2015

Discussion Paper

DISCUSSION PAPER ON THE DETERMINATION OF TARIFF FOR PROCUREMENT OF POWER BY DISTRIBUTION LICENSEES AND OTHERS FROM SOLAR ENERGY PROJECTS FOR THE STATE OF GUJARAT

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Executive Summary

In exercise of the powers conferred under Sections 3 (1), 61 (h), 62 (1) (a), and 86 (1) (e) of The Electricity Act, 2003 and provisions of the National Electricity Policy, 2005 and Tariff Policy, 2006 and all other powers enabling it on this account, the Gujarat Electricity Regulatory Commission (GERC or "this Commission") presents this Discussion Paper ("Discussion Paper") for the determination of tariff for procurement of power by Distribution Licensees and others from solar energy projects. The National Action Plan on Climate Change (NAPCC) launched by the Government of India in June 2008 is a comprehensive plan with eight missions that target specific issues and address the urgent and critical concerns of the country through a directional shift in the development pathway; further, the NAPCC targets an increase in renewable energy purchase by 1% a year with a target to achieve 15% renewable in India's energy mix by 2020. Gujarat's Solar Power Policy-2009 was launched in January 2009 with a target of installing 500 MW of solar photovoltaic and solar thermal generating plants by 2014, while the Jawaharlal Nehru National Solar Mission (JNNSM) launched in January 2010 targets 20,000 MW of net installed solar generating capacity throughout India by 2022. Subsequently the Government of India has revised the goals of JNNSM to 100,000 MW by 2022.

GERC passed its first solar tariff order on January 29, 2010 titled "Determination of tariff for Procurement of Power by the Distribution Licensees and Others from Solar Energy Projects". The levelized tariff for solar photovoltaic projects were determined as INR 12.54 per kWh (distributed as INR 15.00 per kWh for the first 12 years and INR 5.00 per kWh for the next 13 years) and for solar thermal projects at INR 9.29 per kWh (distributed as INR 11.00 per kWh for the first 12 years and INR 4.00 per kWh for the next 13 years).

GERC passed its second solar tariff Order No. 1 of 2012 titled "Determination of tariff for Procurement of Power by the Distribution Licensees and others from Solar Energy Projects" on January 27, 2012 and thereafter Honorable Commission passed a suo-motu order dated July 7, 2014 and also issued a corrigendum to it dated July 11, 2014. The levelized tariff for solar photovoltaic projects were determined as under:

Table 0.1: Solar Tariffs as per GERC Corrigendum order in Suo-Motu proceedings in Order No. 1 of 2012 dated July 11, 2014

Period	January 29, 2012 to March 31, 2013	April 1, 2013 to March 31, 2014	April 1, 2014 to March 31, 2015
For megawatt-scale photovoltaic projects availing accelerated depreciation			
Levelized Tariff for 25 years	INR 9.70 per kWh	INR 9.02 per kWh	INR 8.39 per kWh
For first 12 years	INR 10.52 per kWh	INR 9.64 per kWh	INR 8.82 per kWh
For subsequent 13 years	INR 7.00 per kWh	INR 7.00 per kWh	INR 7.00 per kWh
For megawatt-scale photovoltaic projects not availing accelerated depreciation			

Levelized Tariff for 25 years	INR 10.92 per kWh	INR 10.15 per kWh	INR 9.44 per kWh
For first 12 years	INR 11.97 per kWh	INR 10.96 per kWh	INR 10.03 per kWh
For subsequent 13 years	INR 7.50 per kWh	INR 7.50 per kWh	INR 7.50 per kWh
For kilowatt-scale photovoltaic projects availing accelerated depreciation			
Levelized Tariff for 25 years	INR 11.64 per kWh	INR 10.82 per kWh	INR 10.07 per kWh
For kilowatt-scale photovoltaic projects not availing accelerated depreciation			
Levelized Tariff for 25 years	INR 13.10 per kWh	INR 12.18 per kWh	INR 11.33 per kWh
Levelized Tariff for Solar Thermal Projects availing accelerated depreciation			
With accelerated depreciation benefit		INR 11.83 per kWh for 25 years	
Levelized Tariff for Solar Thermal Projects not availing accelerated depreciation			
Without accelerated depreciation benefit		INR 13.23 per kWh for 25 years	

GERC has further mandated a specific solar Renewable Purchase Obligation (RPO) at 1%, 1% and 1.25% for 2012-13, 2013-14 and 2014-15 respectively.

More recently, in March 2015, the Central Electricity Regulatory Commission (CERC) passed an order dated March 3, 2015, in a suo-motu petition No.SM/004/2015 determining tariffs for various renewable energy sources and suo-motu petition No.SM/005/2015 for determining benchmark capital cost norm for solar PV power projects and solar thermal power projects for FY 2015-16. Many states have directly adopted the CERC-determined tariff directly, while other states have determined solar energy tariffs independently.

Since the Gujarat Solar Power Policy-2009, more than 80 national and international companies have signed Power Purchase Agreements (PPA) of more than 965 MW, which have resulted in a total installed capacity of 910.5 MW[1]. The Government of Gujarat has completed projects such as the 500 MW Solar Park near Charanka Village, Patan District, and the pilot 5 MW Gandhinagar Photovoltaic Rooftop Program.

The Commission now releases this Discussion Paper to determine the tariff for procurement of power from solar PV and thermal power plants in the state of Gujarat for the control period 2015-2018.

Solar Photovoltaic Technology:

Solar photovoltaic (PV) technology, although evolving, is a robust technology along with its advantages such as simplicity, modularity and low maintenance. The cost of photovoltaic modules, which contributes to more than 50% of the cost of the photovoltaic power plant, is steadily declining along with inverter costs.

[1] Gujarat SLDC: Real-time Generation of Solar Plants in Gujarat. http://bit.ly/1Nqisrj

Based on the basic differences between implementation of megawatt-scale ground-mounted photovoltaic systems, and kilowatt-scale rooftop photovoltaic systems, all photovoltaic systems can be categorized basically into two types for tariff applicability:

Table 0.2: Photovoltaic system classification for tariff applicability

System Size	System Type	Evacuation Specification	Applicable Tariff
1 kW – 6 kW	Rooftop	230 V, 1-ph, 50 Hz	Kilowatt-scale Photovoltaic Tariff
6 kW – 100 kW	Rooftop	415 V, 3-ph, 50 Hz	
100 kW – 1 MW	Rooftop/ Ground-mounted	11 kV, 3-ph, 50 Hz	Megawatt-scale Photovoltaic Tariff
1 MW – 4 MW	Ground-mounted	11 kV, 3-ph, 50 Hz	
> 4MW	Ground-mounted	66 kV, 3-ph, 50 Hz	

The Discussion Paper considers predominant technologies available and deployed globally for the purpose of tariff determination. This Discussion Paper recognizes the fact that cost of modules differs significantly based on whether the module and cell is manufactured locally in India or procured from international markets. In order to encourage manufacturing as per Government of India policy and Make in India campaign, GERC has also taken up the initiative by introducing separate categories and tariffs for domestic and imported modules & cells. Table 0.3 shows the cost differences between the modules (and/or cells) manufactured locally versus imported from foreign countries.

Table 0.3: Capital cost for Solar Photovoltaic Power Plant

Sr.	Capital Cost	Megawatt Scale (INR)	Kilowatt Scale (INR)
1	Capital Cost (Open Modules)	6.00 Cr/MW	80,000 /kW
1.1	Add for Domestic Modules (to Sr.1)	50 Lakhs/MW	5,000 /kW
1.2	Add for Domestic Cells and Modules (to Sr. 1)	1.00 Cr/MW	10,000 /kW

The various parameters considered for tariff determination of solar photovoltaic projects are presented as follows:

Table 0.4: Summary of parameters for solar photovoltaic power plants

Parameter	Value		
Plant Cost			
Capital Cost	INR	600	Lakhs per MW for megawatt-scale syste (Refer Table 0.2)
		650	
		700	
	INR	0.80	Lakhs per kW for kilowatt-scale system (Refer Table 0.2)
		0.85	
		0.90	
O & M Cost	INR	10.75	Lakhs/MW/annum
		0.0129	Lakhs/kW/annum
Escalation in O & M Cost		5.72%	Annually
Performance Parameters			
Capacity Utilization Factor		19%	
Performance Degradation		1%	Annually
Auxiliary Consumption		0.25%	of Energy Generation for megawatt scale
		NIL	of Energy Generation for kilowatt scale
Useful Life		25	Years
Financial Parameters			
Debt : Equity Ratio		70 : 30	
Loan Tenure		10	Years
Interest Rate on Loan		12.85%	Annually
Insurance Cost		0.35%	Annually
Interest on Working Capital		12.00%	Annually
Working Capital	Sum of:	1	Month's O&M Expense
		1	Months' Energy Charges at normative CUF
Rate of Depreciation		6%	Annually for the first 10 years
		2%	Annually for the next 15 years
Minimum Alternate Tax Rate		20.008%	Annually for the first 10 years
Corporate Tax Rate		33.99%	Annually from the 11th year until 25th year
Return on Equity		14%	Annually
Discount Rate		10.138%	Annually

