Investment Decision and Financial Feasibility in Solar Energy Sector in India

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Abstract

Solar energy is becoming an important source of energy all over the World and especially in India. Very few solar plants have been installed in India so far, and therefore no historical experience are available. The objective of this paper is to investigate the Investment Decision and financial feasibility of solar power plants in India. The analysis is carried out on the basis of Financial Parameters based on CERC Generic Tariff Model. The paper concludes that power purchase costs constitute the largest cost element. In the paper the sensitivity analyses on various key parameters like capacity utilization factor, Capital cost, interest rate and return on equity and depreciation was also performed both in Solar Thermal and Solar PV power plants.

Key Words: Solar Energy, Solar Thermal Power Projects Parameters, Solar PV Power Projects Parameters, Financial feasibility.

INTRODUCTION

India is one of the fastest growing countries in terms of Energy consumption. Currently, it is the fifth largest consumer of energy in the world, and will be the third largest by 2030. The country is heavily dependent on fossil sources of energy for most of its demand.

India is located in the equatorial sun belt of the earth, thereby receiving abundant radiant energy from the sun. The India Meteorological Department (IMD) maintains a nationwide network of radiation stations which measure solar radiation and also the daily duration of sunshine. In most parts of India, clear sunny weather is experienced 250 to 300 days a year. The annual global radiation varies from 1600 to 2200 kWh/sq.m which is comparable with radiation received in the tropical and sub-tropical regions. The equivalent energy potential is about 6,000 million GWh of energy per year. The highest annual global radiation is received in Rajasthan and northern Gujarat. In Rajasthan, large areas of land are barren and sparsely populated, making these areas suitable as locations for large central power stations based on solar energy.

The Indian government has launched Jawaharlal Nehru National Solar Mission (JNNSM) with a target of achieving 20000 MW by 2022. The goal is to make India one of the

leaders in solar energy. Although solar energy is still expensive today, but costs are coming down with technology development, right governmental policies and Research and Development efforts.

2. OBJECTIVES AND METHODOLOGY

The objective of the paper is to investigate the Investment Decision and financial feasibility of solar power plants in India that results in correct investment decisions. The analysis is carried out on the basis of Financial Parameters based on CERC Generic Tariff Model such as (assumption of solar PV power projects and assumption of solar thermal power projects). Assumptions are related to the Cost of Generation over the life of the Project consisting of various costs factors such as Operation and Maintenance Expenses, Interest on Term Loan, Interest on Working Capital, and Return on Equity & Depreciation.

METHODOLOGY

To achieve the above mentioned objective the capital budgeting technique such as NPV, IRR for the Project & Equity IRR were used. Sensitivity Analysis was also carried out when certain basic parameters including financial parameters and assumptions are varied.

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3. SOME INSIGHTS OF SOLAR ENERGY SECTOR

Solar power generation technologies can be broadly classified into two broad categories first is Solar Photovoltaic technologies and second Solar thermal power plants

3.1 Indian Solar Market Trends

The Indian solar gadget market is still in a nascent stage and not in a position to bring out innovative products every now and then. Solar gadgets may not be as sleek or stylish as other tech gadgets and in terms of price appear bit costly at the initial stage. Like any other electronics manufacturing sector, manufacturers of solar products also depend on countries like China and Taiwan for imports. The products are cheap as well as meet the user requirements. As manufacturing requires huge capital, it is tough to start manufacturing in India considering high capital cost of around 18-24 per cent per annum and end number of taxes and permissions required to set up a manufacturing unit, marketing and providing after sales service. India till date has no silicon refining plant, which is the basic material used for manufacturing solar panels, glass, silver ribbon and other components.

The Indian manufacturing industry currently has an overall production capacity of about 1,300MW for modules and 700MW for cells. These capacities far exceed PV installations in India and will do so for some years, even considering the annual growth rates. The Indian PV industry has grown based on exports to international solar markets and continues to depend on the European countries for more than 80% of its revenues. More than 70% of cells and 80% of modules manufactured in India are still exported.

