Mission (JNNSM) has taken place, many State Electricity Regulatory Commissions (SERCs) have determined generic tariff for Solar PV and Solar Thermal power project PPA have been signed by the project developers in various States.

2 Benchmark Capital Cost Norm for Solar PV Power Projects for the FY 2011-12

2.1 In Solar PV power project, the two major sub-systems are Solar PV modules and balance of Systems (BoS). Solar PV modules constitute 65-70 % of the cost while BoS comprises the rest. The Solar PV modules are predominantly crystalline Silicon based. Within the modules the intermediate products at different stages of the manufacturing process are Poly-silicon, Silicon Wafer, Solar Cell, and Solar PV Module. There is presently negligible domestic manufacturing capacity for Poly-silicon and Silicon Wafer in our country. The manufacturing capacity including projects under execution for Solar Cells and Modules are about 600 MW and 1000 MW respectively. The PV modules manufactured in the country meet the international standards.

Factors affecting SPV Cells and Module price

2.2 SPV cells are priced based on the number of watts of electricity they can generate and on their Conversion Efficiency. Pricing per Watt of SPV cells is principally affected by following factors:

i. Manufacturing costs Per Watt which depends on the efficiency and yield levels of technology and the cost of Silicon Wafer;

ii. Overall market demand for SPV cells;

iii. Prevailing market prices when SPV manufacturer enter into sales contracts with customers;

iv. Size of the contract or the purchase order;

v. Strength, history and prospects of manufacturer's relationship with the customer; and

vi. Some other factors, such as the currency exchange and interest rates.

Decline in the price of SPV Sells

2.3 Increased economies of scale and process technology advancements in the past resulted in a steady reduction in manufacturing costs and the price Per Watt of SPV cells. Since fourth quarter of 2008, expected growth rate in demand slowed down due to the global economic

downturn. However, manufacturing capacity grew at the expected rate. This decline in growth in demand continued in the 2009 and is project by industry experts to continue for one or two years. The impact of this gap between demand and supply is seen in the declining trend in the prices of PV Cells.

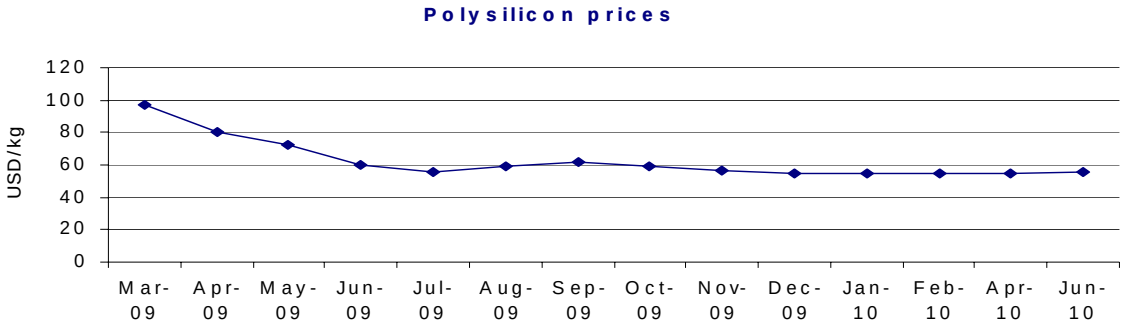
2.4 The impact of excess production capacity and the global economic downturn was also observed in the FY 09-10. According to the draft Red Herring Prospectus submitted recently to SEBI by IndoSolar Limited, a SPV manufacturer (planning for initial public offering, having commercial production capacity of 160 MW of Poly-crystalline SPV cells with an average conversion efficiency rating of 16+%), the average selling price of their SPV cells since commercial production up to December 31, 2009 is approximately Rs. 58.53 per Watt (@ $1.25 per Watt with exchange rate of $ 1= Rs.46.7). It further states that in case of shortage of SPV cells, the selling price will increase, however, if demand for solar products decline and the oversupply of solar products situation exists, the average selling price of SPV cells will be adversely affected. If we add the cost of conversion from cell to module as $0.5 per watt, the module cost would be $1.75 per Watt. According to a project developer in India who has commissioned 1 MW solar PV power plant in 2010, delivered price of the module is $1.75/Watt.

Trend of average spot selling prices of Polysilicon, Wafer, Cell and Module from April 2009 to June 2010

2.5 According to the PVinsight, the Polysilicon prices have dropped globally from last year March 2009 by 42.8%. The figure below presents the trend of Polysilicon prices from March 2009 to June 2010.