The levelized tariffs for solar photovoltaic plants for a period from **July 1, 2015 to March 31, 2018** are arrived through a financial analysis and are as follows:

Table 0.5: Levelized tariff for megawatt-scale and kilowatt-scale photovoltaic systems commissioned between July 1, 2015 and March 31, 2018

For Megawatt Scale Power Plant			
	Imported Modules	**Domestic Modules (Imported Cells)**	**Domestic Cells and Modules**
Without Accelerated Depreciation Benefit	INR 6.68	INR 7.15	INR 7.61
With Accelerated Depreciation Benefit	INR 6.00	INR 6.41	INR 6.81
For Kilowatt Scale Power Plant			
Without Accelerated Depreciation Benefit	INR 8.74	INR 9.20	INR 9.66
With Accelerated Depreciation Benefit	INR 7.83	INR 8.23	INR 8.64

Solar Thermal Technology:

While there are many solar thermal technology options such as parabolic trough, linear Fresnel reflector, power tower and parabolic dish technologies, all except the parabolic trough technology are yet to be realized at a mature and commercial level. India has a total installed solar thermal capacity of around 203.5 MW – most of which are in Rajasthan and are of parabolic trough technology. Predominant technologies are considered for determination of solar thermal tariff, and the various parameters are as follows:

Table 0.6: Summary of parameters for solar thermal power plants

Parameter	Value		
Plant Cost			
Capital Cost	INR	1200	Lakhs per MW for megawatt-sca system
O & M Cost		1.5%[2]	of Capital Cost per megawatt per year
Escalation in O & M Cost		5.72%	Annually
Performance Parameters			
Capacity Utilization Factor		23%	
Performance Degradation		0.25%	Annually
Auxiliary Consumption		10%	of energy generation
Useful Life		25	Years
Financial Parameters			
Debt : Equity Ratio		70 : 30	
Loan Tenure		10	Years
Interest Rate on Loan		12.85%	Annually
Insurance Cost		0.35%	Annually on depreciated asset value
Interest on Working Capital		12.00%	Annually
Working Capital	Sum of:	1	Month's O&M Expense

[2] Honorable GERC retains the O&M escalation at 1.5% of capital cost as the capital cost of solar thermal projects has not seen a dramatic decline as compared to solar PV plants. Moreover, there is a paucity of data available in the market with regards to the operations of solar thermal plants to arrive at a number.

	1	Months' Energy Charges at normative CUF
Rate of Depreciation	6%	Annually for the first 10 years
	2%	Annually for the next15 years
Minimum Alternate Tax Rate	20.008%	Annually for the first 10 years
Corporate Tax Rate	33.99%	Annually from the 11th year until 25th year
Return on Equity	14%	Annually
Discount Rate	10.138%	Annually

The levelized tariffs for solar thermal plants for a period from **July 1, 2015 to March 31, 2018** are arrived through a financial analysis and are as follows:

Table 0.7: Levelized tariff for solar thermal power plants commissioned between July 1, 2015 and March 31, 2018

	Levelized Tariff
Without Accelerated Depreciation Benefit	INR 11.27
With Accelerated Depreciation Benefit	INR 10.09

Other Considerations:

- Solar Power Projects established with only new plants and machinery would be eligible for the benefit of tariff determined within the scope of this Discussion Paper.
- Electricity consumed prior to commissioning of the project for construction purposes, would qualify as construction power. This electricity shall be procured by the project developer from the respective distribution licensee in the area the project is situated. The tariff payable by the project developer would be as per the tariff schedule approved by the Commission in its tariff order from time to time.
- The start-up power and stand-by supply are already considered within the scope of the auxiliary power consumption of the respective solar energy technology and any energy receive/drawn from the distribution licensees shall be set-off against the injection of energy from the plant on kWh to kWh adjustment basis.
- The Commission proposes that State Transmission Utility (STU) / Distribution Licensee shall provide auxiliary power for the solar generator under kWh to kWh adjustment basis.
- The Reactive Power Charges as approved by the Commission in tariff orders for the Gujarat Energy Transmission Corporation Ltd. (GETCO) from time to time shall be applicable to such projects.
- Switchyard equipment, metering and protection arrangement and Remote Terminal Units (RTU) at generator end shall be provided by the owners of solar generators at their cost, while the transmission line from the switchyard of generator to the GETCO substation shall be laid by GETCO.
-

- Wheeling:
  - ➢ Injection at 66 kV voltage level and above:
  - o As per the scope of the current Discussion Paper, this clause will be applicable to solar plants of capacity greater than 4 MW.
  - o For wheeling of power to consumption site at 66 kV voltage level and above, the wheeling of electricity generated from the Solar Power Generators to the desired location(s) within the State shall be allowed on payment of transmission charges and transmission losses applicable to normal Open-Access Consumer.
  - o For wheeling of power to consumption site at a voltage below 66 KV, the wheeling of electricity generated from the solar power Generators to the desired location(s) within the State shall be allowed on payment of transmission charges as applicable to normal open-access customers and transmission and wheeling loss @ 7% of the energy fed into the grid. This loss shall be shared between the transmission and distribution licensees in the ratio of 4:3.

  - ➢ Injection at 11 kV or above and below 66 kV:
  - o As per the scope of the current Discussion Paper, this Clause will be applicable to ground-mounted or rooftop solar plant of capacity between 100 kW and 1 MW, and ground-mounted solar plants of capacity between 1 MW and 4 MW.
  - o The wheeling of power generated by such generators to the desired location(s) within the area of same distribution licensee shall be allowed on payment (in kind) of distribution loss @ 3% of the energy fed in to the grid.
  - o The wheeling of power generated by such generator to the desired location(s) within the State but in the area of a different distribution licensee shall be allowed on payment of transmission charges as applicable to normal Open-Access Customers and transmission and distribution loss @ 10% of the energy fed in to the grid. These losses shall be shared among the transmission licensee and two distribution licensees involved in the ratio of 3:4:3.

  - o Injection at 415 V or below:
  - o As per the scope of the current Discussion Paper, this clause will be applicable to rooftop solar installations of capacity between 1 kW and 6 kW feeding at 220 V, 1φ; and rooftop solar installations of capacity between 6 kW and 100 kW feeding at 415 V, 3φ.
  - o No wheeling charges shall apply for wheeling of power generated by such projects, to the desired locations(s), as such projects decrease the transmission and distribution losses for the utility, and increase the efficiency of the grid.
- As a promotional measure for solar power, which is still in its nascent stage, no cross-subsidy surcharges would be levied in case of third-party sale.
- The Intra-state ABT order will not be applicable to solar power generation projects.
- 100% of the gross proceeds on account of Clean Development Mechanism (CDM) benefit to be retained by the project Developer in the first year after the date of commercial operation of the generating station. In the second year, the share of the beneficiaries shall be 10%

which shall be progressively increased by 10% every year till it reaches 50%, where after the proceeds shall be shared in equal proportion, by the generating company and the beneficiaries.

- The control period proposed for the solar energy tariff order is from **July 1, 2015 to March 31, 2018**.
- Considering the nature of solar energy, all solar energy power plants will be considered as 'must-run' facilities, and the power generated from such power plants will be kept out from the merit order dispatch principles.

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Abbreviations

ABT	:	Availability-Based Tariff
AC	:	Alternating Current
APPC	:	Averaged Power Purchase Cost
APTEL	:	Appellate Tribunal For Electricity
CDM	:	Clean Development Mechanism
CdS	:	Cadmium Sulphide
CdTe	:	Cadmium Telluride
CEA	:	Central Electricity Authority
CERC	:	Central Electricity Regulatory Commission
CUF	:	Capacity Utilization Factor
CTR	:	Corporate Tax Rate
DC	:	Direct Current
EPC	:	Engineering, Procurement & Commission
EPD	:	Energy and Petrochemicals Department
FIFO	:	First In First Out
GEDA	:	Gujarat Energy Development Agency
GERC	:	Gujarat Electricity Regulatory Commission
GETCO	:	Gujarat Energy Transmission Corporation Ltd.
GHI	:	Global Horizontal Insolation
GOG	:	Government of Gujarat
GOI	:	Government of India
GTI	:	Global Tilt Insolation
h	:	Hour
Hz	:	Hertz
IEC	:	International Electrotechnical Commission
IMD	:	India Meteorological Department
INR	:	Indian Rupees
JNNSM	:	Jawaharlal Nehru National Solar Mission
kWh	:	Kilowatt-hour (also known as a ‘Unit’)