3.2 Indian Solar Market Potential

It is believed that Indian Photovoltaic market have huge potential. The future generation of gadgets will mostly comprise those powered by the solar energy. Depleting non-renewable energy resources, rising electricity bill and increasing awareness about green energy sources, have prompted people to adopt technologies to harness the abundantly available solar energy. It is clean, reliable and safe and if used skilfully, can reduce our dependency on conventional form of energy and save money as well as environment. Today, there is a wide range of solar devices available in the market including solar mobile phones, solar chargers, solar shaver, solar candles, solar lamps, solar headphones, solar exhaust fans, solar heating devices, solar

energy saver etc.

Electricity demand is growing at 8% annually, similar to the growth of the economy. According to ministry of new and renewable energy commission, there is a 92 GW electricity demand over the next 10 years. India has a power generation capacity of about 170k MW of which only about 8 – 10% is generated through renewable sources. The country has an estimated renewable energy potential of around 85 GW from commercially exploitable sources: wind: 45 GW, small hydro: 15 GW and biomass/bio-energy: 25 GW. India has the potential to generate 35 MW/km² using solar photovoltaic and solar thermal energy.

The Government of India and its state governments have created a major initiative called ‘The National Solar Mission’. One of the main features of the Mission is to make India a global leader in solar energy and the mission envisages an installed solar generation capacity of 20 GW by 2022. This could in fact be much larger due to private initiatives that will no longer need state aid.

3.3 Demand and Opportunities in Solar Market

There is an immense potential for solar gadgets in India, but certain hurdles prevent the rise in their demand. Environmental awareness is a prime factor fuelling the demand of solar gadgets; however, in India this awareness is not as high as it should be. About 70 per cent of India lives in villages with very poor or no electricity supply. The demand for solar gadgets has increased in the past two to three years and the solar market has gained momentum. During the last quarter we have noticed a 25 to 30 percent rise in sales. However, this demand has mostly come from small scale industries and villages. Although the market potential for solar products is huge, availability of coal generated electricity at Rs. 2.80/Kwh is the biggest hindrance for selling solar generated electricity that costs Rs 7-15/Kwh. It implies that when it comes to spending money, people prefer to save rather than care for the environment.

Based on likely predictions of growth for the next decade, the solar module demand worldwide until is forecasted in Table 1.

Table 1 Demand for Solar PV Modules by Year (GW)

					Expected Demand	
2010	2011	2012	2013	2014	2017	2020
13.6	20.2	23.8	33	45.3	85	200

The JNNSM guidelines stipulate that all the grid connected Solar PV plants in India coming under the scheme will have to use Solar PV modules that are made in India.

3.4 Barriers to the Development and Deployment of Solar Power Techniques

Indian solar market is growing very fast. Although there is huge potential for harnessing solar power but some there are some hurdles in the development and deployment of solar power techniques that are categorized in to three categories technical, economic and institutional barriers. The main constraints in there developments are as follows:

3.4.1 Technical Barriers:

- The efficiency constraint: 4–12% (for thin film) and under 22% (for crystalline) in the current market.
- Performance limitations of balance of system (BOS) components such as batteries, inverters and other power conditioning equipment.
- Silicon supply: strong demand for PV outpaced the supply and partly stalled the growth of solar sector.
- Cadmium and tellurium supply for certain thin film cells: these two components are by-products from respectively the zinc mining and copper processing and their availability depends on the evolution of these industries.
- Lack of adequate infrastructure to interconnect for hassle-free metering and billing.

3.4.2 Economic barriers:

- High initial cost and lack of easy and consistent financing options forms one of the biggest barriers primarily in developing countries.
- Unusually high risks determined by finance institutions because of their lack of experience with projects.
- Cost of BOS is not declining proportional to the decline in module price.
- Bias against distributed technology platforms among conventional energy agencies and utilities.

3.4.3 Institutional barriers

- Lack of effective and appropriate laws and policies for utilities, to encourage wider adoption.
- The limited ability to train adequate number of technicians to effectively work in a new solar energy

infrastructure.

