

Tamil Nadu Electricity Regulatory Commission

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

(Comments/Suggestions are invited on or before 20-05-2010)

1.0 Preamble

Widespread use of coal and other fossil fuels has led to accumulation of enormous amount of carbon dioxide in the earth's atmosphere and a resultant global warming. The need for adoption of clean technology, improving end use efficiency and diversifying energy bases etc., has been seriously considered by the Government of India since the Sixth Five Year Plan. The country is poised for considerable increase in the use of renewable energy sources in its transition to a sustainable energy base. Renewable energy sources such as wind, solar, hydro and bio mass not only augment energy generation but also contribute to improvement in the quality of the environment, drought control, energy conservation, employment generation, upgrading of health and hygiene, social welfare, security of drinking water, increased agricultural yield and production of bio-fertilizers. The pace of development has been accelerated by the Government through promotional policies such as fiscal and tax incentives.

Amongst the above options of renewable energy sources, solar power generation undoubtedly offers the most promising and viable option for electricity generation for the present and future. It is understood that solar power generated over 1% of the land area in the country is adequate to meet its entire electricity requirements till 2030.

2.0 Need for the consultative paper

Overwhelming emphasis has been laid in the Electricity Act 2003, National Tariff Policy and National Electricity Policy to promote environmental friendly renewable sources of energy such as Wind, Hydel, Solar and Biomass. Taking into consideration the huge deficit of power in the State, growth importance of solar energy and the high solar energy incidence in Tamil Nadu, Commission considers that there is an urgent need to put in place, the necessary regulating mechanism to develop solar power in the State. In order to encourage and facilitate expeditious development of grid connected solar based power generation, it is critical that regulatory clarity and certainty are in place for solar power projects which are at nascent stage of development. The Commission floats this consultative paper to elucidate the views of stakeholders.

3. Potential for Solar Power

The country receives solar energy equivalent to nearly 5,000 trillion kWh/year, which is equivalent to 600 GW- far more than the country's total energy consumption today. But, the utilization of solar energy is negligible. Solar applications can be broadly divided into grid-connected and off-grid. Considering the potential for solar power, grid connected electricity generation projects need to be promoted if necessary, by giving preferential tariff. Broadly, solar electricity generation uses two types of technologies namely photovoltaic (SPV) and solar thermal.

The country receives solar radiation of 4.6 to 6.4 kWh/m²/day for 300 to 330 days in a year. The average annual global solar radiant exposure in Chennai is 5.37 kWh/m² / day. The power generation potential for the country using solar PV

technology is estimated to be about 20 MW/km² and that using solar thermal generation about 35 MW/km². Further, this estimated potential is at current levels of technology efficiency. If technology is improved, then the potential could increase significantly. Solar energy systems do not require any fuel and, therefore, the running cost is low. The other advantage of solar energy systems is that the systems are modular, long-lasting, reliable and require less maintenance.

Tamil Nadu is blessed with conducive natural meteorological and topographical setting. Excepting for some of the experimental units such as the 15 KW unit setup by TEDA, 100 KW unit setup by M/s NEPC and 2x25 KW unit setup by M/s Udaya Semi conductors, no major attempt has been made in the State for solar power generation. Based on the MNRE's guidelines on generation based incentive scheme, TEDA has initiated moves for the establishment of Grid Interactive Solar Photovoltaic Power Plants of 1MW to 10MW capacity in Tamil Nadu under Build Own Operate basis.

4. Renewable sources of energy: Regulatory Framework and Related provisions in the Electricity Act and National Policies:

Extracts of the relevant provisions in the Electricity Act 2003, National Tariff Policy, National Electricity Policy, National Electricity Plan etc., are documented in annexure 1

The Electricity Act, 2003 has radically changed the legal and regulatory framework for the renewable energy sector. It envisages, inter alia, *that* State Electricity Regulatory Commissions (SERCs) should take steps to promote renewable and non-conventional sources of energy.

The Electricity Act,2003 and various policy documents such as the National Electricity Policy, Tariff Policy etc, provide for promotion and preferential treatment including tariff for renewable energy sources as well as stipulation of renewable power purchase obligation by SERCs.

As per Section 61 and 62 of the Electricity Act, 2003, the Commission is required to determine the tariff for supply of electricity by a generating company to a distribution licensee. Section 61(h) of the Electricity Act, 2003 stipulates that while determining tariff, the Commission shall be guided by the aspects of promotion of co-generation and generation from renewable sources of energy.

Section 3 of the Electricity Act, 2003 clearly mandates that the formulation of the National Electricity Policy, Tariff Policy and Plan thereof for development of power systems shall be based on optimal utilization of all resources including renewable sources of energy. Clause 6.4 of the Tariff Policy notified by the Ministry of Power, Government of India, stipulates that the Appropriate Commission shall determine Preferential Tariff for procurement of Renewable Energy (RE) by Distribution Licensees under Renewable Purchase Standards (RPS) obligation as envisaged under Section 86(1)(e) of EA 2003, which is reproduced below:

“6.4It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission.

(2) Such procurement by Distribution Licensees for future requirements shall be done, as far as possible, through competitive bidding process under

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

Section 63 of the Act within suppliers offering energy from same type of non-conventional sources. In the long-term, these technologies would need to compete with other sources in terms of full costs.”

The Government of India, realizing that energy is a vital input to the economy, and that it is necessary to ensure reliable availability of energy to sustain higher growth rates, directed the Planning Commission to constitute an expert committee to undertake a comprehensive review and to make policy recommendations on this subject. The expert committee submitted its final report entitled the “*Integrated Energy Policy Report*”. The specific recommendations to Regulators for solar power development in India made in this report are reproduced below:-

***Policy for Renewable and Non-Conventional Energy Sources [Chapter 7
Para 3 of IEPR]***

“Respective power regulators should mandate feed-in laws for renewable energy, where appropriate, as provided under the Electricity Act and as mandated in many countries. The following specific policies to promote various renewables are recommended.

Solar thermal power plants: The economic viability of solar thermal plants has not yet been fully established. To encourage entrepreneurs to invest in the technology, a higher premium on feed-in tariff may be given. The higher premium can be justified on grounds of the higher risk and may be made available only to the first 5000 MW of solar thermal plants.

Solar photovoltaic: Although the present cost is very high, since the ultimate potential is very large, incentive to commercialize and lower the cost may be

provided through a higher feed-in tariff, again for the first 5000 MW of installed capacity”.

Jawaharlal Nehru National Solar Mission

The Government of India has approved a new policy on development of solar energy in the country by launching of the Jawaharlal Nehru National Solar Mission. This Mission is one of the eight key National Missions which comprise India’s National Action Plan on Climate Change. It has a twin objective – to contribute to India’s long term energy security as well as its ecological security. The Solar Mission recommends the implementation in 3 stages leading up to an installed capacity of 20,000 MW by the end of the 13th Five Year Plan in 2022. It is envisaged that as a result of rapid scale up as well as technological developments, the price of solar power will attain parity with grid power at the end of the Mission, enabling accelerated and large-scale expansion thereafter. The Mission will adopt a 3-phase approach, spanning the remaining period of the 11th Plan and first year of the 12th Plan (up to 2012-13) as Phase 1, the remaining 4 years of the 12th Plan (2013-17) as Phase 2 and the 13th Plan (2017-22) as Phase 3.

As per the above Policy, the solar power purchase obligation for States may start with 0.25% in the phase I and to go up to 3% by 2022. This could be complemented with a solar specific Renewable Energy Certificate (REC) mechanism to allow utilities and solar power generation companies to buy and sell certificates to meet their solar power purchase obligations.

As per the mission, NTPC Vidyut Vyapar Nigam Ltd. (NVTN), subsidiary company of NTPC Limited, engaged in the business of trading is designated as nodal agency by the Ministry of Power (MoP) for entering into a Power Purchase Agreement (PPA) with Solar Power Developers to purchase solar power fed to 33 KV and above grid, in accordance with the tariff and PPA duration as fixed by the Central Electricity Regulatory Commission. The Ministry of Power shall allocate to NVTN, equivalent megawatt capacity, from the Central unallocated quota, from NTPC power stations, at the rate notified by the CERC for bundling together with solar power. NVTN will undertake the sale of the bundled power to State utilities at the rates determined as per CERC regulations.

The mission also encourages rooftop solar PV and other small solar power plants, connected to LT/11 KV grid, to replace conventional power and diesel-based generators. The distribution utility will pay the tariff determined by the State Electricity Regulatory Commission for the metered electricity generated from such applications (whether consumed by the grid connected owner of the rooftop/ground mounted installation or fed into the grid). Under the Solar Mission, a normative Generation Based Incentive will be payable to the utility and would be derived as the difference between the solar tariff determined by the Central Electricity Regulatory Commission for the concerned solar generation technology less an assumed base price of Rs. 5.50/kWh with 3% annual escalation. Funds will be disbursed through Indian Renewable Energy Development Agency (IREDA), a PSU under MNRE. The distribution utilities will be entitled to account such electricity generated and consumed within their license areas for fulfillment of RPOs. The metering and billing arrangements between the utility and the rooftop PV operator, will be as per guidelines/regulations of the appropriate commission.

In line with the above, the Ministry of Power, Government of India, has proposed to amend the clause 6.4 (1) of the National Tariff Policy to specify 0.25% solar RPO with effect from 1.4.2010 and 3% by 2022. The proposed amendment also specifies the introduction of solar specific Renewable Energy Certificate (REC) mechanism.

5. Policy Guidelines for Generation Based Incentive for Grid Interactive Solar Power Generation Plants

With a view to develop and demonstrate technical performance of grid interactive solar power generation, achieve reduction in the cost of the grid connected solar power generation in the country, the Ministry of New and Renewable Energy (MNRE), Government of India issued guidelines during January and March 2008 on generation based incentive scheme to encourage grid connected solar photovoltaic (SPV) and solar thermal power generation from megawatt size solar power plants. The Ministry considered support for a maximum capacity up to 50 MW (including solar photovoltaic as well as solar thermal power generation) during the 11th plan period.

As per the above guidelines, The Ministry provided through IREDA, a generation-based incentive of a maximum of Rs.12.00 per kWh (for Solar PV) and Rs.10.00 per kWh (for Solar Thermal) generation to eligible projects, which are commissioned by 31st December, 2009, after taking into account the power purchase rate (per kWh) provided by the State Electricity Regulatory Commission or utility for that project. Any project commissioned after 31st December, 2009 would be eligible for a maximum incentive with a 5% reduction and ceiling of

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

Rs.11.40 per kWh for solar PV generation project and Rs.9.50 for solar thermal generation project. The maximum amount of generation based incentive applicable for a project will be determined after deducting the power purchase rate for which PPA has been signed by the utility with a project developer, from a notional amount of Rs.15.00 per kWh for solar PV generation power projects. In all cases, the maximum amount of generation-based incentive shall not exceed Rs.12.00 per kWh for Solar PV and Rs.13.00 per kWh for solar thermal generation power projects. In all cases the maximum amount of generation-based incentive shall not exceed Rs.10.00 per kWh.

In continuation to the above, MNRE has issued the following draft guidelines as per the National Solar Mission for development of Solar Power in the country, which will be effective from 01-04-2010:

5.1 Jawaharlal Nehru National Solar Mission (JNNSM) guidelines for Selection of New Grid Connected Solar Projects under Phase 1 of JNNSM;

Under this scheme the minimum Project capacity shall be 5 MW and 20 MW in case of Solar Photo Voltaic Projects and Solar Thermal Project respectively. The maximum capacity for each project of Solar Photo Voltaic technology would be 25 MW and 100 MW for Solar thermal technology. The evacuation under this scheme will be 33 kV and above.