L	:	Litre
LCOE	:	Levelized Cost of Electricity
MAT	:	Minimum Alternate Tax
MNRE	:	Ministry of New and Renewable Energy
MOP	:	Ministry of Power
MPPT	:	Maximum Power Point Tracking
MR	:	Market Rate of Interest
MW	:	Megawatt
MYT	:	Multi Year Tariff
NASA	:	National Aeronautics and Space Administration
NAPCC	:	National Action Plan on Climate Change
NSM	:	National Solar Mission
NTPC	:	National Thermal Power Corporation Ltd.
NVVN	:	NTPC Vidyut Vyapar Nigam Ltd.
O&M	:	Operation and Maintenance
ph	:	Phase
PPA	:	Power Purchase Agreement
PR	:	Performance Ratio
PV	:	Photovoltaic(s)
RBI	:	Reserve Bank of India
REC	:	Renewable Energy Certificate
ROE	:	Return of Equity
RPO	:	Renewable Purchase Obligation
RRF	:	Renewable Regulatory Fund
SBI	:	State Bank of India
SLDC	:	State Load Dispatch Centre
SECI	:	Solar Energy Corporation of India
SERC	:	State Electricity Regulatory Commission
SESI	:	Solar Energy Society of India
SEZ	:	Special Economic Zone
SPP	:	Solar Power Policy

sq.	:	Square
STC	:	Standard Testing Conditions
STU	:	State Transmission Utility
V	:	Voltage
VGF	:	Viability Gap Funding
W	:	Watt
WACC	:	Weighted Average Cost of Capital

:: End of Abbreviations ::

1. Introduction

1.1 The Electricity Act, 2003

The following provisions of the Act provide the legal framework for the involvement of regulatory commissions in renewable energy:

1.1.1 Section 86.1 (e) of the Electricity Act 2003 mandates promotion of cogeneration and generation of electricity from renewable sources of energy:

"Promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution license."

1.1.2 Section 61 (h) of the Act provides that, while specifying the terms and conditions of determination of tariff, the Commission shall be guided by the objective of promotion of cogeneration and generation of electricity from renewable sources of energy.

"The promotion of cogeneration and generation of electricity from renewable sources of energy"

1.1.3 Section 62 (1) (a) of the Act provides for determination of tariff for supply of electricity by a generating company to a distribution licensee.

"Supply of electricity by a generating company to a distribution licensee: Provided that the Appropriate Commission may, in case of shortage of supply of electricity, fix the minimum and maximum ceiling of tariff for sale or purchase of electricity in pursuance of an agreement, entered into between a generating company and a licensee or between licensees, for a period not exceeding one year to ensure reasonable prices of electricity."

1.1.4 Section 3 (1) of the Electricity Act 2003 requires the Central Government to formulate, inter alia, the National Electricity Policy in consultation with the Central Electricity Authority (CEA) and State Governments. The provision is quoted below:

"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."

1.2 National Electricity Policy, 2005

The National Electricity Policy, 2005 formulated in compliance with the above-stated Section 3 of the Electricity Act envisages:

"The Electricity Act 2003 provides that co-generation and generation of electricity from non-conventional sources would be promoted by the State Electricity Regulatory Commission (SERC) 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 SERC. 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."

1.3 Tariff Policy, 2006

The Tariff Policy, 2006 issued by the Ministry of Power (MOP), Government of India (GOI), also emphasizes on the importance of non-conventional sources of energy generation and states:

"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."

1.4 National Action Plan on Climate Change

The Prime Minister of India released the country's National Action Plan on Climate Change (NAPCC) on June 30, 2008. There are Eight National Missions which form the core of the National Action Plan. The NAPCC consists of several targets on climate change issues and addresses the urgent and critical concerns of the country through a directional shift in the development pathway. It outlines measures on climate change related adaptation and mitigation while simultaneously advancing development. The Missions form the core of the Plan, representing multi-pronged, long-term and integrated strategies for achieving goals in the context of climate change. NAPCC set the target of 5% renewable energy purchase for FY 2009-10. Further, NAPCC envisages that such target will increase by 1% annually for the next 10 years. This would mean NAPCC envisages renewable energy to constitute approximate 15% of the energy mix of India.

The NAPCC is the national strategy of India to achieve a sustainable development path that simultaneously advances economic and environmental objectives. The National Action Plan hinges on the development and use of new technologies. The National Solar Mission (NSM) is one of the eight national missions which form the core of the National Action Plan. Based on this vision a JNNSM was launched.

1.5 Gujarat Solar Power Policy, 2009

The Gujarat Solar Power Policy was announced on January 6, 2009, by the Energy and Petrochemicals Dept. (EPD), Government of Gujarat, with the following objectives:

- Promoting generation of green and clean power in the State using solar energy.
- To put in place an appropriate investment climate, that could leverage the Clean Development Mechanism (CDM).
- Productive use of the wastelands, thereby engendering a socio-economic transformation.
- Employment generation and skill enhancement of local youth.
- Promotion of R&D and facilitation of technology transfer.
- Establish core technical competence in professionals in the State to initiate and sustain use and effective management of newer applications.
- Promotion of local manufacturing facilities.
- Creation of environmental consciousness among citizens.

This Policy is effective up to March 31, 2014 and targets a net installed solar generation capacity of 500 MW.

1.6 Jawaharlal Nehru National Solar Mission

The Jawaharlal Nehru National Solar Mission (JNNSM) was announced in 2009. JNNSM aims to promote the development of solar energy for grid connected and off-grid power generation. The ultimate objective is to make solar power competitive with fossil based applications by 2020-2022. The mission aims to achieve 22 GW of both off-grid and on-grid solar power by 2022. The JNNSM has recently been upward revised to a target of 100 GW by 2022.

In order to encourage rapid scale-up, a scheme is introduced in cooperation with the Ministry of Power, National Thermal Power Corporation Ltd. (NTPC) and Central Electricity Authority (CEA) to off-take solar power and reduces the financial burden on the government. NTPC Vidyut Vyapar Nigam Ltd. (NVVN), a wholly owned subsidiary of NTPC, was chosen as the nodal agency for entering into Power Purchase Agreement (PPA) with solar power Developers during Phase 1 (Batch 1&2). In the Phase 2 (Batch 1) of the JNNSM, the Solar Energy Corporation of India (SECI) signed the PPA on behalf of the government due to absence of unallocated power for bundling purposes.

State Governments are also encouraged to promote and establish solar generation parks with dedicated infrastructure for setting up utility scale plants to ensure ease of capacity creation.

Government commitments through JNNSM for development of long-term solar projects have attracted a large number of investors towards this sector in a short time frame. About 3.3 GW of solar capacity have been commissioned in India during the last six years largely supported by the Feed-in Tariff.

The JNNSM document also indicates that the Tariff Policy 2006 would be modified to mandate that State Electricity Regulators would fix a percentage for purchase of solar power. Further, the Mission document states that the solar power purchase obligation for States may start with 0.25% in Phase I (by 2013) and go up to 3% by 2022. This could be complemented by 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.

1.7 GERC Multi Year Tariff Regulations, 2011

The Multi Year Tariff Regulations (MYT), 2011 was notified by Gujarat Electricity Regulatory Commission (GERC) for the control period from FY 2010-11 to FY 2015-16 that extended to the whole of the state of Gujarat. The objective of MYT was:

- Provide regulatory certainty to the utilities, investors and consumers.
- Address the risk sharing mechanism between utilities and consumers based on controllable and uncontrollable factors.
- Ensure financial viability of the sector to attract investment, ensure growth and safeguard the interest of the consumers.
- Review operational norms for generation, transmission, distribution and supply.
- Promote operational efficiency and through its improvement in long term rationalize tariffs.

1.8 GERC Solar Tariff Order, 2012

Gujarat Electricity Regulatory Commission (GERC), in its Order No. 1 of 2012 dated January 27, 2012 determined the tariff for procurement of power by the Distribution Licensees and others from solar energy projects for the state of Gujarat. In fact, GERC was the first SERC in the country to issue a comprehensive Tariff Order on solar energy being Order No. 2 of 2010 dated January 29, 2010.

The said order was challenged by Solar Energy Society of India (SESI) by filling appeal No. 75 of 2012 before Hon'ble Appellate Tribunal for Electricity (APTEL). Hon'ble APTEL passed an order dated April 17, 2013 in the said appeal and remanded matter to the Commission directing to pass the consequential order in terms of the observation and directions given in the said Judgment. Based on the above Judgment the Commission passed an order dated July 7, 2014 and also issue corrigendum

to it by order dated July 11, 2014. In the said order/corrigendum GERC unveiled tariffs as listed in the table below:

Table 1.1: Solar Tariffs as per GERC order July 11, 2014

Period	January 29, 2012 to March 31, 2013	April 1, 2013 to March 31, 2014	April 1, 2014 to March 31, 2015
For megawatt-scale photovoltaic projects availing accelerated depreciation			
Levelized Tariff for 25 years	INR 9.70 per kWh	INR 9.02 per kWh	INR 8.39 per kWh
For first 12 years	INR 10.52 per kWh	INR 9.64 per kWh	INR 8.82 per kWh
For subsequent 13 years	INR 7.00 per kWh	INR 7.00 per kWh	INR 7.00 per kWh
For megawatt-scale photovoltaic projects not availing accelerated depreciation			
Levelized Tariff for 25 years	INR 10.92 per kWh	INR 10.15 per kWh	INR 9.44 per kWh
For first 12 years	INR 11.97 per kWh	INR 10.96 per kWh	INR 10.03 per kWh
For subsequent 13 years	INR 7.50 per kWh	INR 7.50 per kWh	INR 7.50 per kWh
For kilowatt-scale photovoltaic projects availing accelerated depreciation			
Levelized Tariff for 25 years	INR 11.64 per kWh	INR 10.82 per kWh	INR 10.07 per kWh
For kilowatt-scale photovoltaic projects not availing accelerated depreciation			
Levelized Tariff for 25 years	INR 13.10 per kWh	INR 12.18 per kWh	INR 11.33 per kWh