- Limited understanding among key national and local institutions of basic system and finance factors.
- The fragileness of solar development partnerships: many PV projects are based on development partnerships and with the early departure of a partner the revenue to complete, operate and maintain the system may falter.
- Procedural problems such as the need to secure financing from multiple sources and approvals from several agencies (e.g., in India, MNRE, IREDA, the Planning Commission, and the Ministry of Agriculture and Rural Development).

3.5 Types of Tariff

1. Cost Plus Tariff as determined/Approved by Appropriate Regulatory Commission.
2. Tariff Based on Competitive Bidding as per latest Guidelines issued by Ministry of Power w.e.f. 5.1.2011 and Draft Guideline issued by Ministry of New and Renewable Energy on 12th December, 2012.
3. Purchase by Distribution Companies of Power on Average Pooled Power Costs without purchasing the environmental attributed i.e. REC which can be traded by the Generating Company at Power Exchanges at a price between Forbearance Price and Floor Prices.

As a part of Forum of Regulators, Central Commission i.e. CERC every year notifies Generic Tariff for Renewable Energy Sources including Solar which is main guiding factor for the State Commissions to determine tariff of Renewable Energy in their respective States. The broad features of CERC Tariff Regulations for Solar Energy issued for 2013-14 are as follows :-

1. Useful life of Solar PV and Solar Thermal Plants has been kept at 25 Years.
2. The Control Period or Review Period under these Regulations shall be of five years, of which the first year shall be the financial year 2012-13.
3. Benchmark capital cost for Solar PV and Solar Thermal projects will be reviewed annually by the Commission.
4. The Tariff Period shall be twenty five years (25) years In case of Solar PV and Solar thermal power projects.

3.5.1 Tariff Structure

The tariff for renewable energy technologies shall be single part tariff consisting of the following fixed cost components:

- (A) Return on equity;
- (B) Interest on loan capital;
- (C) Depreciation;
- (D) Interest on working capital;
- (E) Operation and maintenance expenses;

3.5.2 Tariff Design

- (1) The generic tariff shall be determined on levelled basis for the Tariff Period. Provided that for renewable energy technologies having single part tariff with two components, tariff shall be determined on levelled basis considering the year of commissioning of the project for fixed cost component while the fuel cost component shall be specified on year of operation basis.
- (2) For the purpose of levelled tariff computation, the discount factor equivalent to Post Tax weighted average cost of capital shall be considered.
- (3) Levellisation shall be carried out for the 'useful life' of the Renewable Energy project while Tariff shall be specified for the period equivalent to 'Tariff Period'.

3.6 Financial Principles

The general financial principles for solar energy sector are summarized below:

- 1. **Capital Cost:** Capital Cost in Generic Tariff inclusive of all capital work including plant and machinery, civil work, erection and commissioning, financing and interest during construction, and evacuation infrastructure up to inter-connection point.
- 2. **Debt Equity Ratio:** For generic tariff the debt equity ratio shall be 70:30.
- 3. **Loan Tenure:** For the purpose of determination of tariff, loan tenure of 12 years shall be considered.
- 4. **Interest Rate:** normative interest rate shall be considered as average State Bank of India (SBI) Base rate prevalent during the first six months of the previous year plus 300 basis points.

Notwithstanding any moratorium period availed by the generating company, the repayment of loan shall be considered from the first year of commercial operation of the project and shall be equal to the annual depreciation allowed. The present rate of Interest on Loan is 13%.

3.7 Depreciation

- 1. The value base for the purpose of depreciation shall be the Capital Cost of the asset admitted by the Commission. The Salvage value of the asset shall be considered as 10% and depreciation shall be allowed up to maximum of 90% of the Capital Cost of the asset.
- 2. Depreciation per annum shall be based on 'Differential Depreciation Approach' over loan period beyond loan tenure over useful life computed on 'Straight Line Method'. The depreciation rate for the first 12 years of the Tariff Period shall be 5.83% per annum and the remaining depreciation shall be spread over the remaining useful life of the project from 13th year onwards.
- 3. 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, depreciation shall be charged on pro rata basis.

3.8 Return on Equity

- 1. The value base for the equity shall be 30% of the capital cost or actual equity (in case of project specific tariff determination) as determined under Regulation 13.
- 2. The normative Return on Equity shall be:
 - a) 20% per annum for the first 10 years.
 - b) 24% per annum 11th years onwards.