Poly-silicon Prices

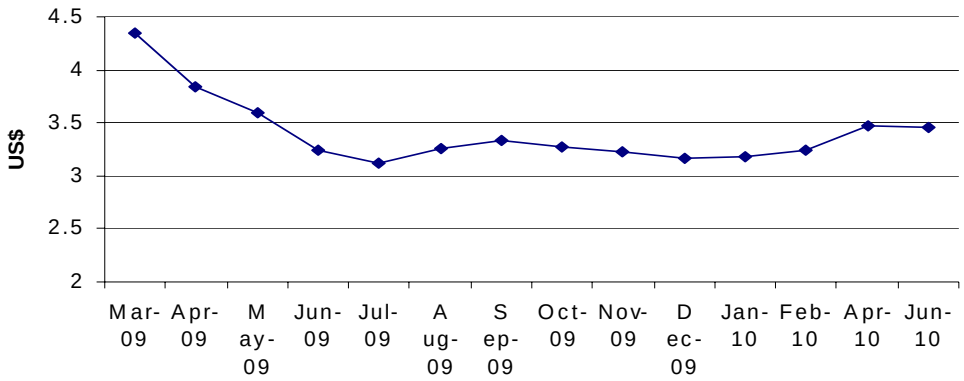
Name (US$/KG)	Closing Value (US$/KG) 16th June, '10	Closing Value (US$/KG) 28th April, '10	Closing Value (US$/KG) 27th Feb, '10	Last Year March 2009
Polysilicon	55.60	54.50 (2.00%)	54.75 (1.60%)	97.2 (-42.80%)



2.6 According to the PVinsight, the Poly Wafer prices have dropped globally from last year March 2009 by 20.3 %. The figure below presents the trend of Poly Wafer prices from March 2009 to June 2010.

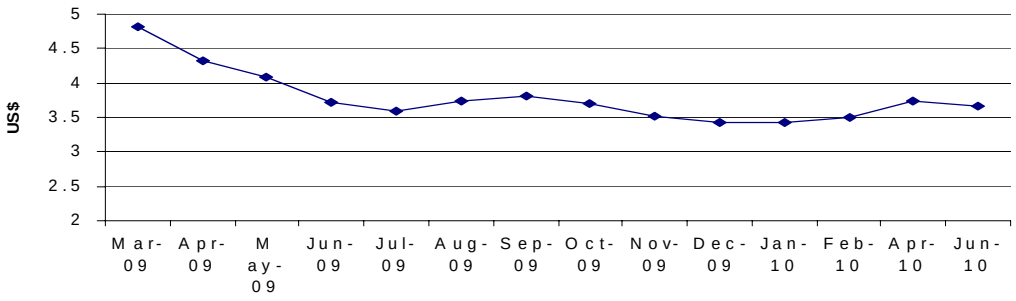
Wafer Prices

Poly Wafer Prices



Source: PVinsight

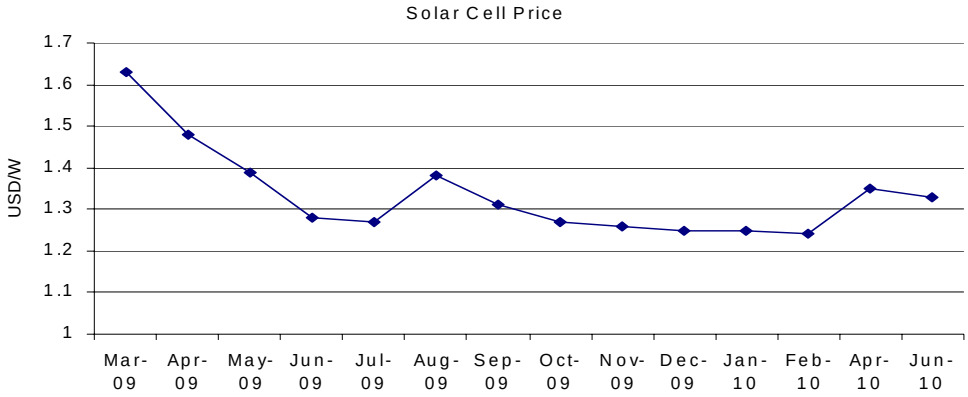
Mono Wafer Prices

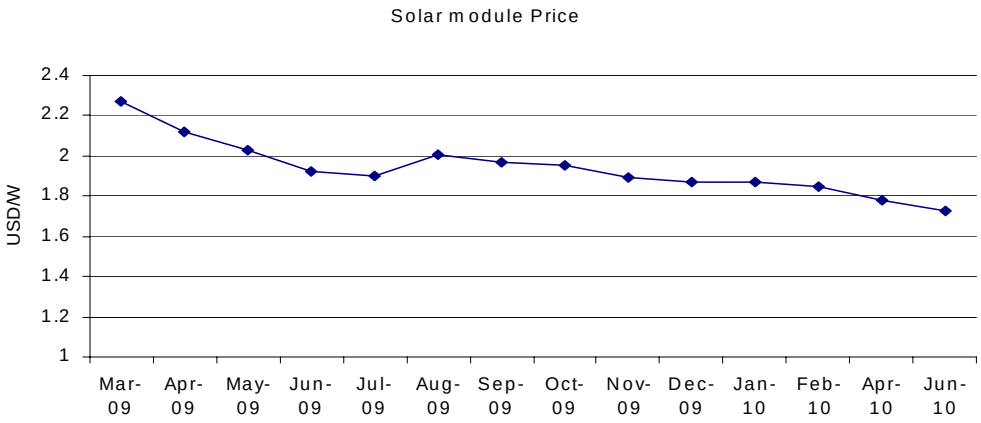


2.7 According to the PVinsight, the Cell and Module spot prices have been dropped globally from last year March 2009 by 18.4% and 23.8 %. The figure below presents the trend of Poly Cell and Module spot prices from March 2009 to June 2010.