Levelized Tariff for Solar Thermal Projects availing accelerated depreciation	
With accelerated depreciation benefit	INR 11.83 per kWh for 25 years
Levelized Tariff for Solar Thermal Projects not availing accelerated depreciation	
Without accelerated depreciation benefit	INR 13.23 per kWh for 25 years

1.9 Solar Tariff Orders in Other States

Regulatory commissions of many states of India including Karnataka, Tamil Nadu, Uttar Pradesh, Rajasthan, etc. have determined their solar tariffs recently and they are listed below:

Table 1.2: Levelized Tariff of Different States – 2014

Category	Rajasthan (INR/kWh)	Uttar Pradesh (INR/kWh)	Karnataka (INR/kWh)	Tamil Nadu (INR/kWh)
Solar Photovoltaic	7.50	15.00	8.40	7.01
Solar Thermal	11.67	13.00	10.92	11.03

It must also be noted that while the benchmark tariff under the Phase 1 of JNNSM is higher than the solar tariffs for many states, the tariff discovered during the reverse bidding process resulted in discounts of up to INR 4 per kWh.

1.10 Gujarat's Renewable Purchase Obligation

GERC, in its regulations titled 'Procurement of Energy from Renewable Sources' (Notification No. 3 of 2010) dated April 17, 2010 has revised its earlier regulations and mandated to obligatory entities for minimum purchase of electricity (in kWh) from renewable energy sources.

Table 1.3: Renewable Purchase Obligation for Gujarat, 2010-2013

Minimum quantum of purchase from renewable energy sources (% of total energy in kWh)				
Year	**Total**	**Wind**	**Solar**	**Biomass, Bagasse and others**
2010-11	5%	4.5%	0.25%	0.25%
2011-12	6%	5.0%	0.50%	0.50%
2012-13	7%	5.5%	1.00%	0.50%

In the matter of compliance of the GERC (Procurement of Energy from Renewable Sources) Regulations, 2010 and GERC (Procurement of Energy from Renewable Sources) (First Amendment) Regulations dated March 4, 2014 notified by the Commission the following Renewable Purchase Obligation (RPO) percentage are stipulated:

Table 1.4: Renewable Purchase Obligation for Gujarat, 2013-2017

Minimum quantum of purchase from renewable energy sources (% of total energy in kWh)				
Year	**Total**	**Wind**	**Solar**	**Biomass, Bagasse and others**
2013 – 14	7%	5.5%	1.0%	0.5%
2014 – 15	8%	6.25%	1.25%	0.5%
2015 – 16	9%	7.0%	1.5%	0.5%
2016 – 17	10%	7.75%	1.75%	0.5%

This RPO applies to:

- .
- Distribution licensee
- Any other person consuming electricity (i) generated from conventional Captive Generating Plant having capacity of 5 MW and above for his own use and / or (ii) procured from conventional generation through open access and third party sale.

Further, this regulation recognizes the REC issued within the scope of CERC Notification No. L-1/12/2010-CERC dated January 14, 2010 as the valid instruments for the discharge of the mandatory obligations set out in these Regulations for the obligated entities to purchase electricity from renewable energy sources.

1.11 Developments in Gujarat

With over 300 days of sunshine and solar radiation of 5.6–6.0 kWh/m2/day, the state of Gujarat has a potential of generating large amount of power from solar energy. To capture this huge potential, in January 2009, the Government of Gujarat (GOG) introduced the solar power policy (SPP) 2009 as a commitment to climate change initiatives, to address energy security, to support India's JNNSM and to provide favorable environment for implementation of solar energy. The Solar Power Policy 2009 with an overarching aim of promoting alternative sources of energy through investment from private developers was an important step for solar power development in the state. From the release of the SPP in 2009 to early 2014, the state contributed to about 900 MW (including 500 MW Charanka Solar Park) of the total installed 1600 MW (approx.) grid connected capacity in the country.

To promote kilowatt-scale distributed rooftop systems within the State, the Government of Gujarat has declared Gandhinagar as solar city and the current distributed solar energy systems and solar photovoltaic (PV) rooftop installations account for about 7 MW in the city, likely to increase in near future with the announcement of solar rooftop policy. MNRE has declared six cities of Gujarat would be transformed to smart cities. The total installed capacity of rooftop solar in Gujarat is around 50 MW as of date.

The greater goal of this program is to:

- Establish a practice/ philosophy of distributed solar and other energy generation.
- Bring a level of comfort to all stakeholders for further scale-up.
- Encourage public participation.

Now, as GERC's existing order for determination of tariff for procurement of power by the Distribution Licensee and others from solar energy projects, Order No. 1 of 2012 dated January 27, 2012 as amended vide order dated July 7, 2014 and thereafter the corrigendum dated July 11, 2014 is approaching the end of its control period, GERC presents this Discussion Paper to invite comments from potential stakeholders for the tariff order to take effect beyond the existing control period. All the values of parameters and the proposed tariffs are indicative and will be finalized with the tariff order.

:: End of Chapter 1 ::

2. Solar Photovoltaic Power

2.1 Cost of Photovoltaic System

2.1.1 Cost of Photovoltaic Modules

The cost of the photovoltaic modules account for about half the cost of the entire photovoltaic power plant, and hence, have a substantial impact on the resultant Levelized Cost of Electricity (LCOE). However, the photovoltaic module prices, irrespective of module technology, have been steadily declining owing to research and development, industry adaptation and economies of scale. The module prices have declined by more than half over the last decade. Moreover, the price for modules varies depending on the country of origin.

Table 2.1: Indicative prices of photovoltaic modules of various origins[3,4]

Sr.	Module Type (Origin)	Price, July 2014 (INR/Wp)
1	Crystalline Silicon (Germany)	45.28
2	Crystalline Silicon (Japan)	45.98
3	Crystalline Silicon (China)	38.91
4	Thin-film Amorphous/ Microcrystalline	26.88
5	Thin-film CdTe / CdS	38.20

The above table indicates the prices of photovoltaic modules of different origin as of the first half of 2014. In order to encourage manufacturing as per Government of India policy and Make in India campaign, GERC has also taken up the initiative by introducing separate categories and tariffs for domestic and imported modules and cells. The JNNSM mandates the use of India-made modules in case of crystalline and poly-crystalline silicon modules, the costs for which are higher than their Chinese-made counterparts. Recent quotations for such modules obtained from domestic and international suppliers have indicated a price range of INR 30 - 45 per watt. Additionally, the results from the SECI tender under JNNSM Phase 2 Batch 1 showed that the average difference between viability gap funding (VGF) stated by bidders in the Domestic category versus Open category was 1.061 Crore.

[3] pvXchange GmbH online portal (http://www.pvxchange.com/) and converted to INR based on standard conversion rate
[4] Bridge to India – India Solar Compass (October, 2014)

2.1.2 Capital Cost of Megawatt-Scale Photovoltaic Plant

The current capital cost of a 1 MW photovoltaic power plant consisting of imported poly-crystalline silicon modules, and including land cost, is determined to be INR 6 Crore. Also Indicative costs of various components for such plants are shown in Table 2.2.

The capital cost of megawatt-scale photovoltaic power plants is determined taking a standard plant size of 1 MW The cost is determined based on independent surveys of components, and feedback from private developers, Engineering Procurement & Commission (EPC) contractors and government agencies. While the costs of individual heads indicated in Table 2.2 may vary slightly from case to case, no major deviation in the total (capital) cost of such plants is observed. Along with imported modules the cost of locally manufactured modules (where the cells are imported) and modules in which both the cells and modules are manufactured locally is considered. The inverter replacement cost has also been included in the capital cost itself.

Hence, the capital cost per megawatt for a megawatt-scale photovoltaic power plant considering imported poly-silicon modules is taken as INR 6.0 Crore.

Table 2.2: Typical cost heads per MW ground-mounted grid-connected photovoltaic power plant

Sr. No.	Head	Cost (INR Cr.)
1	Photovoltaic Modules	3.50
2	Inverters	0.30
3	Module Mounting Structures	0.50
4	Land, Building and Civil Works	0.40
5	Evacuation Switchyard	0.30
6	Cables and Electrical Accessories	0.50
7	Engineering and Project Management	0.20
8	Contingency	0.30
9	**TOTAL**	**6.00**
Capital Cost Per Megawatt (Imported Modules): INR 6.00 Crore		
Capital Cost Per Megawatt (Domestic Modules, Imported Cells): INR 6.50 Crore		
Capital Cost Per Megawatt (Domestic Cells And Modules): INR 7.00 Crore		

2.1.3 Capital Cost of Kilowatt-Scale Photovoltaic Plant

One of the major differences affecting the normalized cost of kilowatt-scale photovoltaic power plants compared to megawatt-scale plants is the cost of inverters and other equipment and accessories which are found to be on the higher side as indicated in Table 2.3.