For each MW installed capacity of solar power for which a PPA is signed by NVVN, the Ministry of Power (MoP) shall allocate to NVVN an equivalent amount of MW (upto a maximum of 1000 MW) capacity from

the unallocated quota of NTPC coal based stations and NVVN will supply this “bundled” power to the Distribution Utilities.

5.2 Guidelines for Rooftop PV and other small Solar Power Plants connected to distribution network (below 33 kV) under JNNSM;

This scheme is presently applicable to the projects with installed capacity of 1 MW and up to 3MW having grid connectivity at HT level (below 33 kV) of the distribution network. Once the Central Electricity Authority (CEA) finalized the standards for interfacing of small solar generators with LT distribution network, this scheme will be extended to solar generators connected at LT level.

The local distribution utility in whose area the plant is located, would sign a Power Purchase Agreement (PPA) with the Project Proponent **at a tariff determined by the appropriate State Electricity Regulatory Commission (SERC)**. Generation Based Incentive (GBI) will be payable to the distribution utility for power purchased from solar power project selected under these guidelines. The GBI shall be equal to the difference between the tariff determined by the Central Electricity Regulatory Commission (CERC) and the Base Rate, which will be Rs 5.50 per kWh in the first fiscal year of commissioning to be escalated by 3% every year. The applicable Base Rate for projects to be commissioned during each subsequent year shall be modified at escalation factor of 3% p.a. and such escalated Base Rate shall remain constant over duration of 25 years.

MNRE has proposed to develop solar PV capacity of 100 MW under these guidelines. This capacity addition shall be achieved by developing the projects in the following manner:

| Sl. No. | Project Category | Capacity Limit |
|----------------|--|-----------------------|
| 1 | Projects connected at HT level of distribution network with installed capacity of 1 MW and upto 3 MW | 80 MW |
| 2 | Projects connected at LT level of distribution network with installed capacity lower than 1 MW | 20 MW |

Apart from the above, MNRE has also taken steps to develop off-grid solar applications. More details on the above guidelines are available on MNRE website -www.mnre.gov.in

6.0 Initiatives taken by Central Electricity Regulatory Commission (CERC) to promote solar power

CERC has notified the tariff regulation for electricity generated from renewable energy sources vide notification dated 16-09-2009. Specifying capital cost norms and fixing tariff upfront for the whole tariff period are the two main features of this regulation. The tariff period for solar power has been kept as 25 years and for small hydro below 5 MW, it has been kept as 35 years in view of the special considerations required for these technologies. However, the tariff permitted to other projects under these regulations would apply for the whole tariff period of 13 years.

Based on the regulations, CERC has notified tariff rates for various sources of non-conventional energy vide order dated 03-12-2009 in Petition No. 284/2009 (Suo Motu). Tariff rates for solar energy fixed by CERC are mentioned below:

| | Levellised total tariff in Rs./kWh | Benefit of Accelerated depreciation, if availed in Rs./kWh | Net Levellised Tariff upon adjusting for accelerated Depreciation benefit, (if availed) in Rs./kWh |
|---------------|------------------------------------|--|--|
| Solar PV | 18.44 | 1.30 | 17.14 |
| Solar Thermal | 13.45 | 0.91 | 12.54 |

Now, CERC vide their **draft order dated** 26-02-2010 in Petition No. 53/2010 (Suo Motu) has revised the tariff rates for various sources of non-conventional energy duly taking into account the revised capital cost norms, interest rate, etc. The revised tariff rates for solar energy are given below:

| | Levellised total tariff in Rs./kWh | Benefit of Accelerated depreciation, if availed in Rs./kWh | Net Levellised Tariff upon adjusting for accelerated Depreciation benefit, (if availed) in Rs./kWh |
|---------------|------------------------------------|--|--|
| Solar PV | 17.91 | 2.96 | 14.95 |
| Solar Thermal | 15.31 | 2.46 | 12.85 |

Further, as per the recommendations of the Forum of Regulators (FOR), the CERC has notified Regulation on Renewable Energy Certificate (REC) in fulfillment of its mandate to promote renewable sources of energy and

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

development of market in electricity. REC mechanism will be an alternative route for fulfilling renewable purchase obligations. This mechanism is mainly aimed at addressing the mismatch between renewable resources availability in the local region and the renewable purchase obligations.

7.0 Initiatives taken in Tamil Nadu to promote solar power

During the year 2006, the Commission notified an order on “Power purchase and allied issues in respect of Non-Conventional Energy Sources based Generating Plants and Non-Conventional Energy Sources based Co-Generation Plants” vide order No. 3 dated 15-5-2006. The said order fixed the tariff for power procurement by the distribution licensee from Wind Energy Generators (WEGs), Biomass based generators and Bagasse based co-generators. The order did not specify the tariff for purchase of power from solar power generation plants. In section 9.6 of the said order, the Commission noted the following in respect of setting of tariff for solar power generation plants.

“The quantum of grid connected solar system in Tamil Nadu is at present only 0.165 MW and that of India is 47 MW. The capital cost required for installing a solar generating station is 30 times more than that of the conventional generating station. Technical advancements are being achieved in the field of tapping of solar energy. The number of grid connected solar generators is yet to take off to the desired level. Hence, the Commission can specify the cost of purchase of solar energy separately.”

Based on the MNRE’s guidelines on generation based incentive for grid interactive solar power generation projects, many organizations have approached the Government of Tamil Nadu and the Tamil Nadu Energy Development Agency (TEDA).

The Commission fixed a provisional tariff of Rs.3.15 per kWh (Maximum tariff fixed for NCES generators at that time) as purchase rate for procurement of power by the distribution licensee from Solar Photovoltaic and Solar Thermal Power Generation Plants vide Commission's order No.6 dated 11-07-2008. This order is provisional, to enable the developers to avail the incentives offered by the MNRE as per their guidelines dated 29-01-08. Subsequent to this, Commission in their order No. 2 of 2009 dated 27-04-2009 on Comprehensive tariff order for biomass based power plants fixed a purchase rate of Rs.4.50 per kWh for the biomass based power plants for the period up to 31-03-2010 and it is the maximum tariff fixed by the Commission in force as on date in respect of NCES power in the State. Therefore, the Commission re-fixed tariff of Rs.4.50 per kWh as purchase rate for procurement of power by the distribution licensee from the solar photovoltaic and solar thermal power generation plants vide amending order No. 6 – 1 dated 22.09.2009.

Commission also conducted a round table conference on 16-07-2008 to elicit the views of the solar energy experts and other related stake holders. Based on the views expressed by the participants, taking into account the orders issued by other Commissions in this regard and the policies in the National Solar Mission, the Commission has proposed to issue this consultative paper to determine regular tariff for power purchase from solar energy generators.

Further, Commission is in the process of formulating Renewable Purchase Obligation and its compliance Regulations, 2010, which will facilitate purchase of renewable power / Renewable Energy Certificate (including solar) by the obligated entities in Tamil Nadu.

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

8.0 Electricity generation from solar power –available technology

Basically there are two types being followed for generation of electricity using solar power. They are Photo Voltaic array based and solar thermal based. Detailed write up on these two technologies is furnished in Annexure 2

9.0 Power scenario in Tamil Nadu

The generating capacity connected to TNEB's grid including the allocation from Central Generating Station is 10122 MW as on 31-12-2009 comprising 2970 MW from TNEB's four thermal stations, 424 MW from four gas turbine stations, 2187 MW from 33 hydro stations, 17.55 MW from TNEB's wind farm, 1180 MW from private sector power projects, 214 MW as contribution to Tamil Nadu grid by sale of electricity from captive generating plants, 2825 MW as Tamil Nadu's share from central generating stations and 305 MW as external assistance.

Generating capacity from privately owned wind farms is 4579.24 MW as on 31-12-2009. The installed capacity of cogeneration in sugar mills is 466.10 MW and biomass power project is 147.55 MW as on 01-12-2009.

The average power availability during the year 2009-10 (Up to December 2009) is around 8400 MW. The expected peak demand will be around 10,500 MW which leaves a deficit of around 2100 MW. Therefore, any capacity addition will help the State to a great extent to tide over the shortage of power prevailing in the State.

10.0 Applicability of this order

In line with the Commission's earlier orders on renewable energy, the proposed order shall come into force from the date of issue. The tariff fixed in the proposed order shall be applicable to all the Solar Energy Generators (SEGs) with installed capacity of 1 MW and up to 3MW having grid connectivity at HT level (below 33 kV) of the distribution network, commissioned on or after the date of this order and before the end of the control period.

It should be noted that the existing contracts and agreements between the SEGs and the distribution licensees signed prior to this order would continue to remain in force. However, the SEGs and the distribution licensees shall have the option to mutually re-negotiate the existing agreements / contracts in line with this order before the expiry of the contracts / agreements. Any renewal of the said contracts / agreements, new contracts / agreements shall be in conformity with this order. The tariff would be with reference to the date of commissioning and the rate in force on that day.

11.0 Tariff Determination Process

In exercise of the powers conferred under section 61(h) read with section 86(1)(e) and section 181 of the Electricity Act, 2003, the Commission notified the "Power Procurement from New and Renewable Sources of Energy Regulations 2008" on 8-2-2008. Clauses 4(2) and 4(3) of the said Regulations read as below:

"4(2) While deciding the tariff for power purchase by distribution licensee from new and renewable sources based generators, the Commission shall, as far as possible, be guided by the principles and methodologies specified by:

Consultative Paper on "Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level"

- (a) Central Electricity Regulatory Commission
- (b) National Electricity Policy
- (c) Tariff Policy issued by the Government of India
- (d) Rural Electrification Policy
- (e) Forum of Regulators (FOR)
- (f) Central and State Governments”

The following portions of the regulation are also relevant:

“(3) The Commission shall, by a general or specific order, determine the tariff for the purchase of power from each kind of new and renewable sources based generators by the distribution licensee

(5) While determining the tariff, the Commission shall adopt appropriate financial and operational parameters.

(6) While determining the tariff the Commission may adopt appropriate tariff methodology.”

The MNRE’s draft guidelines for Rooftop PV and other small Solar Power Plants connected to distribution network (below 33 kV) under Jawaharlal Nehru National Solar Mission specified that the Solar project schemes from States wherein Tariff tenure for duration of 25 years with tariff structure on **levellised basis has been determined by SERCs shall alone be considered** to be eligible to participate in this Programme.

Therefore, it is proposed by the Commission to adopt levellised tariff as adopted by CERC in their order dated 03-12-2009. Levellised Tariff is calculated by carrying out levellisation for ‘useful life’ duly considering the discount factor for time value of money. The discount factor considered for this purpose is equal to the weighted average cost of the capital on the basis of normative debt: equity

ratio (70:30) specified in the Regulations. Considering the normative debt equity ratio and weighted average of the rates for interest and equity component, the discount factor is calculated. Net levelled tariff is calculated after adjusting for accelerated depreciation benefit (if availed) from the levelled tariff.

At this juncture it is also relevant to discuss the following stipulations of National Tariff Policy which are reproduced below:

***Para 6.4(1):** Pursuant to provisions of section 86(1)(e) of the Act, the appropriate Commission shall fix a minimum percentage for purchase of energy from such sources taking into account availability of such resources in the region and its impact on retail tariffs. Such percentage for purchase of energy should be made applicable for the tariffs to be determined by the SERCs latest by April 1, 2006. It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the appropriate Commission.*

***Para 6.4(2):** Such procurement by distribution licensees for future requirements shall be done, as far as possible, through competitive bidding process under Section 63 of the Act within suppliers offering energy from same type of non-conventional sources. In the long-term, these technologies would need to compete with other sources in terms of full costs*

Germany, Spain and the USA are leaders in developing technology for solar based electricity generation. This development has become possible in the above countries due to feed-in tariff adopted by them which is comparatively higher than the cost of generation from other sources. The cost of solar energy has been on the decline since the technology was first introduced in the market. Even then, in most cases, solar energy cannot yet compete with electricity generated from fossil fuels. Though it is expected that the cost of electricity

generated from fossil fuels would keep rising, it is still very important to maintain a strong momentum in bringing down the cost of solar energy. Till such time, appropriate feed-in tariff for promoting solar energy would be necessary. The Forum of Regulators, which is a body consisting of Chairmen of all State Electricity Regulatory Commissions and the Chairman of the Central Electricity Regulatory Commission considered this issue and has recommended that cost based tariff on reasonable norms should be permitted for renewable energy. The Commission endorses this recommendation of the Forum of Regulators and decides to continue the present system of preferential tariff.