Silicon Cell & Module Prices

Name (Spot Prices)	Closing Value (US$/W) 16th June , '10	Closing Value (US$/W) 28th April, '10	Closing Value (US$/W) 27th Feb, '10	Last Year March 2009
Cell	1.33	1.35 (-1.5%)	1.24 (7.3%)	1.63 (-18.4%)
Module	1.73	1.78 (-2.8%)	1.85 (-6.5%)	2.27 (-23.8%)





2.8 According to the PVinsight, the Silicon Module and Thin Film Module's weekly spot prices per watt as on 25th September 2010 was around US$ 1.70 and US$ 1.31 per Watt respectively.

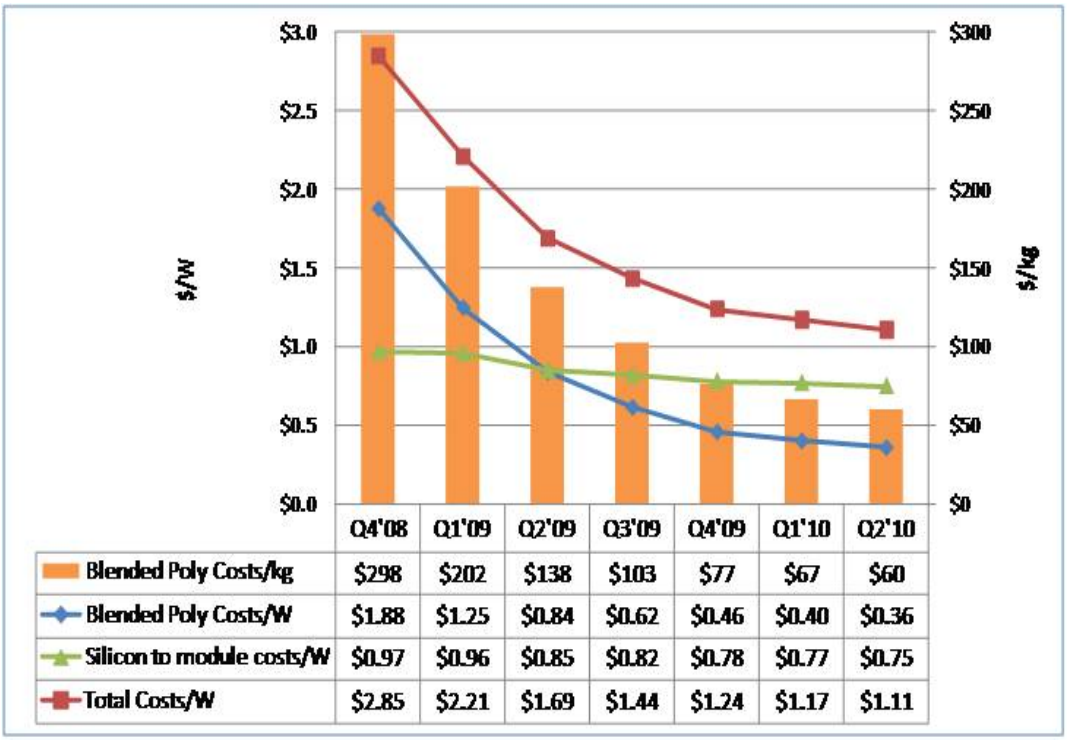
Solar Panel / Solar Module Weekly Spot Price					
Item	**High**	**Low**	**Average**	**AvgChg**	**AvgChg%**
Silicon Module Per Watt	**1.90**	**1.64**	**1.70**	**↓0.00**	**↓0.00%**
Thin Film Module Per Watt	**1.50**	**1.25**	**1.31**	**↓0.00**	**↓0.00%**
Unit: US$				***Last Update:*** **2010-08-25**	

Source: PVinsights

2.9 The current trend of spot price of Solar cell matches with the information revealed by M/s IndoSolar in the red herring prospectus about the wholesale price of a PV cell as referred in para 2.4.

2.10 Preliminary findings from the Q1'10 issue of IMS Research's *PV Supply Chain Health Report* indicate that from a cost standpoint, major PV manufacturer M/s Trina reported a 14% decline in module costs in Q4'09 to $1.24/W as shown in Figure 2 and is expecting another 5% decline in Q1'10. IMS research estimated that module cost will further decline by another 5% in Q2'10 bringing them to $1.11/W. Further it states that, Trina is targeting $1.00/W in Q4'10 which appears achievable if non-silicon costs approach $0.70/W as indicated in their guidance. Trina's blended poly costs fell from $77/kg in Q4'09 to $67/kg in Q1'10 even though they purchased new poly in Q4'09 at $55/kg. Blended poly costs of $50/kg should get them to $1.00/W.