Hence, the capital cost per kilowatt for a kilowatt-scale photovoltaic power plant is taken as INR 80,000.

Table 2.3: Typical cost heads per kW rooftop grid-connected photovoltaic power plant

Sr. No.	Head	Cost (INR '000)
1	Photovoltaic Modules	35
2	Inverters	13.6
3	Module Mounting Structures	11.4
4	Building and Civil Works	7
5	Isolation Transformer	4
6	Wires and Electrical	1
7	Engineering and Project Management	3
8	Contingency	5
9	**TOTAL**	80
Capital Cost Per Kilowatt (Imported Modules): INR 80,000/-		
Capital Cost Per Kilowatt (Domestic Modules): INR 85,000/-		
Capital Cost Per Kilowatt (Domestic Modules And Cells): INR 90,000/-		

2.1.4 Evacuation Cost

The Solar Power Policy, 2009 of the Government of Gujarat provides that the transmission line from the switchyard of the substation of the megawatt-scale solar power plant to the Gujarat Energy Transmission Corporation Ltd. (GETCO) substation shall be laid by GETCO.

For smaller photovoltaic systems such as rooftop systems that are connected to the distribution grid at 11kV or below, the infrastructure typically exists as the solar power Generator is also the Consumer of the Distribution Utility. **However, in case the existing infrastructure is not sufficient for evacuation of solar power, such infrastructure should be developed or upgraded by the relevant distribution company.**

Hence, evacuation cost is not considered for calculation of solar tariff.

2.1.5 Operation and Maintenance Cost and its Escalation

Photovoltaic power plants are characterized by their simple and low-cost operation and maintenance (O&M). The operation and maintenance of a photovoltaic power plant mainly involves cleaning of the photovoltaic modules at a regular interval. The cleaning frequency of the modules of a commercial plant may be as high as once per week or as low as once per month.

In addition to cleaning staff, the photovoltaic power plants typically require security staff and site supervisors. Performance monitoring of such plants are typically done remotely, and an engineer is deployed onsite only during troubleshooting of issues.

Many earlier CERC and GERC tariff orders considered the operation and maintenance cost of 0.5% of the plant capital cost. However, the capital costs of the solar power plant equipment (especially the modules and inverters) have substantially reduced, while the labor cost involved in the operation and maintenance has seen escalation.

Hence, for the near term, the typical operation and maintenance cost of photovoltaic power plants is considered to be INR 10.75 lakh/MW/annum. This number has been arrived considering Honorable APTELs direction vide Judgment dated April 17, 2013 in Appeal No. 75 of 2012. Accordingly Honorable GERC passed Order No.1 of 2012 dated July 7, 2012 where the Commission determined the O&M to be fixed at INR 9.10 lakh/MW/annum escalating at 5.72% annually. Considering this as the cost for 2012-2013 and subsequently escalating this by 5.72% for the years 2013-14, 2014-15 and 2015-16 the Commission has arrived at the figure of INR 10.75 lakh/MW/annum escalation at 5.72% per annum.

Further, as most of this cost is human resource-related, **the annual escalation of the operation and maintenance cost is considered to be 5.72% annually.**

2.2 Performance Parameters of the Photovoltaic Power Plant

The energy output of a photovoltaic power plant primarily depends on two parameters:

- Plant Performance Parameters
- Weather Parameters

2.2.1 Plant Capacity

The capacity of a solar photovoltaic power plant can be defined as the cumulative rated capacity of the photovoltaic modules at Standard Testing Condition (STC) used in that power plant. Further, as it may not be practical to achieve the exactly desired plant capacity due to design constraints, a tolerance of ±2% is allowed.

Additionally, during the supply of photovoltaic modules, the actual power output of the module at STC may be different from the rated module power due to the nature of its manufacturing. The net allowable module tolerance between the module rating and actual performance in a photovoltaic power plant is considered at ±3%.

2.2.2 Performance Ratio

The plant performance parameters are collectively represented through a single value known as the Plant Performance Ratio (PR). This performance ratio is a measure of the quality of a photovoltaic plant that is independent of the location and incident irradiation, and hence, often known as the 'Quality Factor.'

The performance ratio is expressed as a percentage value and indicates the fraction of nominal incident solar radiation energy incident on a plant array that is converted into useful electrical energy injected into the grid. The performance ratio takes into account energy losses within a photovoltaic power plant such as thermal losses, module mismatch losses, ohmic (resistive) losses, inverter losses, etc. The procedure for determining the performance ratio of a photovoltaic power plant is prescribed in the Standard *IEC 61724: Photovoltaic System Performance Monitoring: Guidelines for Measurement, Data Exchange and Analysis*.

Based on independent surveys, analysis and feedback from private Developers, EPC contractors and government agencies it is determined that typical photovoltaic plants in Gujarat and India have recorded or quoted performance ratios between 70% and 80%, while 75% is an acceptable industry standard.

Table 2.4: Typical losses affecting the performance ratio of a photovoltaic power plant

Loss Mechanism	Loss
Loss due to temperature	13%
Loss due to inverter efficiency	3%
PV module mismatch loss	2%
DC and AC wiring ohmic (resistive) losses	2%
Soiling loss	3%
Transformer loss	1%
Other losses	1%
TOTAL LOSS	25%
NET PERFORMANCE RATIO	75%

2.2.3 Irradiance Data

As solar radiation is the primary fuel for the photovoltaic power plant, it is obvious that the energy output of the plant will be site specific; similar plants installed at different geographical locations will yield different energy outputs.

Gujarat is an attractive state for installation of solar energy systems due to the high levels of solar radiation that it receives. While irradiation and other weather data are available from the India Meteorological Department (IMD) and National Aeronautics and Space Administration (NASA) based on a limited number of observatories, many other private services are now available that claim to provide more site-specific and accurate weather data by interpolating existing long-term data with short-term measured data and advanced modeling.

2.2.4 Capacity Utilization Factor

The electrical energy output of a photovoltaic power plant can be calculated using the performance ratio and the global irradiance on the plane of the photovoltaic arrays, which are oriented at an optimum tilt angle. Further, the Capacity Utilization Factor (CUF) can be calculated based on the energy output of the plant. In Gujarat, the well-established solar generating plants are at Charanka and referring to the generation data of Charanka solar plants presented by Gujarat State Load Dispatch Centre (SLDC) and considering the average CUF of all solar PV generating plants **the CUF of Gujarat is considered 19%**in this document for the purpose of determination of tariff.

2.2.5 Annual Degradation in Performance

A performance warranty for 25 years on photovoltaic modules is an industry standard today. Typical warranties guarantee a performance of more than 90% for the first 10 years, and a performance of more than 80% for the next 15 years, adding to a total of 25 years. This implies an annual degradation rate of 0.9% for the photovoltaic modules.

Looking at some studies done based on long-term performance of modules in the climatic conditions of India; the Commission considers the degradation to be 1% per annum over the lifetime of the solar power plants.

No substantial degradation is expected in the performance of the balance of system.

Hence, the acceptable annual degradation in the performance of the grid-connected photovoltaic system is 1%.[5,6]

[5] All-India Survey of Photovoltaic Module Degradation: 2013, National Centre for Photovoltaic (NCPRE), IIT Bombay & Solar Energy Centre, Gurgaon: http://bit.ly/1bLCiBR

[6] PERFORMANCE OF SOLAR POWER PLANTS IN INDIA, Submitted To Central Electricity Regulatory Commission, New Delhi**:** http://bit.ly/1bvSD5L

2.2.6 Auxiliary Energy Consumption of Photovoltaic Power Plant

A photovoltaic power plant consumes minimal energy for auxiliary purposes. Auxiliary power may be required for air-conditioning in inverter and control rooms, cleaning water softening and pumping system, security night lighting and general office lights and fans.

The auxiliary consumption of the mega-watt scale photovoltaic power plant can be estimated at 0.25% of the total energy generation and that of kilo-watt scale photovoltaic plant is estimated to be NIL.

2.2.7 Useful Life

The standard warranty of photovoltaic modules, which account for more than half of the cost of the entire plant, is for a period of 25 year. However, the photovoltaic power plant including the modules is expected to last substantially beyond this period.

GERC, in its current Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has stipulated a solar power plant life of 25 years. Further, CERC in Clause 2 (1) (aa) of its Renewable Energy Regulation No L-1/94/CERC/2011 dated February 6, 2012 also defines the useful life of solar photovoltaic or a solar thermal power plant as 25 years.

Hence, the useful life of solar photovoltaic projects is taken as 25 years for calculation of the tariff.