12.0 Components of tariffs

The Power Procurement from New and Renewable Sources of Energy, 2008 Regulations of the Commission specifies that while determining the tariff, the Commission shall adopt appropriate financial and operational parameters. The tariff, if determined in a cost-plus scenario, would depend significantly on the following operating and financing parameters. The key drivers of cost are:

1. Capital Cost
2. Capacity Utilization Factor
3. De-Rating Factor
4. Debt-equity ratio
5. Term of the loan
6. Interest rate on loan
7. Interest on working capital
8. Return on equity
9. Life of plant and machinery
10. Depreciation of plant and machinery

11. Operation and maintenance expenditure.

12. Auxiliary Consumption.

Each of the above parameters is discussed below in detail.

12.1 Capital Cost

Capital cost is one of the most important parameters for solar power tariff determination. The cost of a solar power project is mainly dependent on the cost of PV modules / plant and machinery, technology adopted, location of the site and capacity. Over and above, there is a very limited experience in this area of generation. The capital cost (in Rupees Crores/MW), available as on date are:

| Organisation | Reference | Capital cost per MW for Solar PV based Generation | Capital cost per MW for Solar thermal generation |
|----------------------|--|--|--|
| KERC | Draft 27-8-08 | Rs 22.5 crs | Rs 22.5 crs |
| UPERC | Order 27-6-08 | Rs 18 crs | |
| GERC | Order 29-01-2010 | Rs 16.50 crs | Rs 13 crs |
| TEDA | | Rs 18-24 crs | Rs 14-16 crs |
| IREDA | Lr dt 4-6-09 | Rs 18-20 crs (thin film tech) and Rs 22-25 crs for crystalline | Rs 15-20 crs |
| CERC | NCES Regulations dated 16-09-2009 (Order dated 25.02.2010 in Petition no. 13/2010) | Rs 16.90 crs | Rs 15.30 crs |
| Petition before RERC | | Rs 20.06 to 21.15 crs | |

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

With further development in technology and economies of scale, production costs for Solar Energy Projects may decline and be competitive or at least comparable to other renewable energy options. Commission is of the opinion that the capital cost suggested by CERC is reasonable. **Therefore, Commission proposes to consider a capital cost of Rs. 16.90 Crores / MW for solar photovoltaic power project and Rs. 15.30 Crores / MW for solar thermal power project as suggested by CERC in their order dated 25-02-2010.**

12.2 Capacity Utilization Factor (CUF)

CUF is the ratio of actual energy generated by the Solar PV / Thermal project over the year to the equivalent energy output at its rated capacity over the yearly period. CUF for Solar PV project depends on solar radiation and number of clear sunny days. Further, the CUF depends on site specific parameters like insolation, ambient conditions, conversion efficiencies of PV cell, etc. The information on CUF, available as on date are:

| Organisation | CUF for PV based Generation | CUF for thermal generation |
|----------------------|-----------------------------|----------------------------|
| KERC | 21% | 21% |
| UPERC | 18.26% | |
| GERC | 20% | 25% |
| TEDA | 20-22% | 22-27% |
| IREDA | 15-20% | 25-30% |
| CERC | 19% | 23% |
| Petition before RERC | 20.34% - 21.69% | |

The Central Electricity Regulatory Commission has considered average number of clear sunny days of around 300 and daily average global solar radiation to be around 5.8 kWh/Sq.mtr/day.

During the Round Table Conference, experts opined that CUF varies from 15 to 20% for Solar photovoltaic & 20 to 30% for Solar Thermal. M/s.ACME Ltd, Gurgaon during their presentation to the Commission on 27-04-2009 indicated a CUF of 22% for concentrated solar power tower technology in Tamil Nadu.

As the solar insolation level in Rajasthan is slightly higher than in Tamil Nadu, the Commission proposes to consider a CUF of 19% for solar PV project and 23% for solar thermal project as recommended by CERC in their Terms and Conditions for Tariff determination from Renewable Energy Sources Regulations, 2009

12.3 De-Rating Factor

Derating factor has not been foreseen by other State Commissions / CERC and even the promoters who have filed petitions before RERC / GERC. Being a new area without information on past performance parameters, fixation of derating factor for a Solar PV / Thermal Plant can only be a very approximate figure and on the basis of similar equipments. As such, wind energy generators are allowed 1 % as a derating factor after 10 years. Wind generators are not static equipment like the solar equipments. However the allowed rate is minimum. **Hence, the Commission proposes to adopt 1% derating factor for every year after 10 years of operation for solar PV / Thermal Power Plants.**

12.4 Debt - equity ratio

As per the guide lines specified in the tariff policy for financing of future capital cost of projects, a debt: equity ratio of **70:30 should be adopted.** This ratio has

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

been adopted by most other Commissions. It is proposed to retain the same for the proposed tariff order for solar power projects.

12.5 Term of the loan

CERC in their regulation has proposed loan tenure of 10 years. IREDA loans are available with the term structure of 10 years with a moratorium of one year. The Commission in its Order Nos.1, 2 and 3 of 2009 for wind, biomass and bagasse based co-generation energy tariff determination, have considered the **terms of loan as 10 years with one year moratorium period.** Therefore, it is proposed to retain the same for the proposed tariff order for solar power projects also.

12.6 Interest rate on Loan

The Commission in its Order Nos.1, 2 and 3 of 2009 for wind, biomass and bagasse based co-generation energy tariff determination, adopted an interest rate of 12%. Interest rates adopted by others are tabulated below:

| Organisation | Interest Rate |
|----------------------|---|
| KERC | 8% |
| UPERC | 8% |
| GERC | 10.75% |
| IREDA | 11.75 – 12.90% |
| CERC | Long Term Prime Lending Rate (LTPLR) of State Bank of India (SBI) prevalent during the previous year plus 150 basis points. |
| Petition before RERC | 12.50 – 13.25% |

Considering the above, Commission proposes an interest rate of 12%.

12.7 Interest on Working Capital

The Central Electricity Regulatory Commission has included the following components in working capital in their Regulations, 2009:

- (i) Operation and Maintenance expenses for one month;
- (ii) Maintenance spares @ 15% of the O&M expenses,
- (iii) Receivables equivalent to 2 months of energy charges for sale of electricity calculated on the normative CUF;

CERC fixed an interest rate equivalent to average State Bank of India short term PLR during the previous year plus 100 basis points.

The GERC in their order No. 2/2009 have considered the following components for working capital requirement:

1. Receivables equivalent to one month's energy charges for sale of electricity calculated on a normative CUF.
2. One month's cost on operation and maintenance expenses.

The interest rate on working capital considered by GERC is 11.75% per annum. The interest rates for working capital adopted by the various promoters, who have filed petitions before the RERC for determination of solar power tariff, are given below:

| Sl. No. | Name of the promoter | Interest rate in %. |
|---------|-----------------------------|--|
| 1 | M/s. OPG ENERGY (P) Ltd. | --- |
| 2 | SWISS PARK VANIJYA (P) Ltd. | --- |
| 3 | M/s Videocon Industries Ltd | 8% O&M – 1 month Receivables - 1½ months |

In the Commission's latest order Nos. 2 and 3 of 2009, receivables equivalent to one month of energy charges was included in the working capital as the distribution licensee has to make payment to the generator within 30 days of receipt of the bill. Regarding the components of the working capital, it is the general opinion that the spares required for solar PV project is very low (or practically negligible) compared with the solar thermal projects.

Considering the above, Commission proposed to adopt an interest rate of 12% on working capital as considered in order No. 2 and 3 of 2009 by the Commission along with the following working capital component:

| Solar PV | Solar Thermal |
|---|---|
| <u>(i) Operation and Maintenance expenses for one month;</u> | <u>(i) Operation and Maintenance expenses for one month;</u> |
| <u>(ii) Maintenance spares @ 1% of the O&M expenses;</u> | <u>(ii) Maintenance spares @ 15% of the O&M expenses;</u> |
| <u>(iii) Receivables equivalent to 1 month of energy charges for sale of electricity calculated on the normative CUF.</u> | <u>(iii) Receivables equivalent to 1 month of energy charges for sale of electricity calculated on the normative CUF.</u> |

12.8 Return on equity

The Tariff Regulations of the Commission stipulate 14% post tax RoE for conventional fuel based generating stations. With the objective of promoting renewable energy, Commission in its Order Nos.1, 2 and 3 of 2009 for wind, biomass and bagasse based co-generation energy tariff determination have considered a 19.85% pre-tax return on equity from 01-04-2009, which was arrived on the basis of CERC's rate of 15.5% post-tax in its Terms and

Conditions of Tariff, Regulations for 2009. The RoE adopted by others are given below:

| Name of the ERC | RoE |
|------------------------|---|
| Kerala | 14% Post Tax |
| UP ERC | 14% Post Tax |
| GERC | 14% Post Tax |
| CERC | 19% Pre-Tax for the first 10 years 24% Pre-Tax from the 11 th year onwards. |

Commission proposes to adopt the same rate of 19.85% pre-tax RoE for the solar power projects also. If tax exemptions are provided by GoI, the RoE shall be revised accordingly.

12.9 Life of plant and machinery

During the Round Table Conference, experts suggested the expected life time as 20-25 years. The table below summarizes the life of the solar plants that has been considered by others.

| Organization | Life Span |
|----------------------|---------------------|
| KERC | 20 years |
| UPERC | 20 years (solar PV) |
| GERC | 25 years |
| TEDA | 20 years |
| CERC | 25 years |
| Petition before RERC | 25 years |

Based on the above, Commission proposed to consider the plant life of 25 years for the solar power projects.

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

12.10 Depreciation of plant and machinery

The CERC's regulations recommended 'Differential Depreciation Approach' over loan tenure and period beyond loan tenure over useful life computed on 'Straight Line Method'. The depreciation rates that have been used by others are summarized in the table below:

| Organization | Depreciation |
|----------------------|---|
| KERC | 4.5% |
| UPERC | 4.5% |
| GERC | 6% of project cost for the initial 10 years and 2% from 11th year to 25th year of the plant |
| CERC | 7% for the initial 10 years and 1.33% for the remaining years |
| Petition before RERC | 5.28% |

It is proposed to adopt the rate prescribed in the CERC's regulation, i.e. depreciation rate of 7% for the initial 10 years and 1.33% for the remaining years.

12.11 Operation and maintenance expenditure

The O&M expense includes the expenditure on manpower, repairs, spares, consumables, insurance and overheads. The O&M expense assumed by others are tabulated below:

| Name of the ERC | O&M expenses (including insurance) |
|-----------------|--|
| Kerala | 0.5% of the capital investment |
| UP ERC | 1.5% of the capital cost with 6% annual escalation. |
| GERC | Solar PV: 0.5% of the capital cost (Rs. 8.25 lakhs) for the first year with escalation of 5% per annum. |

| | |
|----------------------|--|
| | Solar Thermal: 11%of the capital cost (Rs. 13 lakhs) for the first year with escalation of 5% per annum. |
| CERC | Solar PV: Rs.9.00 Lakhs per MW for the 1 st year (2009-10) and shall be escalated at the rate of 5.72% per annum for the remaining periods. Solar Thermal: Rs.13.00 Lakhs per MW for the 1 st year (2009-10) and shall be escalated at the rate of 5.72% per annum for the remaining periods. |
| Petition before RERC | 1.25% - 1.5% of the capital cost with 5.72% escalation per annum. |

Considering the above, it is proposed to adopt the rate prescribed in the CERC's regulation with escalation rate for the year 2009-10. i.e. **O&M expenses for solar PV projects for the first year of the Control period (2010-11) shall be Rs.9.515 Lakhs per MW and shall be escalated at the rate of 5.72% per annum for the remaining periods. The O&M expenses for solar thermal power projects for the first year of the Control period (2010-11) shall be Rs.13.74 Lakhs per MW and shall be escalated at the rate of 5.72% per annum for the remaining periods.** No separate Renovation & Modernization works are contemplated during the entire life of the project.