2.11 Figure 2: Trina's Q4'08 – Q2'10 Module and Silicon Costs



	Q4'08	Q1'09	Q2'09	Q3'09	Q4'09	Q1'10	Q2'10
Blended Poly Costs/kg	$298	$202	$138	$103	$77	$67	$60
Blended Poly Costs/W	$1.88	$1.25	$0.84	$0.62	$0.46	$0.40	$0.36
Silicon to module costs/W	$0.97	$0.96	$0.85	$0.82	$0.78	$0.77	$0.75
Total Costs/W	$2.85	$2.21	$1.69	$1.44	$1.24	$1.17	$1.11

Source: Trina Solar, IMS estimates. IMS Research's Weekly PV Supply Chain Health Report

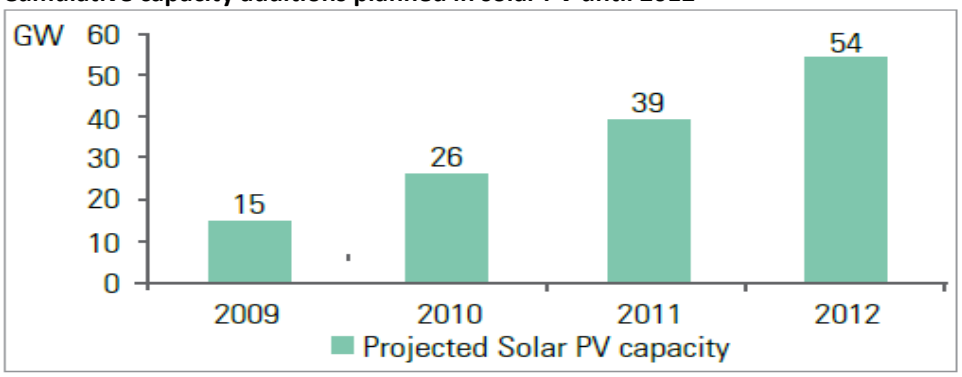
2.12 Domestic Companies are presently offering complete **EPC (Engineering Procurement & Construction)** contract on turnkey basis for setting up 1 MW Solar Grid Connected Power Plant with Crystalline Solar PV Modules at around 14.5 Crore and with a-Si Thin Films solar PV modules at around 13.5 Crore(excluding transportation cost upto project site land cost and preliminary and pre operative expenses). The price of Crystalline Solar PV Modules quoted is around Rs. 9.2 Crore per MW. It is to be noted that, according to the solar PV industry experts, such quoted prices are non-negotiated and could be reduced further by 10-15% at negotiation stage. These clearly show that price of Solar PV Modules is decreasing. It is to be noted that even the 54 kW Solar PV project has been installed by M/s Moser Bear for NDPL , Delhi at project cost of Rs. 75 lakh last year 2009-10 with the generation guarantee of 17% CUF, which works out to project cost of less than Rs. 14

Crore/MW. It is also to be noted that in the month of July, 2010, around more than 400 MW PPAs signed in Gujarat State with GERC determined levellised Tariff of Rs. 12.54 per unit.

Future trends expected in global solar PV industry

2.13 In 2010, increase in global PV manufacturing capacity and reduction in demand due to global recession has resulted solar PV module price decline. According to the Clean Energy Trends-2010, the price drop, along with other internal financial and policy drivers, is causing some countries to reduce national incentive programs. Germany plans to reduce feed-in tariffs at the beginning of July 2010 by 11 to 16 percent, depending on the application. This move will further intensify the demand for less expensive PV in the solar market. Further, according to the Navigant Consulting report, as quoted in the Indian Semiconductor Association 's report on Solar PV Industry 2010 : Contemporary scenario and emerging trends : May 2010, the global capacity of solar PV modules is expected to reach 54 GW by end of year 2012 as indicated in the graph below:

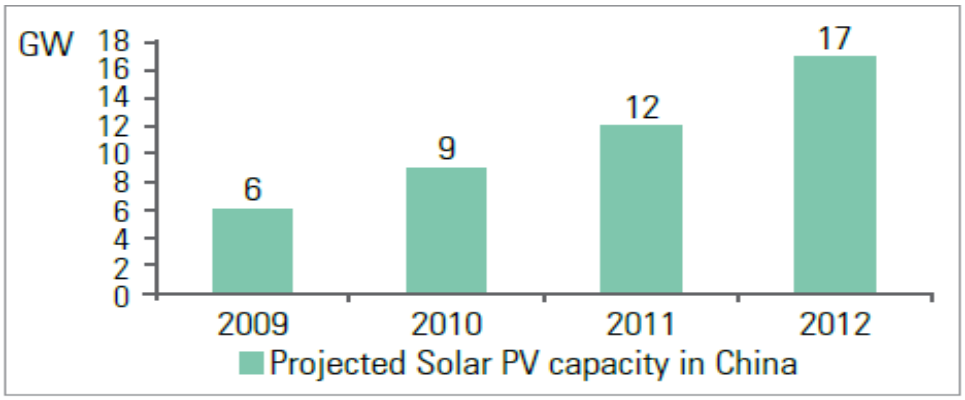
Cumulative capacity additions planned in solar PV until 2012



Source: Navigant

2.14 The above referred report further states that the capacity addition relies mainly on the implementation of projects in China, which has ambitious plans to add capacity. The graph below indicates China's growth plans in the next 4 years. If China achieves its planned target, it will account for 32% of the total worldwide production capacity by 2012.