2.3 Finance – Related Parameters of the Photovoltaic Power Plant

2.3.1 Debt – Equity Ratio

The GERC MYT Regulations, 2011, notified by the Commission provides a normative debt-equity ratio of 70:30 for Generating Companies/ Licensees. Further, Clause 5.3 (b) of the Tariff Policy, 2006, notified by the Ministry of Power, GOI, stipulates a debt –equity ratio of 70:30 for financing of power projects. Further, the GERC, in its current Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has stipulated the same debt-equity ratio.

Hence, the debt-equity ratio of 70:30 is considered for financing.

2.3.2 Loan Tenure

The GERC MYT Regulation, 2011, notified by the Commission provides for a loan tenure of 10 years. Further, GERC in its last Solar Tariff Order has stipulated the same loan tenure.

Hence, loan tenure of 10 years is considered.

2.3.3 Interest Rate on Loan

The interest rates have increased substantially in the Indian financial market due to the continuously rising inflation rate. While there is adequate data to show that inflation is falling largely supported due to falling price of crude oil, inflation still remains a concern. This is reflected in the interest rates of all major banks in India. While all banks have their own base rates, project financing interest rates are typically indicated by their relation with the State Bank of India (SBI) base rate. A reasonably sound project usually gets funding at rate 100 to 300 basis points above the base rate.

While the Reserve Bank of India (RBI) has already cut repo rate (the rate at which RBI lends to banks) and likely to do so in line with falling inflation, there seems to be no reason to expect a significant reduction in interest rates. This is partly because India's growth cycle is on the upward trend and inflation is strongly correlated to growth. In the current scenario, the base rate of SBI is 9.85%. A reasonable mark-up of 300 basis points on this base rate would result in an effective interest rate of 12.85%, which could be used for tariff determination purpose in this discussion document. The Hon'ble GERC has used the same methodology to determine the interest rate in its Order No. 2 of 2012, "In the matter of: Determination of Tariff for procurement of Power by the Distribution Licensee and Others from Wind Power Projects" and Order No. 4 of 2013: In the matter of: Determination of Tariff for Procurement of Power by the Distribution Licensees and Others from Biomass based Power Projects and Bagasse based Co-generation Projects"

Hence, the interest rate on loan for tariff computation is determined to be 12.85 %.

2.3.4 Insurance Cost

Insurance cost at the rate of 0.35% of the capital cost is considered annually. This insurance cost is as per GERC's last Solar Tariff Order, and is considered over and above the operation and maintenance cost.

2.3.5 Working Capital

GERC, in its last Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has considered the following to be included as working capital, which is also considered here:

- **One month's expense on operation and maintenance expenses, and**
- **Receivables equivalent to one month's energy charges for sale of electricity calculated on a normative CUF.**

2.3.6 Interest Rate on Working Capital

Interest rates on working capital are found to be lower than long-term interest rates for power project over the last ten years. This gap between the long-term loan and working capital loan rate is typically

between 150 and 250 basis points. The working capital is decided based on different parameters, and hence, **interest rate on working capital is decided 12.00%.**

2.3.7 Discount Rate

The Honorable GERC had determined the discount rate as in CERC order in its suo-motu Petition No. SM/004/2015 dated March 3, 2015.

The explanation for determining the discount rate is as under:

Discount Rate to be used for bid evaluation Weighted Average Cost of Capital (WACC) has been considered as discount rate.
The WACC has been computed as under:

WACC = Cost of Debt + Cost of Equity

Where, Cost of Debt=0.70 x (Market Rate of Interest) x (1-Corporate Tax Rate)

Cost of Equity= 0.30 x Return on Equity

Discount Rate has been computed using following table:

Table 2.5: Discount rate calculating parameters

Components of Debt/Equity	Assumptions (%)
Debt	70
Equity	30
Corporate Tax Rate (CTR)	33.99
Market Rate of Interest (MR)	12.85
Return on Equity	14

The WACC computed by the above formula 10.138%has been notified as discount rate for solar tariff determination.

2.3.8 Rate of Depreciation

CERC, in Clause 15 of its Renewable Energy Regulation No L-1/94/CERC/2011 dated February 6, 2012 indicates that the value base for purpose of depreciation shall be based on the capital cost of the asset; salvage value of the asset shall be considered as 10% and depreciation shall be allowed up to maximum of 90% of the capital cost. Depreciation per annum shall be based on 'Differential Depreciation Approach' over loan tenure and the period beyond loan tenure over useful life computed on 'Straight Line Method'. Depreciation shall be chargeable from the first year of

commercial operation. Provided that in case of commercial operation of the asset for part of the year the depreciation shall be charged on *pro rata* basis.

GERC, in its last Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has considered a high rate of depreciation as a promotional measure during the loan tenure, and then the remaining depreciation is spread over the remaining useful life.

Hence, depreciation of 6% per annum is considered for the first 10 years, and 2% for the next 15 years.

2.3.9 Return on Equity (ROE)

The GERC MYT Regulation, 2011, notified by the Commission provides norms for the Return on Equity as 14% per annum. GERC has also allowed Income Tax at 20.008% (18.5% MAT + 5% Surcharge + 3% Education Cess) per annum for 10 years, and Corporate Tax at 33.99% per annum from 11th year onwards. Any further enhancement in the Return of Equity will burden the consumers. (Ref. MYT)

This was challenged vide Appeal No.75 of 2012 dated 17th April 2013 before the Hon'ble APTEL, in the matter of SESI versus GERC and Gujarat Urja Vikas Nigam Ltd. (GUVNL). Accordingly, Hon'ble GERC in its Order No.1 of 2012 dated 07.07.2014 and subsequent corrigendum dated July 11, 2014, determined that solar project developers are "eligible for ROE available 14% post-tax with grossing up of Income Tax" (clause 12.3).

Hence, the return on equity considered is 14% post tax and grossed up.

2.4 Tariff for Photovoltaic Systems

2.4.1 System Classification

Based on the basic differences between implementation of megawatt-scale ground-mounted photovoltaic systems, and kilowatt-scale rooftop photovoltaic systems, all photovoltaic systems can be categorized basically into two types (kilowatt scale and megawatt scale) for tariff applicability:

Table 2.6: Photovoltaic system classification for tariff applicability

System Size	System Type	Evacuation Specification	Applicable Tariff
1 kW – 6 kW	Rooftop	230 V, 1-ph, 50 Hz	Kilowatt-scale Photovoltaic Tariff
6 kW – 100 kW	Rooftop	415 V, 3-ph, 50 Hz	
100 kW – 1 MW	Rooftop/ Ground-mounted	11 kV, 3-ph, 50 Hz	Megawatt-scale Photovoltaic Tariff
1 MW – 4 MW	Ground-mounted	11 kV, 3-ph, 50 Hz	
> 4MW	Ground-mounted	66 kV, 3-ph, 50 Hz	

2.4.2 Levelized Tariff

The various parameters for determination of tariff for solar photovoltaic power projects can be summarized as below:

Table 2.8: Summary of parameters for photovoltaic power projects

Parameters	Value		
Plant Cost			
Capital Cost	INR	600	Lakhs per MW for megawatt-sca system (Refer Table 0.2)
		650	
		700	
	INR	0.80	Lakhs per kW for kilowatt-scale system (Refer Table 0.2)
		0.85	
		0.90	
O & M Cost	INR	10.75	Lakhs/MW/annum
		0.0129	Lakhs/kW/annum
Escalation in O & M Cost		5.72%	Annually
Performance Parameters			
Capacity Utilization Factor		19%	
Performance Degradation		1%	Annually
Auxiliary Consumption		0.25%	of Energy Generation for megawatt scale
		NIL	of Energy Generation for kilowatt scale
Useful Life		25	Years
Financial Parameters			
Debt : Equity Ratio		70 : 30	
Loan Tenure		10	Years
Interest Rate on Loan		12.85%	Annually
Insurance Cost		0.35%	Annually
Interest on Working Capital		12.00%	Annually
Working Capital	Sum of:	1	Month's O&M Expense
		1	Months' Energy Charges at normative CUF
Rate of Depreciation		6%	Annually for the first10 years
		2%	Annually for the next15 years
Minimum Alternate Tax Rate		20.008%	Annually for the first10 years
Corporate Tax Rate		33.99%	Annually from the 11th year until 25th year
Return on Equity		14%	Annually
Discount Rate		10.138%	Annually

Based on the technical and financial inputs considered in this chapter, the levelized tariff including return on equity for megawatt-scale and kilowatt-scale solar photovoltaic power projects availing the accelerated depreciation and not availing the accelerated depreciation benefit using a discount rate of 10.138% is calculated as shown in following Table 2.8.