3.9 Interest on Working Capital : shall be computed in accordance with the following:

- 1. Operation & Maintenance expenses for one month;
- 2. Receivables equivalent to 2 (Two) months of energy charges for sale of electricity calculated on the normative CUF;
- 3. Maintenance spare @ 15% of operation and maintenance expenses The present Rate of Interest on working Capital is 13.5%

3.10 Operation and Maintenance Expenses

- 1. 'Operation and Maintenance or O&M expenses' shall comprise repair and maintenance (R&M), establishment including employee expenses and administrative & general expenses.
- 2. Operation and maintenance expenses shall be determined for the Tariff Period based on normative O&M expenses specified by the Commission subsequently in these Regulations for the first Year of Control Period.
- 3. Normative O&M expenses allowed during first year of

the Control Period (i.e. FY 2012-13) under these Regulations shall be escalated at the rate of 5.72% per annum over the Tariff Period.

3.11 Sharing of CDM Benefits

1. The proceeds of carbon credit from approved CDM project shall be shared between generating company and concerned beneficiaries in the following manner, namely
2. 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;
3. 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.

3.12 Taxes and Duties

Tariff determined under these regulations shall be exclusive of taxes and duties as may be levied by the appropriate Government. Provided that the taxes and duties levied by the appropriate Government shall be allowed as pass through on actual incurred basis.

4. TECHNOLOGY SPECIFIC PARAMETERS

4.1 Technology Specific Parameters for Solar PV Power Project

1. Technology Aspects
Norms for Solar Photovoltaic (PV) power under the Regulations shall be applicable for grid connected PV systems that directly convert solar energy into electricity and are based on the technologies such as crystalline silicon or thin film etc. as may be approved by MNRE.
2. Capital Cost
The normative capital cost for setting up Solar Photovoltaic Power Project shall be ₹ 800 Lakh/MW for FY 2013-14.
3. Capacity Utilization Factor
The Capacity utilization factor for Solar PV project shall be 19%.
4. Operation and Maintenance Expenses
 - a. The O&M Expenses shall be Rs. 11.63 Lakh/MW for the 1st year of operation.
 - b. Normative O&M expenses allowed at the commencement of the Control Period under these Regulations shall be escalated at the rate of 5.72% per annum

4.2 Technology specific parameters for Solar Thermal Power Project

1. Technology Aspects: Norms for Solar thermal power under these Regulations shall be applicable for Concentrated solar power (CSP) technologies viz. line focusing or point focusing, as may be approved by MNRE, and uses direct sunlight, concentrating it several times to reach higher energy densities and thus higher temperatures whereby the heat generated is used to operate a conventional power cycle to generate electricity.
2. Capital Cost: The normative capital cost for setting up Solar Thermal Power Project shall be ₹ 1200 Lakh/MW for FY 2013-14.
3. Capacity Utilization Factor (CUF): The Capacity Utilization Factor shall be 23%.
4. Operation and Maintenance Expenses:
 - a) The O&M Expenses shall be ₹ 15.86 Lakh/MW for 1st year operation.
 - b) Normative Operation and Maintenance Expenses allowed at the commencement of the Control Period under these Regulations shall be escalated at the rate of 5.72% per annum.
5. Auxiliary Consumption: The auxiliary consumption factor shall be 10%.
6. Discount Factor: The discount factor considered for this purpose is equal to the Post Tax 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 post-tax rates for interest and equity component, the discount factor is calculated.

Interest Rate considered for the loan component (i.e.70%) of Capital Cost is 13.00%. For equity component (i.e. 30%) rate of Return on Equity (ROE) considered at Post Tax ROE of 16% considered. The discount factor derived by this method for all technologies is 10.95% $((13.0\% \times 0.70 \times (1 - 32.445\%)) + (16.0\% \times 0.30))$.

4.3 Computation of Levellised Generic Tariff

Based on the parameters mentioned in section 4.2 the Levellised Generic Tariff for Solar PV Power Plants is summarized in Table 2.