Solar PV production capacity addition plans of China



Source: Navigant

2.15 According to the Photon Consulting new report on "The True Cost of Solar Power: How Low can you GO?" published in April 2010 concludes that the Chinese and Taiwanese companies have become the most important cost leaders at the ingot/wafer, cell and module steps of c-Si supply chain. Due to silicon feed stock cost reduction and other geographic cost structure advantages like: lower unit material costs, lower equipment costs, and lower unit labor costs compared to manufactures in Europe, Japan and the US report conclude that solar cost benchmarks for average and best-practice cost are falling rapidly with a select group of leading companies likely to go below the $1 per Watt all in cost bar by 2013.

2.16 According to GTM Research, the installed capacity of PV on the whole is forecasted to reach more than 20 GW globally by 2013 (equating to roughly US$60 billion in revenue), and the cost of PV panels is projected to fall to US$1.20/W by that same date.

2.17 The above analysis reveals that the current thin film module price per watt varies in the range of $1.25 to $1.50 and crystalline module price varies in the range of $1.64 to $1.90. Most of the international studies reveal that the prices are expected to decline in future. The Commission proposes to consider base module cost at $1.75 per watt (CIF) for the determination of benchmark capital cost for solar PV projects. With the exchange rate of Rs 46.70/US$, the module cost works out to Rs. 8.17Crore/ MW**.**

2.18 The module cost which constitutes about 60 to 65% of the capital cost and capacity utilization factor (CUF) have the most significant impact on the levelised tariff and consequent cost recovery for the developers. While determining the module price it is therefore important to take into account the CUF specified and its impact on the tariff.

2.19 With due regard to this fact the Commission had commissioned a study to assess as to whether the CUF of 19% for solar PV was adequate given the solar radiation in the country. The preliminary report suggests that out of 46 selected locations across the country, the average CUF at more than 80% locations works out to be more than 19% for solar PV plant based on thin film technology. Similarly, the average CUF at more than 50% locations works out to be more than 19% for solar PV plants based on crystalline technology. It can thus be inferred that in most of the places CUF is around 19%. In Rajasthan and Gujarat CUF is found mostly in the range of 20% for crystalline technology and around 21% for thin film technology. There are, however, some locations where the CUF is around 18%. The Commission is of the view that since most of the locations have CUF approximating the benchmark CUF of 19%, no additional compensation is required to this account.

2.20 Some stakeholders had raised the issue regarding degradation and its impact on tariff. The Commission took note of this concern and required the above referred study to examine the impact of degradation as well. Accordingly, the said study has also examined the impact of degradation, if any on the solar PV plants and found that the module performance degrades over time due to ageing. One can fairly assume degradation of maximum 0.5% per year from 4th year of deployment. The Commission feels that the module price to be considered for the purpose of capital cost of solar PV projects should factor in reasonable compensation for degradation due to ageing. The Commission is of the view that

additional module cost of Rs.4 lakhs per year for addition of 5 KW of modules per MW per year from 4th year to 25th year of operation should be compensated. The Net Present Value (NPV) of this additional module cost works out to Rs. 15.56 Lakhs/MW.

2.21 The Commission, therefore, proposes to fix the module cost at Rs. 8.33 Crore per MW for the FY 2011-12 for determination of benchmark cost for Solar PV projects for FY 2011-12. This figure includes base module cost of Rs. 8.17 Crore/ MW (Ref. Para 2.17) plus additional module cost due to degradation of Rs. 15.56 Lakhs/MW (Ref. Para 2.20).

Non-Module Cost Component:

2.22 The non-module cost components comprise cost towards land, civil & general works, ground mounting structures, power conditioning unit, cabling & transformer/ switchgears and preliminary/pre-operating expenses & financing costs. The non-module component together contributes to approximately 35 to 40 % of overall capital cost requirement of solar PV based power projects. Each component of above referred non-module cost of Solar PV based power plant is estimated as under for the determination of benchmark capital cost of Solar PV projects for FY2011-12.

Land:

2.23 The land requirement for Solar PV based power project depends upon the technology employed i.e. Crystalline or Thin film, conversion efficiency and solar radiation incident in respective area. The Commission, while determining the benchmark capital cost for Solar PV projects for the year 2010-11, had considered land requirement of 5 Acre/MW and its cost was considered as Rs. 3 Lakh/Acre or 0.15 crore / MW. The Commission proposes to consider the same land cost for the determination of benchmark capital cost of Solar PV projects for FY2011-12.

Civil and General Works:

2.24 The cost associated with civil works includes testing of soil, preparation of soil/ground with all necessary works like earthmoving, digging holes for the foundations/pilings and leveling, fencing of the land, development of approach road, cable trenches, water supply arrangement in solar farm, control room etc. The General works include security of solar farm, setting up of power back-up generator; yard lighting, Earthling Kits, etc. The Commission, while determining the benchmark capital cost for Solar PV projects for the year 2010-11, had considered the civil and general works together as Rs. 0.9 Crore/MW. After allowing cost escalation of 5% over the last year's cost the Commission proposes to consider 0.95 Crore/MW as the cost for Civil and General work for benchmark capital cost of Solar PV projects for FY2011-12. The escalation of 5% is based on the escalation of Iron and Steel and Electrical Machinery indices over the last quarter.