12.12 Auxiliary Consumption

The CERC and GERC have adopted the auxiliary consumption of **10% for solar thermal power projects.** The, Commission proposes to adopt the same in this order for solar thermal projects.

Similarly, the auxiliary consumption for solar PV power plant is also to be considered to meet the auxiliary power requirement for equipments/devices for cooling of the power conditioning units, lighting of office ,station yard, water

sprinklers, monitoring and control units & power conditioning units, station stand-by battery chargers, invertors, communication services etc. The auxiliary consumption requirement for solar PV power station is lower than the solar thermal power plant. **Therefore, Commission believes that 2% of auxiliary consumption is sufficient for solar PV power plants.**

13.0 Tariff rate

Many of the SERCs have not announced new tariff based on the National Solar Mission except Gujarat. The tariff rate adopted by the other ERC's for the solar photovoltaic and solar thermal by considering MNREs guidelines dated 29-01-08 on generation based incentives of Rs.12.00 & Rs.10.00 for the SPV & ST respectively commissioned before 31-12-2009 and Rs.11.40 & Rs.9.50 for the SPV & ST respectively commissioned after 31-12-2009 are given below:

| Name of the ERC'S | Date of order | Solar Photovoltaic Power Plants | Solar Thermal Power Plants |
|-------------------|---------------|---|---|
| Rajasthan ERC | 02.04.08 | 1) Rs.15.78/kWh (commissioned upto 31.12.09). 2) Rs.15.18/kWh (commissioned after 31.12.09 but by 31.03.10). * Tariff shall be for a period of 10 years. 3) Rs.15.60/kWh (Projects not covered under Gol scheme) | 1) Rs.13.78/kWh (commissioned upto 31.12.09). 2) Rs.13.18/kWh (commissioned after 31.12.09 but by 31.03.10). * Tariff shall be for a period of 10 years. 3) Rs.15.60/kWh (Projects not covered under Gol scheme) |
| Haryana ERC | 25.04.08 | 1) Rs.15.96/kWh (commissioned upto 31.12.09, fixed for 5 years) 2) Rs.15.16/kWh (commissioned after 31.12.09, but by 31.03.2010 fixed for 5 years) *Tariff is without considering subsidy/ incentive. | - |
| Uttar Pradesh | 27.06.08 | Rs.15.00/kWh (for 20 years, commissioned before 31.12. | Rs.13.00/kWh (for 20 years, commissioned |

| | | | |
|----------------------|----------|---|---|
| ERC | | 2011). | before 31.12. 2011). |
| Chhattisgarh ERC | 08.09.08 | Rs.15.84/unit (commissioned upto 31.12.2010, levelised upto 31.08.2018). | Rs.13.26/unit (commissioned upto 31.12.2010, levelised upto 31.08.2018). |
| Andhra Pradesh ERC | 29.09.08 | - | Rs.7/kWh escalated by WPI on annual basis for next 10 years |
| Andhra Pradesh ERC | 29.12.08 | Rs.3.70/kWh escalated by WPI on annual basis for next 10 years. | - |
| Karnataka ERC | 26.11.08 | Rs.15.40/unit (commissioned before 31.12.2009) and Rs.14.80/unit (commissioned after 31.12 .2009) valid for 10 years | Rs.13.40/unit (commissioned before 31.12.2009) and Rs.12.90/unit (commissioned after 31.12 .2009) valid for 10 years. |
| Gujarat ERC | 29-01-10 | Rs.15/kWh for the initial 12 years and Rs.5/kWh for the remaining periods. | Rs.11/kWh for the initial 12 years and Rs.4/kWh for the remaining periods. |
| Himachal Pradesh ERC | 13.02.09 | Rs.14.87/kWh (commissioned before 31.12.2009) and Rs.14.27/unit (commissioned after 31.12 .2009) valid upto 11 th plan period with annual escalation @ 5%. | Rs.12.87/kWh commissioned before 31.12.2009) and Rs.12.37/unit (commissioned after 31.12 .2009) valid upto 11 th plan period with annual escalation @ 5% |
| CERC | 03-12-09 | Net Levelled Tariff upon adjusting for accelerated Depreciation benefit (if availed) is Rs.17.14/kWh | Net Levelled Tariff upon adjusting for accelerated Depreciation benefit (if availed) is Rs.12.54/kWh |
| CERC (Draft order) | 26-02-10 | Net Levelled Tariff upon adjusting for accelerated Depreciation benefit (if availed) is Rs.14.95/kWh | Net Levelled Tariff upon adjusting for accelerated Depreciation benefit (if availed) is Rs.12.85/kWh |
| Petition before RERC | --- | Rs.18.13/kWh to Rs.20.02/kWh. | --- |

The Chairman & Managing Director/TEDA has suggested a tariff for solar power @ Rs.15/unit which includes MNREs incentives.

The financial and operating parameters proposed in this paper and the levelled tariff for 25 years duly deducting the levelled accelerated depreciation benefit for SPV and ST projects are tabulated below:

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

| Description of financial and operating parameters | Values proposed in the paper for the financial and operating parameters for the Solar PV Projects to be Commissioned in the forthcoming control period | Values proposed in the paper for the financial and operating parameters for the Solar thermal Projects to be Commissioned in the forthcoming control period |
|---|---|---|
| Capacity Utilization Factor | 19% | 23% |
| Life of the plant | 25 years | 25 years |
| Derating Factor | 1% for every year after 10 years of operation | 1% for every year after 10 years of operation |
| Project Capital cost / MW | 16.90 Crores | 15.30 Crores |
| Debt: Equity ratio | 70 : 30 | 70 : 30 |
| Interest on Loan | 12% | 12% |
| Return on Equity | 19.85% | 19.85% |
| Loan Repayment period | 10 years with one year moratorium | 10 years with one year moratorium |
| O&M Charges | Rs.9.515 Lakhs per MW with 5.72% escalation per annum. | Rs.13.74 Lakhs per MW with 5.72% escalation per annum. |
| Depreciation | 7% for the initial 10 years and 1.33% for the remaining years | 7% for the initial 10 years and 1.33% for the remaining years |
| Residual Value | 10% | 10% |
| Auxiliary Consumption | 2% | 10% |
| Interest on working capital | (i)Operation and Maintenance expenses for one month; (ii) Maintenance spares 1% of the O&M expenses, (iii)Receivables equivalent to 1 month of energy charges with 12% interest. | (i)Operation and Maintenance expenses for one month; (ii)Maintenance spares @ 15% of the O&M expenses, (iii)Receivables equivalent to 1 month of energy charges with 12% interest. |
| Cost plus single part levellised average tariff for 25 years | Rs. 17.10 / kWh. (Annexure-3) | Rs. 14.38 / kWh. (Annexure-4) |

Projects availing the benefit of Section 80 IA of the Income Tax Act, 1961, the Minimum Alternate Tax (MAT) @ 16.995% (15% MAT+10% surcharge+3% education cess) for the first ten years and thereafter the normal tax rate @ 33.99% (30% IT rate+ 10% surcharge +3% Education cess) has been considered. For the purpose of determining net depreciation benefits, depreciation @ 5.28% as per straight line method (Book depreciation as per Companies Act, 1956) has been compared with depreciation as per Income Tax rate i.e. 80% of the written down value method and depreciation for the first year has been calculated at the rate of 50% of 80% i.e. 40%, as project is capitalized during the second half of the financial year as per proviso (ii) to Regulation 22 of Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2009.

Tax benefit has been worked out as per the MAT rate for the first 10 years and normal tax rate for the remaining years on the net depreciation benefit. Per unit levellised accelerated depreciation benefit has been computed considering the weighted average cost of capital as discount factor. The rates worked out by the Commission are as follows:

| | Levellised total tariff in Rs./kWh | Benefit of Accelerated depreciation, if availed in Rs./kWh | Net Levellised Tariff upon adjusting for accelerated Depreciation benefit, (if availed) in Rs./kWh |
|---------------|------------------------------------|--|--|
| Solar PV | 18.19 | 1.09 | 17.10 |
| Solar Thermal | 15.27 | 0.89 | 14.38 |

When a solar plant is covered under this GoI incentive scheme, GBI shall be paid by IREDA to the Distribution Licensee. The GoI has restricted the promotional capacity of Rooftop PV and other small Solar Power Plants to maximum of 20 MW aggregate in a State under GBI scheme. It is not sure that the above capacity of solar power under GBI scheme shall come to Tamil Nadu. At the same time, the distribution utility has obligation to meet out the solar RPO prescribed by the Commission. Therefore, to meet out the Solar RPO prescribed by the Commission, the distribution utility in the State may purchase solar power, which do not come under GBI scheme. In such a situation, there can be higher capacity additions of solar power plants in the State without any support of such an incentive scheme. Therefore, the promoters should not be discouraged for want of such a scheme. Under such conditions, the tariff should not be less than the rate worked out by the Commission. Therefore, payout tariff for solar power shall be as in table given below:

| Plants covered under GOI scheme | Payout tariff for Solar PV for 1 st year (Rs. / kWh) | | Payout tariff for Solar Thermal for 1 st year (Rs. / kWh) | |
|---|---|-------|--|------|
| | Licensee | GOI | Licensee | GOI |
| Plants covered under MNRE GBI scheme. | 5.46 | 11.64 | 7.34 | 7.04 |
| Plants not covered under MNRE GBI scheme. | 17.10 | --- | 14.38 | --- |

In case additional capacity becomes available under the GBI scheme, the benefit of the same shall be passed on to the licensee.

14.0 Related Issues

The following are the issues related to solar power generation:

1. CDM benefits
2. Reactive power charges
3. Grid availability charges
4. Harmonics
5. Billing and payments
6. Payment security to the SEGs
- 7 Metering and communication arrangements
8. Evacuation arrangement
9. Energy purchase agreement
10. Renewable energy purchase obligation
11. Tariff Review Period / Control Period
12. Renewable Energy Certificate
13. Other issues

14.1 CDM Benefits

The Forum of Regulators has recommended that CDM benefits should be shared on gross basis starting from 100% to developers in the first year and thereafter reducing by 10% every year till the sharing becomes equal (50:50) between the developer and the consumer in the sixth year. Thereafter, the sharing of CDM benefits will remain equal till such time the benefits accrue. The Commission adopted this formula in its order No. 1 of 2009 on comprehensive tariff order on wind energy. Commission proposes the same formula for solar power projects. STU / Distribution Licensee shall account for the CDM receipts in the next ARR filing.

14.2 Reactive Power Charges

Commission in its tariff order No. 2 and 3 of 2009 on biomass and bagasse based Co-generation has fixed the reactive energy charges as prescribed in Indian Electricity Grid Code. Commission has proposed to adopt the same charges for solar power generation also.

14.3 Grid Availability Charges

Commission fixed grid availability charges such as startup power, standby power, energy charges and demand charges as per order No. 2 dated 15-05-2006 to biomass and bagasse based Co-Gen power plants issued recently vide order No. 2 and 3 of 2009. The Commission proposes to retain the same charges for solar power projects also.