Table 2 Assumption for Solar PV Power Projects Parameters

S. No.	Assumption Head	Sub-Head	Sub-Head (2)	Unit	Assumptions
1	Power Generation	Capacity	Installed Power Generation Capacity Capacity Utilization Factor Useful Life	MW % Years	1 19.0% 25
2	Project Cost	Capital Cost/MW	Power Plant Cost	Rs Lacs/MW	800
3	Financial Assumptions				
			Tariff Period	Years	25
		<u>Debt: Equity</u>	Debt Equity Total Debt Amount Total Equity Amount	% % Rs Lacs Rs Lacs	70% 30% 560.00 240.00
		<u>Debt Component</u>	Loan Amount Moratorium Period Repayment Period(including Moratorium) Interest Rate	Rs Lacs years years %	560.00 0 12 13.00%
		<u>Equity Component</u>	Equity amount Return on Equity for first 10 years RoE Period Return on Equity 11th year onwards	Rs Lacs % p.a Year % p.a	240.00 20.00% 10 24.00%
			Weighted average of ROE Discount Rate		22.40% 10.95%
4	Financial Assumptions				
		<u>Fiscal Assumptions</u>	Income Tax MAT Rate (for first 10 years) 80 IA benefits	% % Yes/No	32.445% 20.000% Yes
		<u>Depreciation</u>	Depreciation Rate for first 12 years	%	5.83%

			Depreciation Rate 13th year onwards Years for 5.83% rate	%	1.54% 12
5	Working Capital	<u>For Fixed Charges</u> O&M Charges Maintenance Spare Receivables for Debtors <u>For Variable Charges</u> Interest On Working Capital	(% of O&M expenses)	Months % Months %	1 15% 2 13.50%
6	Operation & Maintenance	power plant <u>Total O & M</u> <u>Expenses Escalation</u>		Rs. Lacs %	11.63 5.72%

Table 3 Assumptions for Solar Thermal Power Projects Parameters

S. No.	Assumption Head	Sub-Head	Sub-Head (2)	Unit	Assumptions
1	Power Generation	Capacity	Installed Power Generation Capacity Capacity Utilization Factor Auxiliary Consumption Factor Useful Life	 MW % % Years	 1 23.0% 10.0% 25
2	Project Cost	Capital Cost/MW	Power Plant Cost	Rs Lacs/MW	1300.00
3	Sources of Fund	<u>Debt: Equity</u> <u>Debt Component</u> <u>Equity Component</u>	Tariff Period Debt Equity Total Debt Amount Total Equity Amount Loan Amount Moratorium Period Repayment Period(incl Moratorium) Interest Rate	Years % % Rs Lacs Rs Lacs Rs Lacs years years %	25 70% 30% 910 390 910.00 0 12 13.00%
			Equity amount	Rs Lacs	390.00

			Return on Equity for first 10 years	% p.a	20.00%
			RoE Period	Year	10
			Return on Equity 11th year onwards	% p.a	24.00%
			Weighted average of ROE	%	22.40%
			Discount Rate	%	10.95%
4	Financial Assumptions	<u>Fiscal Assumptions</u>	Income Tax	%	32.445%
			MAT Rate (for first 10 years)	%	20.000%
			80 IA benefits	Yes/No	Yes
		<u>Depreciation</u>			
5	Working Capital		Depreciation Rate for first 12 years	%	5.83%
			Depreciation Rate 13th year onwards	%	1.54%
			Years for 5.83% rate		12
		<u>For Fixed Charges</u>			
		O&M Charges		Months	1
		Maintenance Spare	(% of O&M expenses)	%	15%
		Receivables for Debtors		Months	2
		<u>For Variable Charges</u>			
		Interest On Working Capital		%	13.50%
6	Operation & Maintenance				
		power plant		Rs Lacs	15.86
		<u>Total O & M</u>			
		<u>Expenses Escalation</u>		%	5.72%

5 ANALYSIS AND INTERPRETATION

Table 4 represent the electricity generation which is based on assumption 1. Table 5 represent the calculation of depreciation based on assumption 4. Long term debt schedule which is based on assumption 3 is shown in table 6. Table 7 represents the maintenance and operation expenses based on assumption 6.