Ground Mounting Structures:

2.25 This expenditure includes cost associated with manufacturing, delivery, installation and calibration of either hot galvanized steel or aluminum structures including all necessary material, works and installation on prepared foundations/pilings. The Commission, while determining the benchmark capital cost for Solar PV projects for the year 2010-11, had considered the cost of ground mounting structure as Rs. 1.0 Crore/MW. After allowing cost escalation of 5% over the last year's cost the Commission proposes to consider 1.05 Crore/MW towards the cost for Ground Mounting Structures for benchmark capital cost of Solar PV projects for FY2011-12. The escalation of 5% is based on the escalation of Iron and Steel and Electrical Machinery indices over the last quarter.

Power Conditioning Unit

2.26 Power conditioning equipment is an important component of the balance-of-system. Power conditioners process the DC power produced by a photovoltaic system to AC power and match the same with utility's power. According to the project developer, who have commissioned 1 MW Solar PV plant and running it successfully, it contributes to approximately 10% of the total capital cost. Presently, the EPC contractors are offering EPC cost which includes cost of grid inverters at Rs. 1.2 Crore/MW. The Commission, while determining the benchmark capital cost for Solar PV projects for the year 2010-11, had considered the cost of power conditioning unit as Rs. 2.0 Crore/MW. Considering the facts as mentioned above as well as reduction of inverter prices globally, it is proposed that expenditure towards Power Conditioning Unit to be considered as Rs. 1.6 Crore/MW.

Cables and Transformers

2.27 This expenditure includes EPC cost towards DC caballing between Solar PV panels & Inverters including junction boxes, AC cabling between Inverter & sub-station, Earthling arrangements and Transformer. The transformer cost includes the EPC cost of a step up outdoor type transformer, breaker, Current Transformers, Potential Transformers, Isolators, LAs, protection relay and TOD meter. The Commission, while determining the benchmark capital cost for Solar PV projects for the year 2010-11, had considered the cost of cables and transformers and other associated equipments as Rs. 0.85 Crore/MW. After allowing cost escalation of 5% over the last year's cost, the Commission proposes that Rs. 0.90 Crore / MW may be considered as expenditure towards cables and transformers for solar PV projects for the determination of benchmark capital cost of Solar PV projects for FY2011-12.

Preliminary/Pre-operating expenses and Financing Costs

2.28 The preliminary/pre-operating expenses include transportation of equipment, storage of equipment at site, insurance, contingency, taxes and duties, IDC and finance charges etc. Detailed breakup of Preliminary and Pre-operative expenses and financing cost, lump sum in percentage of total capital cost is proposed as under:

i. Insurance Cost: 0.5%

ii. Contingency: 1%
iii. Interest during Construction (IDC): 5%
iv. Financing cost: 1%
v. Project management cost: 1%
vi. Pre-operative Cost: 1.5%

2.29 Preliminary/Pre-operating expenses and Financing Cost contribute to above 10% of total capital cost on average basis. Accordingly, Rs. 1.44 Crore /MW is proposed to be considered as preliminary /Pre-operating expenses and Financing cost.

2.30 The table below presents the breakup of benchmark capital cost norm for Solar PV projects for the FY 2011-12:

Table: Breakup for Capital cost projection

Sr. No.	Particulars	Capital Cost Norm for Solar PV project (Rs Cr/MW)	% of total cost
1	PV Modules	8.33	58%
2	Land Cost	0.15	1%
3	Civil and General Works	0.95	7%
4	Mounting Structures	1.05	7%
5	Power Conditioning Unit	1.60	11%
6	Evacuation Cost up to Inter-connection Point (Cables and Transformers)	0.90	6%
7	Preliminary and Pre-Operative Expenses including IDC and contingency	1.44	10%
8	Total Capital Cost	14.42	100%

2.31 Considering the above facts into consideration, the expenditure towards Non-Module component together works out to Rs. 6.09 Crore/MW. The total cost of Solar Photo voltaic power projects for the FY2011-12 as Rs. 14.42 Crore/MW is proposed to be considered as benchmark project cost of Solar PV projects.