Table 2.8: Levelized tariff for megawatt-scale and kilowatt-scale photovoltaic systems commissioned between July 1, 2015 and 31 March, 2018

	Imported Modules	Domestic Modules (Imported Cells)	Domestic Cells and Modules
For Megawatt Scale Power Plant			
Without Accelerated Depreciation Benefit	INR 6.68	INR 7.15	INR 7.61
With Accelerated Depreciation Benefit	INR 6.00	INR 6.41	INR 6.81
For Kilowatt Scale Power Plant			
Without Accelerated Depreciation Benefit	INR 8.74	INR 9.20	INR 9.66
With Accelerated Depreciation Benefit	INR 7.83	INR 8.23	INR 8.64

2.4.3 Successive Revisions to Tariff

It is the intention of GERC to support the development of a long-term solar industry in Gujarat taking advantage of its enormous solar energy potential, which would accelerate the reduction in solar energy prices both in Gujarat as well as India. However, it may be inappropriate to commit the solar energy tariffs for the long term in view of the dynamically changing prices of solar energy technologies, and the potential economic burden on Consumers in case of deviation or reduction of actual solar energy prices from currently determined project prices.

The global trends in the photovoltaic industry indicate a continual drop in the price of photovoltaic modules of various technologies, and also a steady drop in the price of photovoltaic inverters. Further, the decrease in costs of photovoltaic systems is ensured through widespread industry learning and economies of scale. The Indian market has seen a steep drop in the cost of solar projects during the past years but the recent trends has shown that the prices have reached the saturation point and hence no revision in the tariffs have been included.

:: End of Chapter 2 ::

3. Solar Thermal Power

3.1 Cost of Solar Thermal Technology

3.1.1 Capital Cost

The CERC in its suo-motu Petition No SM/005/2015 dated March 3, 2015 determined the normative capital cost for the Solar Thermal power projects as INR 1200 Lakh/MW for the FY 2014-15. GERC, in its last Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has considered a capital cost of INR 14 crore per megawatt.

Upon reviewing the current state of technology and associated costs, and in order to support the development of solar thermal technology, a capital cost of INR 12 Crore per megawatt is considered.

3.1.2 Evacuation Cost

The Solar Power Policy, 2009 of the Government of Gujarat provides that the transmission line from the switchyard of the substation of the megawatt-scale solar power plant to the GETCO substation shall be laid by GETCO. This is further reflected in GERC's last Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012.

Hence, evacuation cost is not considered for calculation of solar tariff.

3.1.3 Operation and Maintenance Cost and its Escalation

The operation and maintenance costs of solar thermal power plants are higher than solar photovoltaic power plants. In addition to the cost of operating staff, solar thermal power plants also utilize fuels such as diesel for its auxiliary processes, water for cooling, and heat transfer fluids, which have a limited life.

Honorable GERC retains the O&M escalation at 1.5% of capital cost as the capital cost of solar thermal projects has not seen a dramatic decline as compared to solar PV plants. Moreover, there is a paucity of data available in the market with regards to the operations of solar thermal plants to arrive at a number.

Hence, the operation and maintenance cost of solar thermal power plants is considered at 1.5% of the capital cost.

Further, the annual escalation of the operation and maintenance cost is considered to be 5.72%.

3.2 Performance Parameters of Solar Thermal Power Plants

3.2.1 Capacity Utilization Factor

Taking into account the irradiation in the state of Gujarat, **a capacity utilization factor of 23% is considered for solar thermal power plants.**

3.2.2 Annual Degradation in Performance

Considering the nature of the solar thermal power plants, there are many components which may be subject to degradation. Based on learning's from working solar thermal power plants, the net degradation due to degradation in the heat transfer fluid, reflector assembly, thermal storage system, power block, etc. is in the range of 0.25-0.5% annually.

Hence, the annual degradation in performance of solar thermal power plants considered for this Discussion Paper is 0.25%.

3.2.3 Auxiliary Consumption

GERC, in its last Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has considered an auxiliary consumption of solar thermal power plants at 10%. CERC, in its order dated March 3, 2015 in suo-motu Petition No. SM/004/2015 of 2015 also considered an auxiliary consumption of 10%.

Hence, the auxiliary consumption of 10% of the generation of solar thermal power plants is considered.

3.2.4 Useful Life

The useful life for solar thermal power plants is estimated between 20 and 25 years based on the technology. Both GERC, in its last Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012, and CERC, in its order dated March 3, 2015 in suo-motu Petition No. SM/004/2015 of 2015 has considered the useful life for solar thermal power plants as 25 years.

Hence, the useful life of solar thermal power plants for discussion is considered as 25 years.

3.3 Finance Related Parameters

3.3.1 Debt – Equity Ratio

The GERC MYT Regulation, 2011, notified by the Commission provides a normative debt-equity ratio of 70:30 for Generating Companies/ Licensees. Further, Clause 5.3 (b) of the Tariff Policy, 2006, notified by the Ministry of Power, GOI stipulates a debt – equity ratio of 70:30 for financing of power projects. Further, the GERC, in its current Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has stipulated the same debt-equity ratio.

Hence, the debt-equity ratio of 70:30 is considered for financing.

3.3.2 Loan Tenure

The GERC MYT Regulation, 2011, notified by the Commission provides for loan tenure of 10 years. Further, GERC in its last Solar Tariff Order has stipulated the same loan tenure.

Hence, loan tenure of 10 years is considered.

3.3.3 Interest Rate on Loan

As explained in 'Section 2.3.3 Interest Rate on Loan' due to high volatility in the SBI base rate, the average over one year base rate of 9.85% is further marked up by 300 basis points for consideration as the interest rate on long term loan for solar power projects.

Hence, the interest rate on loan for tariff computation is determined to be 12.85%.

3.3.4 Insurance Cost

Insurance cost at the rate of 0.35% of the capital cost is considered annually. This insurance cost is as per GERC's last Solar Tariff Order, and is considered over and above the operation and maintenance cost.

3.3.5 Working Capital

GERC, in its last Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has considered the following to be included as working capital, which is also considered here:

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

3.3.6 Interest Rate on Working Capital

As explained in 'Section 2.3.6 Interest Rate on Working Capital, the interest rate on working capital is decided considering different parameters.

Hence, the interest rate on working capital is considered to be 12.00%.

3.3.7 Rate of Depreciation

CERC, in Clause 15 of its Renewable Energy Regulation No L-1/94/CERC/2011 dated February 6, 2012 indicates that the value base for purpose of depreciation shall be based on the capital cost of the asset; salvage value of the asset shall be considered as 10% and depreciation shall be allowed up to maximum of 90% of the capital cost. Depreciation per annum shall be based on 'Differential Depreciation Approach' over loan tenure and the period beyond loan tenure over useful life computed on 'Straight Line Method'. Depreciation shall be chargeable from the first year of commercial operation. Provided that in case of commercial operation of the asset for part of the year the depreciation shall be charged on *pro rata* basis.

GERC, in its last Solar Tariff Order dated January 27, 2012 in Order No. 1 of 2012 has considered a high rate of depreciation as a promotional measure during the loan tenure, and then the remaining depreciation is spread over the remaining useful life.

Hence, depreciation of 6% per annum is considered for the first 10 years, and 2% for the next 15 years.

3.3.8 Return on Equity

The GERC MYT Regulation, 2011, notified by the Commission provides norms for the Return on Equity as 14% per annum. GERC has also allowed Income Tax at 20.008% (18.5% MAT + 5% Surcharge + 3% Education Cess) per annum for 10 years, and Corporate Tax at 33.99% per annum from 11th year onwards. Any further enhancement in the Return of Equity will burden the consumers.

Hence, the return on equity considered is 14% post tax and grossed up.

3.4 Tariff for Solar Thermal Power Plants

3.4.1 Levelized Tariff

The various parameters for determination of tariff for solar thermal power plants can be summarized as follows:

Table 3.1: Summary of parameters for solar thermal power plants

Parameter	Value		
Plant Cost			
Capital Cost	INR	1200	Lakhs per MW for megawatt-scale syste
O & M Cost		1.5%	of Capital Cost
Escalation in O & M Cost		5.72%	Annually
Performance Parameters			
Capacity Utilization Factor		23%	
Performance Degradation		0.25%	Annually
Auxiliary Consumption		10%	of Energy Generation
Useful Life		25	Years
Financial Parameters			
Debt : Equity Ratio		70 : 30	
Loan Tenure		10	Years
Interest Rate on Loan		12.85%	
Insurance Cost		0.35%	Annually
Interest on Working Capital		12.00%	Annually
Working Capital	Sum of:	1	Month's O&M Expense
		1	Months' Energy Charges at normative CUF
Rate of Depreciation		6%	Annually for the first10 years
		2%	Annually for the next15 years
Minimum Alternate Tax Rate		20.008%	Annually for the first10 years
Corporate Tax Rate		33.99%	Annually from the 11th year until 25th year
Return on Equity		14%	Annually
Discount Rate		10.138%	Annually

Based on the technical and financial inputs considered in this chapter, the levelized tariff including return on equity for solar thermal power projects availing the accelerated depreciation and not availing the accelerated depreciation benefit using a discount rate of 10.138 % is calculated as shown in following Table 3.2.

Table 3.2: Levelized tariff for solar thermal power plants commissioned between July 1, 2015 and March 31, 2018

	Levelized Tariff
Without Accelerated Depreciation Benefit	INR 11.27

With Accelerated Depreciation Benefit	INR 10.09

3.4.2 Tariff for Variants (Hybrid) in Technology

In case a Developer chooses to develop the system with thermal storage or as a hybrid, the tariff determination for such system could be taken up on case-to-case basis under 'project specific' tariff determination route, if necessary based on petition filed by such Developer.