14.4 Harmonics

The SEGs (solar PV projects) shall take necessary steps to restrict the harmonic generation within the limit of Technical Standards for connectivity to the grid Regulations, 2007 of the CEA applicable to the Distribution Licensee and bulk consumers.

14.5 Billing and Payment

As adopted in the Commission's Order No.1 of 2009 dated 20-03-2009, when a SEG sells power to the distribution licensee, the generator shall raise a bill every month for the net energy sold after deducting the charges for start up power. The distribution licensee shall make payment (Tariff portion of Distribution Licensee) to the generator within 30 days of receipt of the bill. Any delayed payment

beyond 30 days is liable for interest at the rate of 1% per month calculated on daily basis.

For claiming the Generation Based Incentive (GBI), the Distribution Utility shall submit the Certificate of Generation to the Programme Administrator (IREDA). The basis for claim for GBI shall be in accordance with the GBI scheme envisaged under these Guidelines for Rooftop PV & Small Solar Generation Programme (RPSSGP). The Certificate of Generation shall pertain to monthly meter readings, however the claim for GBI may be submitted on quarterly basis, by 15th July (for Q1), 15th Oct (for Q2), 15th Jan (for Q3) and 15th Apr (for Q4). The claim for GBI by Utilities shall be accompanied by documentary evidence of payment of electricity bill to the Project Proponent for the relevant monthly period.

14.6 Payment Security to the SEGs

The National Tariff Policy calls for adequate and bankable security arrangements to generating companies. This mechanism has been found impractical, as there are a large number of individual generators (particularly wind energy generators) in Tamil Nadu and it will be difficult for the Distribution Licensee to offer security for such a large number. Therefore, as adopted by the Commission in its order No. 1 of 2009 dated 20-03-2009, penalty of 1% per month for delayed payment by the licensee to the SEGs is proposed.

14.7 Metering and Communication Arrangements

The metering and communication shall be in accordance with the following:

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

- (1) Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006
- (2) Tamil Nadu Electricity Distribution Code 2004
- (3) Tamil Nadu Grid Code 2004
- (4) Tamil Nadu Electricity Intra State Open Access Regulations 2005

14.8 Evacuation arrangement

As per the Commissions Regulations on “Power Procurement from New and Renewable Sources of Energy, 2008”, it is the duty of the STU / Distribution Licensee to develop the evacuation facilities for SEGs. The relevant portions of the regulations are reproduced below:

“3(3) Evacuation facilities shall be provided by the State Transmission Utility (STU) /Distribution licensee as per the Commission’s Intra State Open Access Regulations 2005, Central electricity Authority (Technical Standards for connectivity to the Grid) Regulations, 2006 and Tamil Nadu Electricity Grid Code. The cost of interfacing lines, switch gear, metering, protection arrangement and related other equipments up to the interconnection point shall have to be borne by the generators, but the work shall be executed by STU/distribution licensee. The developer may be permitted to execute the works as per the terms and conditions of the STU/Licensee.

Provided that, in the case of sale of entire power to the distribution licensee by any new and renewable source based generator, the cost of interfacing lines up to the interconnection point shall have to be borne only by the STU/ distribution licensee.

Provided further that in case where the new and renewable source based generator referred to in the first proviso who has entered into an EPA with the distribution licensee referred to therein for the sale of entire power to the said distribution licensee decides to use such power agreed to be sold to the said distribution licensee, for his captive use or for sale of such power to a third person or to a distribution licensee other than the distribution licensee referred to above before the expiry of the period referred to in such EPA, then he shall be bound to reimburse the depreciated (Written down value) cost of interfacing lines to the distribution licensee with whom he has executed such EPA, before

the wheeling of power to his captive use or sale to third person or distribution licensee other than the distribution licensee with whom the said EPA has been executed by him”

Further, as per the MNRE’s proposed draft guidelines for Rooftop PV and other small Solar Power Plants connected to distribution network (below 33 kV) under JNNSM, the distribution utility has to provide necessary approvals and infrastructure for evacuation of the power generated.

14.9 Energy Purchase Agreement

The Distribution Licensee shall execute the Energy Purchase Agreement as per the format already communicated to them within a month of receipt of application from the generator. The parties to the agreement may be given the option of exit in case of violation with three months notice to the other party. The agreement period shall be co terminus with the life of the project.

14.10 Renewable Purchase Obligation

With regard to fixing of minimum purchase requirement from NCES, the following important factors have to be considered:

- Total quantum of energy required for the State
- Total potential for renewable energy generation in the State
- Quantum of renewable energy being generated
- Power purchase tariff for renewable energy
- Firm or infirm nature of the NCES power
- Quantum of penetration of NCES power and its impact on the grid
- Commercial impact on retail tariffs due to purchase of renewable power

Considering the above, Commission in its order No.1 of 2009 dated 20-03-2009 fixed Renewable Energy Purchase Obligation at minimum of 13% for 2009-10 and minimum of 14% for 2010-11 for the distribution licensee from NCES sources out of his total consumption in his area of supply as required by Section 86(1)(e) of the Act.

The Ministry of Power, Government of India has proposed to amend the clause 6.4 (1) of the National Tariff Policy to specify 0.25% solar RPO with effect from 1.4.2010 and 3% by 2022 as mentioned in the National Solar Mission. The proposed amendment also specifies the introduction of solar specific Renewable Energy Certificate (REC) mechanism.

Therefore, it is proposed to fix the following minimum quantum of solar renewable purchase obligation in percentage out of the total renewable purchase obligation:

| Sl.No. | Year | Minimum quantum of solar renewable purchase obligation in percentage out of the total renewable purchase obligation. (in terms of energy in kWh) |
|---------------|-------------|---|
| 1 | 2010-11 | 0.25% |
| 2 | 2011-12 | 0.30% |

14.11 Tariff Review Period / Control Period

With regard to tariff Review Period / Control Period, the specific provisions of Regulation 6 of Regulations on “Power Procurement from New and Renewable Sources of Energy, 2008” are reproduced below:

Consultative Paper on “Comprehensive Tariff Order for Solar Photovoltaic and Solar Thermal Power Plants up to 3 MW having grid connectivity below 33 kV level”

*“The tariff determined by the commission in the tariff order shall be applicable for the power purchase agreement period of **twenty years**. The control period may ordinarily be **two years**. When the Commission revisits the tariff and allied issues after the control period, the revision shall be applicable only to the generator of new and renewable energy sources commissioned after the date of such revised order”*

14.12 Renewable Energy Certificate

The Forum of Regulators (FOR) has evolved a Renewable Energy Certificate (REC) mechanism at national level which will facilitate the interstate transaction of RE sources and hence further accelerate the RE development in India. This mechanism entails model Regulations to be adopted by State Electricity Regulatory Commissions to recognize the REC as a valid instrument for compliance under RPO obligations and to have uniform approach over obligated entities and compliance for RPO. Commission is in the process of issuing draft Renewable Purchase Obligation and its compliance Regulations, 2010. The CERC has already issued Terms and Conditions for recognition and issuance of Renewable Energy Certificate for Renewable Energy Generation Regulations, 2010 to institutionalize the REC mechanism at national level.

14.13 Other Issues

In the case of solar power, due to its high cost of generation, either captive use or third party sale may not be feasible for the present and during the proposed control period of two years. Hence the following issues (which are applicable only when the generated power from solar is used either for captive use or third party sale) have not been discussed:

- i. Categorizing the generated power as firm or infirm

- ii. Banking
- iii. Transmission and wheeling charges
- iv. Cross subsidy surcharge
- v. Adjustment of energy generated
- vi. Scheduling and system operation charges
- vii. Application fees and Agreement fees
- viii. Payment security to the Distribution Licensee
- ix. Power factor incentive / disincentive
- x. Energy wheeling agreement

**Assistant Secretary
Tamil Nadu Electricity Regulatory Commission.**

Annexure 1

Promotional features envisaged in the Act and Policies on Electricity

1. The Electricity Act, 2003:

Section 3(1) of the Electricity Act, 2003 States that *the Central Government shall, from time to time, prepare the National Electricity Policy and tariff policy, in consultation with the State Governments and the Authority for development of the power system based on optimal utilization of resources such as coal, natural gas, nuclear substances or materials, **hydro and renewable sources of energy.***

The section 4 of the Electricity Act, 2003 stipulates that *the Central Government shall, after consultation with the State Governments, prepare and notify a national policy, **permitting stand alone systems (including those based on renewable sources of energy and non-conventional sources of energy) for rural areas.***

Section 61(h) of the Electricity Act provides that while specifying the terms and conditions of determination of tariff, regulatory commission shall also be guided by the promotion of cogeneration and generation of electricity from renewable sources of energy, and National Electricity Policy and National Tariff policy by the Central government.

Section 86(1) (e) of the Act specifies that one of the functions of the Regulatory Commission is to promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with grid and sale of power to any person and also to specify for the purchase of electricity from such sources, a percentage of total consumption of electricity in the area of a distribution licensee.

2. National Electricity Policy:

Clauses 5.12.1 and 5.12.2 of the National Electricity Policy states that,

“5.12.1 Non-conventional sources of energy being the most environment friendly there is an urgent need to promote generation of electricity based on such sources of energy. For this purpose, efforts need to be made to reduce the capital cost of projects based on non-conventional and renewable sources of energy. Promoting competition within such projects can also reduce cost

of energy. At the same time, adequate promotional measures would also have to be taken for development of technologies and a sustained growth of these sources.

5.12.2 The Electricity Act 2003 provides that co-generation and generation of electricity from non-conventional sources would be promoted by the SERCs by providing suitable measures for connectivity with grid and sale of electricity to any person and also by specifying, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee. Such percentage for purchase of power from non-conventional sources should be made applicable for the tariffs to be determined by the SERCs at the earliest. Progressively the share of electricity from non-conventional sources would need to be increased as prescribed by State Electricity Regulatory Commissions. Such purchase by distribution companies shall be through competitive bidding process. Considering the fact that it will take some time before non-conventional technologies compete, in terms of cost, with conventional sources, the Commission may determine an appropriate differential in prices to promote these technologies”.

3. National Tariff Policy

Clause 6.4 of the Tariff Policy states that,

“.....It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission.

(2) Such procurement by Distribution Licensees for future requirements shall be done, as far as possible, through competitive bidding process under Section 63 of the Act within suppliers offering energy from same type of non-conventional sources. In the long-term, these technologies would need to compete with other sources in terms of full costs.

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

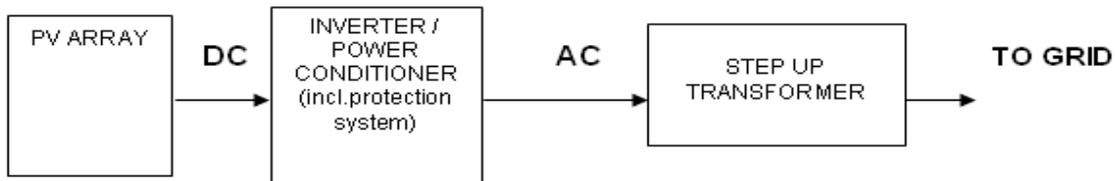
4. National Electricity Plan: The CEA while formulating the National Electricity Plan have recognized the large untapped potential of energy. The said plan states as under:: *“6.0 Our Country has significant potential for generation of power from Non-Conventional energy sources such as wind, small hydro,*

*biomass and solar energy. Limited availability of fossil fuels like coal and gas has further highlighted the importance of power from these sources. In addition, these sources provide a particularly attractive solution for meeting requirement of power at remote locations, in cases where it is not feasible to extend the grid. **All efforts are therefore being made to tap these resources for generation of power to supplement power from conventional sources.***

Annexure 2

Different types of solar power technology available

1. Grid Based PV Plant: Choice of Technology



The Photovoltaic (PV) array consists of several PV modules, each module having collection of PV cells that converts the light energy into electricity (DC Power). When the light rays fall on a solar cell, they penetrate into the solar cell and create a flow of electrons throughout the crystal structure. The crystal structure of silicon contains empty spaces (hole) which accepts these electrons. As one electron moves to fill a hole, it creates another hole and it is this flow of electrons which produces electricity. The generated DC voltage is converted into AC voltage through inverters combined with power conditioning unit and other protection systems and via HT Transformers and the power is fed into the grid. The grid connected solar photovoltaic power plants can deliver power into the grid, eliminating the need for batteries. By deploying solar tracking mechanism i.e., by rotating PV panels perpendicular to the angle of incidence of solar radiation (dual axis), more power generation can be achieved.