3 Benchmark Capita Cost for solar Thermal Power Projects

3.1 Solar thermal power plants capture energy from solar radiation, transform it into heat, and generate electricity from the recovered heat. Over the years, four main types of solar thermal power plants have been developed:

− Parabolic trough technology
− Power Tower

− Parabolic Dish-engine system

− Continuous \linear Fresnel Reflector

3.2 These systems are all different and within each grouping of plants, different technology concepts have been developed. Moreover, the experience and prospects for each of the different technology concepts looks different. According to the Photon International 2010, detailed break-up of CSP technology shares in currently in operation, under construction and in near-term development are as Under:

	Operational	Under Construction	Near term Development by 2013
MW Capacity	821.9 MW	918.5 MW	12460 MW
Parabolic trough	93.6%	94.7%	51.1%
Power Tower	5.1%	5.0%	30%
Stirling dish	0.2%	0.3%	17.9%
CLFR	1.1%	0.0%	1%

Source: Photon International

3.3 From the above table it appears that nearly 94% of the 822 MW of large scale pilot or commercial CSP plants currently in operation rely on parabolic trough technology, while power towers account for only 5%, continuous Linear Fresnel Reflector (CLFR) system only 1.1% and dish concentrators less than 1%. Of approximately 918.5 MW of CSP plant now under construction, trough based plants make up nearly 95%, while power tower represents about5% and Stirling dishes less than 1%. The share of non-trough technologies in deployment picture could change significantly. Of the approximately 12.5 GW of CSP projects scheduled to break ground between 2010 and 2013, parabolic trough share falls to about half, while power tower and Stirling dish projects rise to about 30% and 18% respectively. Only about1% of the near-term CSP projects uses CLFRs technology which in part is due to the cancellation of last year of a 177 MW contract in California by Ausra Inc. (Estimated project cost around $3.1/W)

3.4 Cost and technology features of select CSP plants:

Technology: Parabolic Trough

	Andasol 1	Extresol-1	Nevada Solar One	Shams One	Solana	Valle-1 & 2
Location	Spain	Spain	Nevada USA	Abu Dhabi	Arizona Solar	Spain
Developer	Solar Millennium	ACS, Cobra Group	Acciona	Masdar, other	Abengoa	Torresol Energy
Status	Operational	Operational	Operational	Under development	Under development	Under construction
On line	2008	2009	2007	2011	2013	2011
Capacity	50 MW	50 MW	64 MW	100 MW	280 MW	100 MW
Max. operating Temperature	400 ^{0} C	393^0 C	393^0 C	400^0 C	371^0 C	393^0 C
Storage (full load)	< 8 h	7.5 h	0.5 h	none	6 h	7.5 h
Cooling	wet	wet	wet	dry	Wet*4	wet
Solar resource (annual)	2136 kwh/m2	2168 kwh/m2	2606 kwh/m2	2200 kwh/m2	2700 kwh/m2	2097 kwh/m2
Solar to electrical efficiency (annual)	15%	15%	13-14%	14%	15%	15%
Electricity generation (annual)	158 GWh	158 GWh	134 GWh	220 GWh	903 GWh	340 GWh
Capital cost (per megawatt)	$ 8.2 mn	$ 11.1 mn *2	$ 4.5 mn	$ 4-5 mn	$ 3.57 mn	$ 10 mn
Contract price (per kilowatt hour)	36.4 C	36.4 C	18C *2	-	14 C *2	36.4 C
*2: New Energy Finance Estimate *4: expected to use 75% less water than fallowed agricultural operation on same site						

Source: Photon International

3.5 From the above table, it appears that investment cost varies from $ 3.57 to 11.1 million per MW (equiv. Rs. 16.67 crore to Rs.51.83 crore/MW@ $1=Rs. 46.7)

3.6 **Technology: Power Tower**

	Gemasolar	Ivanpah	PS-10
Location	Spain	California, USA	Spain
Developer	Torresol Energy	Bright Source Energy	Abengoa
Status	Under Construction	Under Development	Operational
On line	2011	2012	2007
Capacity	17 MW	400 MW	10 MW
Max. operating Temperature	565^0 C	550^0 C	257^0 C

Storage (full load)	15 h	none	1 h
Cooling	Wet	Dry	Wet
Solar resource (annual)	2062 kwh/m2	2717 kwh/m2	2012 kwh/m2
Solar to electrical efficiency (annual)	18% *1	18%	18% *1
Electricity generation (annual)	100 GWh	1079 GWh	23.4 GWh
Capital cost (per megawatt)	$23.5mn	$3.4 mn	$5.3 mn *2
Contract price (per kilowatt hour)	36.4 C	11 C *2	36.4 C
*1: Photon International Estimate *2: New Energy Finance Estimate			

Source: Photon International

3.7 From the above table, it appears that investment cost of a project under development stage without storage facility is as low as $ 3.4 million per MW. (equiv. Rs. 15.87 crore /MW@ $1=Rs. 46.7)