:: End of Chapter 3 ::

4. Other Considerations

4.1 Plant and Machinery

Solar Power Projects established with only new Plants and Machinery would be eligible for the benefit of tariff determined within the scope of this Discussion Paper.

Since this Tariff Order delineates different tariffs for imported and domestically manufactured cells and/or modules, solar project developers are required to give an undertaking to Gujarat Energy Development Agency (GEDA) with the details of module and cell make, specifications and country of origin which shall be verified by GEDA.

4.2 Auxiliary Power Supply

The Commission proposed that STU/Distribution Licensee shall provide auxiliary power for the solar generator under kWh to kWh adjustment basis.

4.3 Reactive Energy Charges

The Reactive Energy Charges as approved by the Commission in tariff orders for the GETCO from time to time shall be applicable to such projects. All inverters shall be capable of providing reactive power support to the grid which can be enabled as and when required by GETCO or the Discoms.

4.4 Evacuation Facilities

Interfacing line of appropriate capacity and voltage as per the CEA (Technical Standard for connectivity to the grid) Regulations, 2012 shall be provided by the STU/ Distribution Licensee at their cost. The intending generator shall apply to the STU/ Distribution Licensee concerned well in advance.

Switchyard equipment, metering and protection arrangement and RTUs at generator end shall be provided by the owners of solar generators at their cost. The interconnection voltage at generator switchyard will depend on the quantum of power to be evacuated and as per the connectivity granted by the STU/ Distribution Company in line with the State Grid Code.

The transmission line from the switchyard of generator to the GETCO substation shall be laid by GETCO.

4.5 Transmission/ Wheeling Charge

4.5.1 General

Whenever the power is sold to a Distribution licensee, the generator will supply the power at the interconnection point of the generator-STU i.e. generator bus-bar. Thereafter, the transmission/ wheeling charges will be borne by the distribution licensee.

4.5.2Wheeling with injection at 66 kV or above

As per the scope of the current Discussion Paper, this clause will be applicable to solar plants of capacity greater than 4 MW.

For wheeling of power to consumption site at 66 kV voltage level and above, the wheeling of electricity generated from the Solar Power Generators to the desired location(s) within the State shall be allowed on payment of transmission charges and transmission losses applicable to normal Open-Access Consumer.

For wheeling of power to consumption site at a voltage below 66 KV, the wheeling of electricity generated from the solar power Generators to the desired location(s) within the State shall be allowed on payment of transmission charges as applicable to normal open-access customers and transmission and wheeling loss @ 7% of the energy fed into the grid. This loss shall be shared between the transmission and distribution licensees in the ratio of 4:3.

4.5.3 Wheeling with injection at 11 kV or above and below 66 kV

As per the scope of the current Discussion Paper, this Clause will be applicable to ground-mounted or rooftop solar plant of capacity between 100 kW and 1 MW, and ground-mounted solar plants of capacity between 1 MW and 4 MW.

The wheeling of power generated by such generators to the desired location(s) within the area of same distribution licensee shall be allowed on payment (in kind) of distribution loss @ 3% of the energy fed in to the grid.

The wheeling of power generated by such generator to the desired location(s) within the State but in the area of a different distribution licensee shall be allowed on payment of transmission charges as applicable to normal Open-Access Customers and transmission and distribution loss @ 10% of the energy fed in to the grid. These losses shall be shared among the transmission licensee and two distribution licensees involved in the ratio of 3:4:3.

4.5.4 Wheeling with injection at 415 V or below

As per the scope of the current Discussion Paper, this clause will be applicable to rooftop solar installations of capacity between 1 kW and 6 kW feeding at 220 V, 1φ; and rooftop solar installations of capacity between 6 kW and 100 kW feeding at 415 V, 3φ.

No wheeling charges shall apply for wheeling of power generated by such projects to the desired location(s), if the solar project and consumption location are located within the area of same distribution licensee, as such projects decrease the transmission and distribution losses for the utility, and increase the efficiency of the grid.

4.5.5 Wheeling at Two or More Locations

If a Solar Power Generator owner desires to wheel electricity to more than two locations, he shall pay INR 0.05 per unit on energy fed in the grid to Distribution Company in whose area power is consumed in addition to the abovementioned transmission charges and losses, as applicable.

4.6 Cross-Subsidy Charges

As a promotional measure for solar power, which is still in its nascent stage and not operating under REC mechanism no cross-subsidy surcharges would be levied in case of third-party sale or captive use. However, normal open-access charges as specified in the Section titled "Transmission/ Wheeling Charges" should be levied from Consumers/ Users.

4.7 Banking

All solar power projects that are commissioned under captive generating mode and not operating under the REC route or third party sale shall be eligible for banking of energy for one month period only. The banking period is determined with consideration of billing cycle for recipient units of the concerned distribution licensee, who receive the solar energy as captive use. Banking shall be considered as first in first out (FIFO) energy basis. Any surplus energy of banked units in the given billing cycle available after set-off shall be considered as deemed sale to the concerned distribution licensees at Average Power Purchase Cost (APPC) rate determine by the Commission for relevant year.

4.8 REC Projects

Solar power projects that are set up and operate under the REC route they shall:

(i) Be required to pay the entire transmission and wheeling charges and losses
(ii) Be required to pay the cross subsidy surcharge.
(iii) NOT be eligible for banking facility.

In the situation where there is a third party sale by the solar power project developer and in addition REC is availed, any surplus energy shall be considered as a deemed sale to the distribution licensee in the area of the consumer.

Solar power project developers who are not operating under REC route are eligible to transmit and wheel the energy at the transmission and wheeling charges and losses as proposed in para 4.5 above. However, no banking is allowed in case of third party sale. The energy wheeled is required to be consumed in the same time block. Any unutilized energy is to be considered as sale to the concerned distribution licensee in the area at which the buyer of such energy is situated. The surplus energy if available, after set-off in same time block, will be considered as deemed sale to the concerned distribution licensee at the APPC rate of relevant year as determined by the Commission.

4.9 Applicability of Intra-State ABT

The Intra-state ABT order will not be applicable to solar power generation projects.

4.10 Energy Accounting

Solar based energy generation projects shall be out of the purview of the Intra-State ABT. However, for the purpose of energy accounting, such projects will have to provide ABT compliant meters at the interface points. Interface metering shall conform to the Central Electricity Authority (Installation and Operation Meters) Regulations, 2010. The electricity generated from the Solar Power Generators shall be metered and readings shall be taken jointly by the solar power project Developer with the GEDA, GETCO or Distribution Company at the interconnection point of the generator bus-bar with the transmission or distribution system concerned, as the case may be.

In case of solar rooftop power projects, a separate metering system shall be provided at the output terminal of solar roof-top power project to measure gross energy generation from such project.

4.11 Power Purchase Agreement

The term of the power purchase agreement that the solar Developer signs with the Distribution Licensee will be 25 years. The distribution licensee may sign the PPA at the earliest from the date of submission of the application with all relevant details by the solar generators and get it approved from the Commission.

Further, the Commission decides that the Project Developer shall submit a Bank Guarantee/ Security Deposit of INR 25 lakhs /MW to the Distribution Licensee at the time of signing of PPA.

4.12 Sharing of Clean Development Mechanism (CDM) Benefit

The sharing of CDM benefits as per the recommendation made by the Working Group for Renewable Energy Generation constituted by the Forum of Regulators and as per the CERC, in Clause 21 of its Renewable Energy Regulation No. L-1/94/CERC/2011 dated February 6, 2012:

"100% of the gross proceeds on account of CDM benefit to be retained by the project Developer in the first year after the date of commercial operation of the generating station. In the second year, the share of the Beneficiaries shall be 10% which shall be progressively increased by 10% every year till it reaches 50%, where after the proceeds shall be shared in equal proportion, by the Generating Company and the Beneficiaries."

This order for sharing of CDM benefit may be retained for solar projects in Gujarat.

4.13 Standards of CEA and RRF mechanism of CERC:

The project developer shall require to follow the provisions of the CEA Regulations/standards for grid connectivity of solar projects notified from time to time. The project developers are governed by the CERC regulations "Procedure for the implementation of the Mechanism of Renewable Regulatory Fund" (RRF) under Regulation 6.1 (d) of the CERC (Indian Electricity Grid Code), Regulation 2010 (dated 18-2-2011). Developers shall require complying with the above regulations. In absence of compliance of above regulations GEDA shall not issue the commissioning certificate.

4.14 Control Period

The control period proposed for the solar energy tariff order is from July 1, 2015 to March 31, 2018.

4.15 Non – Applicability of Merit Order

Considering the nature of solar energy, all solar energy power plants will be considered as 'must-run' facilities, and the power generated from such power plants will be kept out from the merit order dispatch principles.

Place: Gandhinagar
Date: 02/06/2015

Sd/-
Secretary
GERC

:: End of Chapter 4 ::