Based on the stage of development and technology, solar cells have been classified into two basic technology types. Both the technologies are suitable for grid based power production. The two technology types are:

(a) Crystalline silicon based technologies

(b) Thin film based technologies

Both the technologies are being deployed commercially internationally. Crystalline being used extensively in the past internationally and also in India, and with the advent of thin film technology the usage of this technology is more user friendly in tropical weathers.

(a) Crystalline Silicon based technologies

Crystalline silicon (c-Si) solar cells basically have a large surface area, are of a high quality. The main advantages of c-Si lies in their being tried and tested, having current industry leadership and thus wide scale familiarity in the user groups as well as among producers.

(b) Thin Film based technologies

The main materials that have been used for creating thin film based solar cells are cadmium telluride (CdTe), Copper Indium Gallium Selenide (CIGS), amorphous silicon and micro-amorphous silicon. These materials are applied in a thin film to a supporting substrate, such as glass or ceramics which, in turn, reduces material inputs and associated costs. These technologies hold promises for future cost reduction through higher conversion efficiencies and significantly reduced production costs. Thin films are expected to take up 30% of the market share by 2010 and most new manufacturers are looking towards thin film technologies for future investments.

As per report published by European Photovoltaic Industry Association (EPIA), a comparison of the cell / module efficiencies and the area required per kW installation for thin film and crystalline wafer technology respectively is presented in the table below:

| Technology | Thin film | | | | Crystalline wafer Based | |
|--|--------------------------|--------------------------|---------------------------------|---|-------------------------|-----------------------|
| | Amorphous Silicon (a-Si) | Cadmium telluride (CdTe) | Copper Indium deselenide CI(G)S | Amorphous Silicon and Multi Crystalline Silicon (a-Si/m-Si) | Mono crystalline | Multi crystalline |
| Cell efficiency at STC* | 5-7% | 8-11% | 7-11% | 8% | 16-19% | 14-15% |
| Module efficiency | --- | --- | --- | --- | 13-15% | 12-14% |
| Area needed per kW** (for modules) | 15 m ² | 11 m ² | 10 m ² | 12 m ² | App. 7 m ² | App. 8 m ² |
| <p>*Standard Testing Conditions : 25°C, light intensity of 1000 W/ m², air mass = 1.5.</p> <p>** kW = kilowatt. Solar PV products and arrays are rated by the power they generate at Standard Testing Conditions.</p> | | | | | | |

Some of the promoters have filed petitions before various State Commissions for determination of solar power tariff. The promoters name and their choice of technology are given below:

| Sl.No. | Name of the promoter | Choice of technology | Commission in which petition filed |
|--------|-------------------------|---|------------------------------------|
| 1 | M/s. OPG ENERGY (P) Ltd | The promoter has selected Amorphous Silicon (a-Si) photovoltaic (PV) modules due to their higher rate of absorption of solar rays as compared to the crystalline | Rajasthan ERC. |

| | | | |
|---|---|--|----------------|
| | | silicon (<i>x-Si</i>) variety. | |
| 2 | SWISS PARK VANIJYA (P) Ltd. | The promoter has selected Amorphous Silicon (<i>a-Si</i>) photovoltaic (PV) modules due to their higher rate of absorption of solar rays as compared to the crystalline silicon (<i>x-Si</i>) variety. | Rajasthan ERC. |
| 3 | M/s Videocon Industries Ltd | The promoter has considered and selected multi-crystalline photovoltaic technology for the project because it is easily available, easy to integrate, has lower maintenance cost and requires less area to install as against amorphous silicon thin film technology. | Rajasthan ERC. |
| 4 | M/s. Astonfield Solar (Gujarat) Pvt Ltd | The promoter has chosen Thin film modules (CdS / CdTe) because of the high temperature possibilities at site and the other associated benefits. | Gujarat ERC |

2. Grid connected Solar Thermal Power Plants

Internationally, there is very limited experience in the field of electricity generation utilizing solar thermal technology. However, efforts are underway at various countries across globe to increase share of solar thermal based power plant installations. Solar thermal technology is one of the most promising renewable energy sources of electricity. Solar thermal power plants, often also called as concentrating solar power (CSP) plants, produce electricity in much the same way as conventional power stations. The difference is that they obtain their energy input through concentrated solar radiation rather than fossil fuels.

The major components of a solar thermal electric power plant are:

1. Mirrors/reflectors for capturing the solar radiation.
2. Receiver, which collects the solar energy and converts it to heat.
3. Heat exchangers that converts the heat energy into steam.
4. Thermal Storage systems for storing heat energy (optional).
5. Steam driven (Rankine cycle) turbo generator for producing electricity.

Solar thermal power plants essentially consist of a solar collector field which collects the sun's radiant energy and focuses the concentrated energy on to a receiver. The receiver through a heat transfer mechanism uses the heat to generate steam. The steam is then used to drive a steam turbine which in turn generates power. A major advantage in solar thermal plant is the option to include a thermal storage system, i.e., before using the heat to generate steam, a part of the heat can be stored for later use. Storing heat energy is cheaper than storing energy in any other form. By building sufficiently large heat storage, it is possible to generate power even when the sun is not shining. Thermal energy storage systems can extend the operational time of solar thermal power plants, with 6 to 12 hours of storage. Thus solar thermal power can complement other

renewable energy sources, such as wind, which may not be available during peak hours.

Base loads and peak loads can be handled well and more importantly plant load factors will be similar to that of conventional power plants. If the solar collector field is increased by about 2 or 3 times that of nominal turbine capacity, it is possible to store as much as 16-18 hours worth of energy. Following are the types of CSP technology deployed in solar thermal systems towards achieving solar thermal power generation:

- a. Power tower
- b. Parabolic Trough
- c. Stirling Dish Engine

a) POWER TOWER

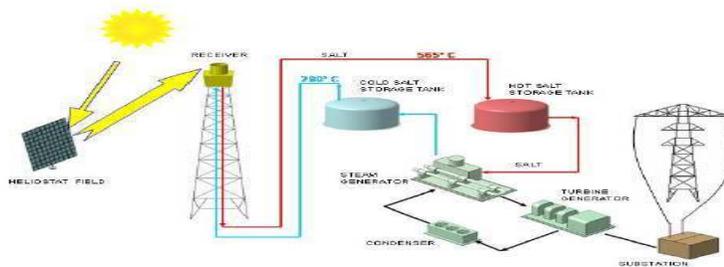


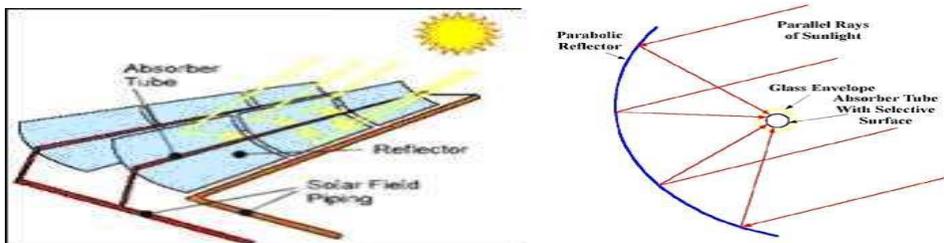
Figure 2. Solar TRES flow schematic

The solar power tower plant comprises of array of heliostats (mirrors) which concentrates the solar radiation to the top of the high tower where the solar receiver is located. Heliostats are 2-axis tracking mirrors, individually tracking the Sun through out the day to reflect the solar radiation onto the boiler. The receiver

collects the concentrated sun radiation and transfers the energy to generate steam to drive a conventional Rankine cycle steam power plant.

In a grid connected solar-thermal plant, hundreds of mirrors tracking the sun from east to west, concentrating sunlight onto the receiver are deployed to capture the heat energy.

b) TROUGH TYPE



Trough solar systems use parabolic curved/ trough shaped reflectors that focus the sun's energy on to a receiver pipe running at the focus of the reflector. The concentrated energy heats a heat transfer fluid (HTF), usually oil, flowing through the pipe. This fluid is then used to generate steam which powers a turbine that drives an electric generator.

To achieve high heat concentration ratio, the trough tracks the sun in one axis continually throughout the day. (To maximize the sunlight incident on the absorber, the reflectance of the parabolic reflector must be as high as possible, eg., say aluminum or silver reflectors.)

In all the types of Concentrated Solar Power technology discussed above, the thermal storage system facilitates in improving the capacity factor, by allowing the heat transfer fluid to store its energy in a large storage system like hot salt tank, containing molten salt or oil. (Molten salts are used due to their ability to store thermal energy and because they are liquid at standard atmospheric

pressure and temperature). The stored heat energy in the hot salt tank is used as a heat source for generation of power through turbines.

Considering the factors discussed above, it is to be stated that the Solar thermal power plant generation cost is governed mainly by the following factors:

1. Number of heliostats /parabolic Collectors deployed (including storage)
2. Reflectivity and cleaning-factor performance of the collector system.
3. Heat transfer fluid deployed
4. Tower height (in respect of power Tower)
5. Receiver system
6. Thermal Storage system (depending on hours of storage)

As interpolated from the web data on project announcements, the probable capital cost of establishing 1MW Solar Thermal Power Plant capacity varies between Rs. 14 - 24 crores, depending on the technology/features.

C) STIRLING DISH ENGINE (KW RANGE)



The solar dish generates electricity by focusing the sun's rays onto a receiver, which transmits the heat energy to an engine. The engine is a sealed system filled with hydrogen, and as the gas heats and cools, its pressure rises and falls.

The change in pressure drives the pistons inside the engine, producing mechanical power. The mechanical power in turn drives a generator and produces electricity.

The solar dish Stirling system could be well deployed for decentralised power generation. (in KW range for minor applications)

CSP based Solar thermal Plants have the following advantages over SPV for large scale power generation:

- a) CSP technology is simple, versatile and commercially proven.
- b) No specific land constraints & various technologies are available to suit the land requirements.
- c) Energy storage facility.
- d) Improved efficiency with reduced cost of generation.
- e) Further technological developments can be expected resulting in increased power generating capacity.
- f) Best suited for high capacity plants, can be scaled up to several hundred megawatts, putting it in the same utility-scale class as coal and nuclear. (Grid connected PV systems are not as economical & not suitable for higher capacity plants both in terms of cost and efficiency)
- g) In contrast to wind power, the heat transfer medium deployed in this technology does not suffer from power fluctuations due to transient clouds.

Solar thermal power plants are among the most cost effective renewable power technologies; they hold promise to become competitive with fossil fuel plants in the near future. Solar thermal power plant technology is well proved and demonstrated.