Technology: Fresnel Lens Reflector & Stirling dish

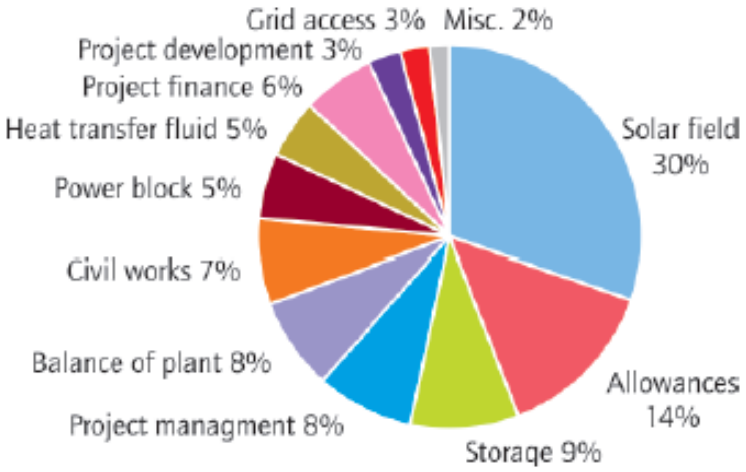
	Puerto Errado2	Western Ranch Solar
Technology	Fresnel Lens Reflector	Stirling dish
Location	Spain	Texas, USA
Developer	Novatech Solar Espana	Tessera Solar
Status	Under developmet	Under development
On line	2011/2012	2011
Capacity	30 MW	27 MW
Max. operating Temperature	270	750
Storage (full load)	None	none
Cooling	Dry	dry
Solar resource (annual)	1700	-
Solar to electrical efficiency (annual)	10-12%	27%
Electricity generation (annual)	-	-
Capital cost (per megawatt)	$ 5.4 mn	< $ 3 mn
Contract price (per kilowatt hour)	36.4 C	15 C

Source: Photon International

3.8 From the above table, it appears that investment cost for Fresnel technology is $ 5.4 million and for Stirling dish technology is<$3 million per MW (equiv. Rs. 14 Crore/MW).

3.9 It is also evident from the above tables that for large, state-of-the-art trough plants under development, with storage facility, current minimum investment cost is around $ 3.57 /W (equiv. Rs. 16.6 Crore/MW) and for Power Tower plant under development without storage facility current minimum investment costs is $ 3.4 /W (equiv. Rs. 15.87/Crore/MW).

3.10 Investment cost for trough plants depends on labour and land costs, technologies, the amount and distribution of DNI, the amount of storage, heat transfer medium and the size of the solar field, size of the project, dry/wet/hybrid cooling. Plants without storage that benefit from excellent DNI are on the low side of the investment cost range; plants with large storage and a higher load factor but at locations with lower DNI (around 2000 kWh/m2/year) are on the high side. Following Figure breaks down investment costs of a 50 MW trough plant with 7 hour storage under Spanish skies (as per IEA 2010 report on Technology Road map for CSP).



3.11 According to IEA report, for solar towers, investment costs are more difficult to estimate, but are generally higher than for trough plants. It also states that increasing efficiency from 15% to 25% will allow a 40% reduction in investment in solar-specific parts of the plants, or 20% of overall investment costs. The recent trends toward numerous mass-produced, small, flat mirrors promises to bring costs down further, as the problems of wind resistance and precision in pointing are resolved using computers. As the solar tower industry rapidly matures, investment costs could fall by 40% to 75%.

3.12 Further, the cost of CSP can be further reduced through indigenization. The critical components of parabolic trough technology are mirrors, heat transfer fluid, receivers and turbine. Out of it, turbine can be manufactured in India with a very short gestation period. There is also possibility of mirror manufacturers putting up manufacturing lines for specialized mirrors provided that the market for these specialized mirrors is assured. Only heat transfer fluid and receivers may require to be imported for some time. The capital cost for solar thermal power plants (without storage facilities) which is under development and

to be commissioned by 2012 has been reported around US $ 3.4/ W (equiv. Rs. 15.87 Crore/MW) can be reduced further upto 15 Crore/MW with indigenization of balance of system including power block and structures along with lower labour cost prevailing in India.

3.13 Since there is very limited experience in the field of electricity generation utilising Solar Thermal Power technology, comparable projects have not yet been set up in any State in the country, reliance could be made on the expert opinion, other available literature and details available from international experience, details available from the various manufacturers through petitions filed before the SERCs.

3.14 The comparative analysis of the Capital Cost requirement as submitted by the M/s Acme Tele Power Ltd. and M/s Entegra Ltd., with RERC, are given in the table below:

Plant Details	**Acme**	**Entegra ***
Technology Options	**Tower**	**Trough**
COST ITEMS	**Rs L/MW**	**Rs L/MW**
Civil and Structural	64	129
Solar Field		2198
Thermal Storage System(cost to be reconfirmed)		413
HTF System Incl.Solar Heat Exchangers	976	163
Power Block/BoP Mechanical System	255	309
Power Block/BoP I&C and electrical system	76	35
Total Equipment Cost	1371	3570
Contractors (interface) engineering	4	5
EPC Contract	1375	3575
Owners/operators cost	14	29
Contigencies	27	
IDC	78	322
Total Project Cost	**1494**	**3926**
Capacity Utilisation Factor (CUF)%	**24%**	**50.5%**

* With solar thermal storage of 8 hours operation

The Commission is of the view that increase in CUF of a project with storage facility should not increase Capital Cost of project exorbitantly. The Capital Cost requirement as submitted by the M/s Acme Tele Power Ltd. is also in line with the observation made under Para 3.12 above.

3.15 Keeping the above facts into consideration, it is proposed to consider benchmark capital cost norm for solar Thermal Power projects for FY 2011-12 as Rs. 15 Crore/MW which is close to estimates of Acme as well as projects under development in USA.