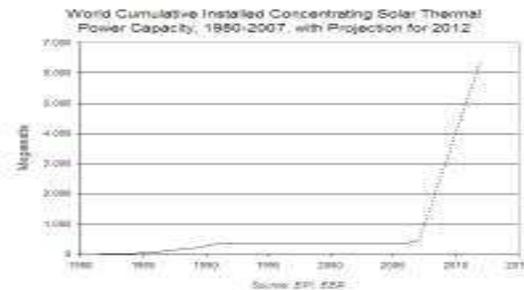
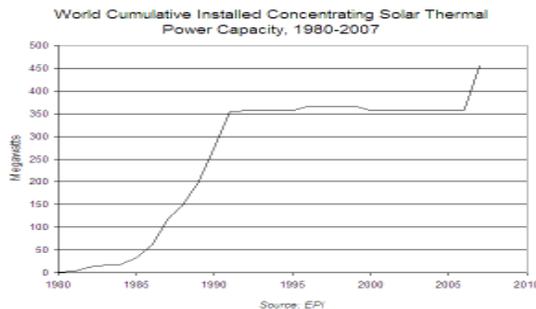
| World List of Selected Proposed Concentrating Solar Thermal Power Projects as of June 2008 | | | | |
|--|---------------------------|---|----------------|------------------------------|
| Location | Company | Project | Power Capacity | Scheduled Year of Completion |
| | | | Megawatts | |
| California, USA | Solel Solar Systems, Ltd. | Mojave Solar Park | 553 | 2011 |
| California, USA | Stirling Energy Systems | Solar One | 500 (850) | 2011 |
| California, USA | BrightSource Energy, Inc. | Ivanpah Solar Electricity Generating System | 400 (900) | 2011 |
| California, USA | Stirling Energy Systems | Solar Two | 300 (900) | not set |
| Andalucía, Spain | Abengoa Solar | Solúcar Platform | 300 | 2013 |
| Florida, USA | Ausra, Inc. | n.a. | 300 | 2011 |
| Arizona, USA | Abengoa Solar | Solana | 280 | 2011 |
| California, USA | Beacon Solar, LLC | Beacon Solar Energy Project | 250 | 2011 |
| California, USA | Harper Lake, LLC | Harper Lake Energy Park | 250 (500) | 2010 |
| Ramat Negev, Israel ⁴ | n.a. | n.a. | 250 | 2011 |
| California, USA | eSolar | n.a. | 245 | 2011 |
| Australia | EnviroMission Ltd. | Solar Mission Project | 200 | not set |
| California, USA | Ausra, Inc. | Carrizo Energy Solar Farm | 177 | 2010 |
| Jordan | n.a. | n.a. | 150 (300) | 2015 |
| Spain | Solel Solar Systems, Ltd. | n.a. | 150 | not set |
| Ciudad Real, | Iberdrola | n.a. | 150 | not set |

| | | | | |
|--|---|----------------------|------------|---------|
| Spain | Renewables | | | |
| Upington, South Africa | Eskom | n.a. | 100 | not set |
| Madinat Zayad, United Arab Emirates | Masdar (Abu Dhabi Future Energy Company) | Shams | 100 | 2010 |
| Greece | Solar Millennium AG | Theseus | 52 | not set |
| China | Solar Millennium AG | n.a. | 50 (1,000) | 2020 |
| Spain | Solar Millennium AG | Extremasol 1 | 50 | 2011 |
| Spain | Solar Millennium AG | Extremasol 2 | 50 | 2012 |
| Spain | Solar Millennium AG | Murciasol 1 | 50 | 2011 |
| Spain | Solar Millennium AG | Murciasol 2 | 50 | not set |
| Córdoba, Spain | Acciona Energy | Palma del Rio I | 50 | not set |
| Córdoba, Spain | Acciona Energy | Palma del Rio II | 50 | not set |
| Ciudad Real, Spain | Abengoa Solar | Helios 1 | 50 | not set |
| Ciudad Real, Spain | Abengoa Solar | Helios 2 | 50 | not set |
| California, United States | Bethel Energy, LLC | Bethel 1 | 50 | 2010 |
| California, United States | Bethel Energy, LLC | Bethel 2 | 50 | 2010 |
| California, United States | n.a. | Victorville 2 | 50 | 2010 |
| Cáceres, Spain | Acciona Energy | Majadas de Tiétar | 50 | not set |
| Badajoz, Spain | Acciona Energy | Alvarado | 50 | 2009 |
| Andalucía, Spain | Abengoa Solar | Ecija 1 | 50 | not set |

| | | | | |
|-------------------------|----------------------|-----------------------|----|---------|
| Andalucía, Spain | Abengoa Solar | Ecija 2 | 50 | not set |
| Andalucía, Spain | Solar Millennium AG | Andasol 1 | 50 | 2008 |
| Andalucía, Spain | Solar Millennium AG | Andasol 2 | 50 | 2009 |
| Andalucía, Spain | Solar Millennium AG | Andasol 3 | 50 | 2010 |
| Spain | Iberdrola Renewables | n.a. | 50 | not set |
| Spain | Iberdrola Renewables | n.a. | 50 | not set |
| Spain | Iberdrola Renewables | n.a. | 50 | not set |
| Spain | Iberdrola Renewables | n.a. | 50 | not set |
| Spain | Iberdrola Renewables | n.a. | 50 | not set |
| Spain | Iberdrola Renewables | n.a. | 50 | not set |
| Spain | Iberdrola Renewables | n.a. | 50 | not set |
| Liddell, Australia | Ausra, Inc. | Liddell Power Station | 37 | 2008 |
| Kuraymat, Egypt | Solar Millennium AG | n.a. | 30 | not set |
| Sonora, Mexico | n.a. | Agua Prieta II | 25 | 2009 |
| Yazd, Iran | n.a. | n.a. | 20 | 2010 |
| Hassi-R'mel, Algeria | Abengoa Solar | n.a. | 20 | 2009 |
| Almaden, Spain | Abengoa Solar | n.a. | 20 | not set |
| Ain-Ben-Mathar, Morocco | Abengoa Solar | n.a. | 20 | 2008 |
| Andalucía, Spain | Sener | Solar Tres | 16 | not set |

| | | | | |
|-------------------------|---|-------------------------------------|--|--|
| Cloncurry, Australia | Lloyd Energy Systems and Ergon Energy | Cloncurry Solar Power Project | | |
|-------------------------|---|-------------------------------------|--|--|

Since 1985, nine parabolic trough type solar thermal plants in California have fed more than 8 billion KWhr of solar electricity into the Southern Californian grid demonstrating the soundness of the concept. The PS-10, 11 MW Central Tower plant in Spain has proven its commercial operation, generating 24 GWhr/annum. The second plant namely PS 20, 20 MW in Spain is being put into commercial operation for generation of 48 GWhrs/annum based on the successful operation of PS-10. Both the plants have thermal storage facility.



Currently CSP projects to a tune of 5500 MW are being taken up worldwide for implementation.

Annexure 3- Calculation of Solar PV Tariff

| Financial/Operational parameters assumed | | | | | | |
|--|---------|--|-------------------------|-----------|-----------|----------|
| CUF | 19.00% | | | | | |
| Life | 25 | years | | | | |
| Capital | 16.90 | Crores Rs. | <u>Loan Outstanding</u> | Interest | Loan | |
| Debt: Equity | 70:30 | | | | Repayment | |
| Interest on Loan | 12.00% | | Year 1 | 118300000 | 14196000 | 0 |
| ROE | 19.85% | Pre-Tax or 15.5% post-tax | Year 2 | 118300000 | 14196000 | 11830000 |
| Loan Repayment | 10 | years with 1 year moratorium period | Year 3 | 106470000 | 12776400 | 11830000 |
| O&M Charges/MW | 9.515 | Ls/Annum with escalation of 5.72% after 1 st year | Year 4 | 94640000 | 11356800 | 11830000 |
| Depreciation | 7.00% | for initial 10 years and 1.33% for the remaining years | Year 5 | 82810000 | 9937200 | 11830000 |
| Residual Value | 10% | | Year 6 | 70980000 | 8517600 | 11830000 |
| Interest on working capital | 12.00% | | Year 7 | 59150000 | 7098000 | 11830000 |
| Auxiliary Consumption | 2.00% | | Year 8 | 47320000 | 5678400 | 11830000 |
| De-rating Factor | 1% | for every year after ten years | Year 9 | 35490000 | 4258800 | 11830000 |
| Discount Factor | 0.14355 | | Year 10 | 23660000 | 2839200 | 11830000 |
| | | | Year 11 | 11830000 | 1419600 | 11830000 |

Levelling tariff

| Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| O & M Charges (Rs.) | 951500 | 1005926 | 1063465 | 1124295 | 1188605 | 1256593 | 1328470 | 1404458 | 1484793 | 1569724 |
| Interest on Loan @ 12.00% (Rs.) | 14196000 | 14196000 | 12776400 | 11356800 | 9937200 | 8517600 | 7098000 | 5678400 | 4258800 | 2839200 |
| Depreciation (Rs.) | 11830000 | 11830000 | 11830000 | 11830000 | 11830000 | 11830000 | 11830000 | 11830000 | 11830000 | 11830000 |
| ROE 19.85% Pre-Tax (Rs.) | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 |
| Operation and Maintenance expenses for one month | 79292 | 83827 | 88622 | 93691 | 99050 | 104716 | 110706 | 117038 | 123733 | 130810 |
| Maintenance spares @ 1% of the O&M expenses | 9515 | 10059 | 10635 | 11243 | 11886 | 12566 | 13285 | 14045 | 14848 | 15697 |
| Receivables equivalent to one month of fixed cost. | 3118864 | 3123497 | 3008899 | 2894582 | 2780561 | 2666853 | 2553476 | 2440449 | 2327792 | 2215526 |
| Total Working Capital | 3207671 | 3217383 | 3108156 | 2999516 | 2891498 | 2784135 | 2677467 | 2571532 | 2466373 | 2362034 |
| Interest on working capital @12% | 384921 | 386086 | 372979 | 359942 | 346980 | 334096 | 321296 | 308584 | 295965 | 283444 |
| Total Cost (Rs.) | 37426371 | 37481962 | 36106793 | 34734987 | 33366734 | 32002239 | 30641716 | 29285392 | 27933508 | 26586318 |
| Units generated for 1 MW | 1631112 | 1631112 | 1631112 | 1631112 | 1631112 | 1631112 | 1631112 | 1631112 | 1631112 | 1631112 |
| Cost/unit (Rs.) | 22.945 | 22.979 | 22.136 | 21.295 | 20.456 | 19.620 | 18.786 | 17.954 | 17.125 | 16.300 |

| | | | | | | | | | | |
|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Discount Factor | 1 | 0.874 | 0.765 | 0.669 | 0.585 | 0.511 | 0.447 | 0.391 | 0.342 | 0.299 |
| Present Value | 22.95 | 20.09 | 16.93 | 14.24 | 11.96 | 10.03 | 8.40 | 7.02 | 5.86 | 4.87 |

| Years | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|--|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| O & M Charges (Rs.) | 1659512 | 1754436 | 1854790 | 1960884 | 2073046 | 2191624 | 2316985 | 2449517 | 2589629 | 2737756 |
| Interest on Loan @ 12.00% (Rs.) | 1419600 | | | | | | | | | |
| Depreciation (Rs.) | 2247700 | 2247700 | 2247700 | 2247700 | 2247700 | 2247700 | 2247700 | 2247700 | 2247700 | 2247700 |
| ROE 19.85% Pre-Tax (Rs.) | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 |
| Operation and Maintenance expenses for one month | 138293 | 146203 | 154566 | 163407 | 172754 | 182635 | 193082 | 204126 | 215802 | 228146 |
| Maintenance spares @ 1% of the O&M expenses | 16595 | 17544 | 18548 | 19609 | 20730 | 21916 | 23170 | 24495 | 25896 | 27378 |
| Receivables equivalent to one month of fixed cost. | 1297083 | 1185668 | 1194210 | 1203240 | 1212787 | 1222881 | 1233551 | 1244832 | 1256758 | 1269366 |
| Total Working Capital | 1451971 | 1349415 | 1367324 | 1386256 | 1406272 | 1427432 | 1449803 | 1473453 | 1498457 | 1524890 |
| Interest on working capital @12% | 174237 | 161930 | 164079 | 166351 | 168753 | 171292 | 173976 | 176814 | 179815 | 182987 |
| Total Cost (Rs.) | 15564998 | 14228016 | 14330518 | 14438884 | 14553449 | 14674566 | 14802612 | 14937981 | 15081094 | 15232393 |
| Units generated for 1 MW | 1614801 | 1598653 | 1582666 | 1566840 | 1551171 | 1535660 | 1520303 | 1505100 | 1490049 | 1475148 |
| Cost/unit (Rs.) | 9.639 | 8.900 | 9.055 | 9.215 | 9.382 | 9.556 | 9.737 | 9.925 | 10.121 | 10.326 |
| Discount Factor | 0.261 | 0.229 | 0.200 | 0.175 | 0.153 | 0.134 | 0.117 | 0.102 | 0.089 | 0.078 |
| Present Value | 2.520 | 2.035 | 1.811 | 1.611 | 1.435 | 1.278 | 1.138 | 1.015 | 0.905 | 0.807 |

| Years | 21 | 22 | 23 | 24 | 25 |
|--|----------|----------|----------|----------|----------|
| O & M Charges (Rs.) | 2894356 | 3059913 | 3234940 | 3419978 | 3615601 |
| Interest on Loan @ 12.00% (Rs.) | 0 | | | | |
| Depreciation (Rs.) | 2247700 | 2247700 | 2247700 | 2247700 | 2247700 |
| ROE 19.85% Pre-Tax (Rs.) | 10063950 | 10063950 | 10063950 | 10063950 | 10063950 |
| Operation and Maintenance expenses for one month | 241196 | 254993 | 269578 | 284998 | 301300 |
| Maintenance spares @ 1% of the O&M expenses | 28944 | 30599 | 32349 | 34200 | 36156 |
| Receivables equivalent to one month of fixed cost. | 1282695 | 1296787 | 1311685 | 1327435 | 1344086 |
| Total Working Capital | 1552835 | 1582379 | 1613613 | 1646633 | 1681542 |
| Interest on working capital @12% | 186340 | 189886 | 193634 | 197596 | 201785 |
| Total Cost (Rs.) | 15392346 | 15561448 | 15740223 | 15929224 | 16129036 |
| Units generated for 1 MW | 1460397 | 1445793 | 1431335 | 1417022 | 1402852 |

| | | | | | |
|-----------------|--------|--------|--------|--------|--------|
| Cost/unit (Rs.) | 10.540 | 10.763 | 10.997 | 11.241 | 11.497 |
| Discount Factor | 0.068 | 0.060 | 0.052 | 0.046 | 0.040 |
| Present Value | 0.721 | 0.644 | 0.575 | 0.514 | 0.460 |

The levellised tariff for 25 years =Rs. 18.19

| | | | | | | | | | | |
|--|----------------|--------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Determination of accelerated depreciation benefit | | | | | | | | | | |
| Depreciation amount | 90% | | | | | | | | | |
| Book depreciation rate | 5.28% | | | | | | | | | |
| Tax depreciation rate | 80% | | | | | | | | | |
| Income Tax (MAT) | 16.995% | | | | | | | | | |
| Income Tax (Normal rate) | 33.990% | | | | | | | | | |
| Capital Cost | 1690 | Lakhs /annum | | | | | | | | |
| Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Book Depreciation (Rs. In Lakhs) | 89.232 | 89.232 | 89.232 | 89.232 | 89.232 | 89.232 | 89.232 | 89.232 | 89.232 | 89.232 |
| Accelerated Depreciation | | | | | | | | | | |
| Opening % | 100% | 60.0% | 12.0% | 2.4% | 0.5% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| Allowed during the year % | 40.0% | 48.00% | 9.60% | 1.92% | 0.38% | 0.08% | 0.02% | 0.00% | 0.00% | 0.00% |
| Closing % | 60.0% | 12.0% | 2.4% | 0.5% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Accelerated Depreciation | 676.00 | 811.20 | 162.24 | 32.45 | 6.49 | 1.30 | 0.26 | 0.05 | 0.01 | 0.00 |
| Net Depreciation Benefit (Rs. In lakhs) | 586.77 | 721.97 | 73.01 | -56.78 | -82.74 | -87.93 | -88.97 | -89.18 | -89.22 | -89.23 |
| Tax Benefit (Rs. In lakhs) | 99.72 | 122.70 | 12.41 | -9.65 | -14.06 | -14.94 | -15.12 | -15.16 | -15.16 | -15.16 |
| Energy Generation MUs | 1.63 | 1.63 | 1.63 | 1.63 | 1.63 | 1.63 | 1.63 | 1.63 | 1.63 | 1.63 |
| Per unit benefit (Rs. / Unit) | 6.11 | 7.52 | 0.76 | -0.59 | -0.86 | -0.92 | -0.93 | -0.93 | -0.93 | -0.93 |
| Discounting Factor | 1.000 | 0.874 | 0.765 | 0.669 | 0.585 | 0.511 | 0.447 | 0.391 | 0.342 | 0.299 |
| Present Value (Rs.) | 6.11 | 6.58 | 0.58 | -0.40 | -0.50 | -0.47 | -0.41 | -0.36 | -0.32 | -0.28 |

| | | | | | | | | | | |
|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Discount Factor | 1 | 0.874 | 0.765 | 0.669 | 0.585 | 0.511 | 0.447 | 0.391 | 0.342 | 0.299 |
| Present Value | 18.99 | 16.64 | 14.04 | 11.83 | 9.96 | 8.37 | 7.03 | 5.89 | 4.93 | 4.12 |

| Years | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|--|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| O & M Charges (Rs.) | 2396394 | 2533468 | 2678382 | 2831586 | 2993553 | 3164784 | 3345809 | 3537190 | 3739517 | 3953417 |
| Interest on Loan @ 12.00% (Rs.) | 1285200 | | | | | | | | | |
| Depreciation (Rs.) | 2034900 | 2034900 | 2034900 | 2034900 | 2034900 | 2034900 | 2034900 | 2034900 | 2034900 | 2034900 |
| ROE 19.85% Pre-Tax (Rs.) | 9111150 | 9111150 | 9111150 | 9111150 | 9111150 | 9111150 | 9111150 | 9111150 | 9111150 | 9111150 |
| Operation and Maintenance expenses for one month | 199700 | 211122 | 223199 | 235965 | 249463 | 263732 | 278817 | 294766 | 311626 | 329451 |
| Maintenance spares @ 15% of the O&M expenses | 359459 | 380020 | 401757 | 424738 | 449033 | 474718 | 501871 | 530578 | 560928 | 593013 |
| Receivables equivalent to one month of fixed cost. | 1253766 | 1157446 | 1169985 | 1183242 | 1197258 | 1212075 | 1227739 | 1244300 | 1261808 | 1280317 |
| Total Working Capital | 1812925 | 1748588 | 1794941 | 1843946 | 1895753 | 1950524 | 2008428 | 2069644 | 2134362 | 2202781 |
| Interest on working capital @12% | 217551 | 209831 | 215393 | 221273 | 227490 | 234063 | 241011 | 248357 | 256123 | 264334 |
| Total Cost (Rs.) | 15045195 | 13889349 | 14039825 | 14198909 | 14367093 | 14544897 | 14732871 | 14931597 | 15141690 | 15363801 |
| Units generated for 1 MW | 1795187 | 1777235 | 1759463 | 1741868 | 1724449 | 1707205 | 1690133 | 1673231 | 1656499 | 1639934 |
| Cost/unit (Rs.) | 8.381 | 7.815 | 7.980 | 8.152 | 8.331 | 8.520 | 8.717 | 8.924 | 9.141 | 9.369 |
| Discount Factor | 0.261 | 0.229 | 0.200 | 0.175 | 0.153 | 0.134 | 0.117 | 0.102 | 0.089 | 0.078 |
| Present Value | 2.191 | 1.787 | 1.596 | 1.425 | 1.274 | 1.139 | 1.019 | 0.912 | 0.817 | 0.733 |

| Years | 21 | 22 | 23 | 24 | 25 |
|--|---------|---------|---------|---------|---------|
| O & M Charges (Rs.) | 4179553 | 4418623 | 4671369 | 4938571 | 5221057 |
| Interest on Loan @ 12.00% (Rs.) | 0 | | | | |
| Depreciation (Rs.) | 2034900 | 2034900 | 2034900 | 2034900 | 2034900 |
| ROE 19.85% Pre-Tax (Rs.) | 9111150 | 9111150 | 9111150 | 9111150 | 9111150 |
| Operation and Maintenance expenses for one month | 348296 | 368219 | 389281 | 411548 | 435088 |
| Maintenance spares @ 15% of the O&M expenses | 626933 | 662793 | 700705 | 740786 | 783159 |
| Receivables equivalent to one month of fixed cost. | 1299885 | 1320572 | 1342442 | 1365564 | 1390008 |
| Total Working Capital | 2275114 | 2351584 | 2432428 | 2517897 | 2608255 |

| | | | | | |
|----------------------------------|----------|----------|----------|----------|----------|
| Interest on working capital @12% | 273014 | 282190 | 291891 | 302148 | 312991 |
| Total Cost (Rs.) | 15598617 | 15846863 | 16109310 | 16386768 | 16680098 |
| Units generated for 1 MW | 1623535 | 1607299 | 1591226 | 1575314 | 1559561 |
| Cost/unit (Rs.) | 9.608 | 9.859 | 10.124 | 10.402 | 10.695 |
| Discount Factor | 0.068 | 0.060 | 0.052 | 0.046 | 0.040 |
| Present Value | 0.657 | 0.590 | 0.529 | 0.476 | 0.428 |

The levellised tariff for 25 years = 15.269

| | | | | |
|--|----------------|-------------|--|--|
| Determination of accelerated depreciation benefit | | | | |
| Depreciation amount | 90% | | | |
| Book depreciation rate | 5.28% | | | |
| Tax depreciation rate | 80% | | | |
| Income Tax (MAT) | 16.995% | | | |
| Income Tax (Normal rate) | 33.990% | | | |
| Capital Cost | 1530 | Lakhs/annum | | |

| Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Book Depreciation (Rs. In Lakhs) | 80.784 | 80.784 | 80.784 | 80.784 | 80.784 | 80.784 | 80.784 | 80.784 | 80.784 | 80.784 |
| Accelerated Depreciation | | | | | | | | | | |
| Opening % | 100% | 60.0% | 12.0% | 2.4% | 0.5% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| Allowed during the year % | 40.0% | 48.00% | 9.60% | 1.92% | 0.38% | 0.08% | 0.02% | 0.00% | 0.00% | 0.00% |
| Closing % | 60.0% | 12.0% | 2.4% | 0.5% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Accelerated Depreciation | 612.00 | 734.40 | 146.88 | 29.38 | 5.88 | 1.18 | 0.24 | 0.05 | 0.01 | 0.00 |
| Net Depreciation Benefit (Rs. In lakhs) | 531.22 | 653.62 | 66.10 | -51.41 | -74.91 | -79.61 | -80.55 | -80.74 | -80.77 | -80.78 |
| Tax Benefit (Rs. In lakhs) | 90.28 | 111.08 | 11.23 | -8.74 | -12.73 | -13.53 | -13.69 | -13.72 | -13.73 | -13.73 |
| Energy Generation MUs | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 |
| Per unit benefit (Rs. / Unit) | 4.98 | 6.13 | 0.62 | -0.48 | -0.70 | -0.75 | -0.75 | -0.76 | -0.76 | -0.76 |
| Discounting Factor | 1.000 | 0.874 | 0.765 | 0.669 | 0.585 | 0.511 | 0.447 | 0.391 | 0.342 | 0.299 |
| Present Value (Rs.) | 4.98 | 5.36 | 0.47 | -0.32 | -0.41 | -0.38 | -0.34 | -0.30 | -0.26 | -0.23 |