Table 8 shows the calculation of working capital based on assumption 5, operating and maintenance expenses and on cost of generation. Accelerated depreciation is shown in table 9 which is based on financial assumption 4 as well on electricity generation.

Table 10 shows the determination of tariff which is based on electricity generation, operating and maintenance expenses, depreciation, loan and interest. Working capital and return on equity. Projected profit and loss account and debt service coverage ratio is shown in Table 11 which is based on electricity generation, cost of generation, depreciation and loan and

interest schedule. Project and equity IRR is shown in Table 12 which is based on assumption 2 and projected profit and loss account.

Three version of project IRR is calculated pretax, post tax without tax shield, and post-tax with tax shield. Two version of equity IRR is calculated namely equity IRR post tax, equity IRR post tax with tax shield.

Table 4 Electricity Generation

Units Generation	Unit	Year																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Installed Capacity	MW	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CUF	%	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
Electricity Generation	MU	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66

Table 5 Depreciation

Unit in Rs. Lakh																										
Power Plant Cost Rs 800 Lakh																										
Life of Plant 25 Years																										
		Years																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Depreciation for power plant	46.64	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
Total Depreciation	46.64	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66

Table 6 Long Term Debt Schedule

Unit in Rs. Lakh													
Particular	Year												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Opening Balance	560	513	467	420	373	327	280	233	187	140	93	47	0
Repayment	46.67	46.67	46.67	46.67	46.67	46.67	46.67	46.67	46.67	46.67	46.67	46.67	0.00
Closing Balance	513	467	420	373	327	280	233	187	140	93.3	46.7	0.0	0.0
Interest	69.77	63.70	57.63	51.57	45.50	39.43	33.37	27.30	21.23	15.17	9.10	3.03	0

Table 7 Maintenance and Operation Expenses

Unit in Rs. Lakh																										
Particular		Year																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
O&M expense for power plant	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63
Total O&M expense	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63

Table 8 Working Capital Requirement

Unit in Rs. Lakh

Particular	Year																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
O&M expense for power plant	0.97	1.00	1.08	1.15	1.22	1.30	1.38	1.45	1.53	1.60	1.68	1.75	1.83	1.90	1.98	2.05	2.13	2.20	2.28	2.35	2.43	2.50	2.58	2.65	2.73
Receivables	3.00	2.09	2.28	2.47	2.65	2.84	3.03	3.22	3.41	3.60	3.79	3.98	4.17	4.36	4.55	4.74	4.93	5.12	5.31	5.50	5.69	5.88	6.07	6.26	6.45
Maintenance Sapro	1.74	1.88	2.02	2.16	2.30	2.44	2.58	2.72	2.86	3.00	3.14	3.28	3.42	3.56	3.70	3.84	3.98	4.12	4.26	4.40	4.54	4.68	4.82	4.96	5.10
Total Working Capital	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22
Interest Rate 13.50%																									
Interest on Working Capital	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3

Table 9 Determination of Accelerated Depreciation

Determination of Accelerated Depreciation Benefit for Solar PV Power Projects																									
Depreciation amount 90%																									
Book Depreciation rate 5.28%																									
Tax Depreciation rate 80%																									
Additional Depreciation 20.00%																									
Income Tax (Normal Rates) 32.445%																									
Capital Cost 800.0																									
particular	Unit	Years																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Book Depreciation		2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Book Depreciation	Rs	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Book Depreciation	L	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4
Book Depreciation	k	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4
Book Depreciation	h	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Accelerated Depreciation																									
Opening	%	0	5	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 10 Determination of Tariff Component - (Solar Thermal)

[illegible][illegible]

	k	3	6	8	0	1	2	2	2	1	0	4	6	9	4	1	8	5	3	2	0	8	5	2	9	4
	h	3	0	3	1	5	4	7	6	8	5	8	2	6	9	2	3	9	9	0	1	0	6	7	1	9
DSC		1	1	1	1	1	1	1	1	1	1															
R		.	.	.	.	.	.	.	.	.	.															
		1	1	2	2	3	4	4	5	7	8															
		1	6	1	7	3	0	9	8	0	3															
Min 1.11																										
Average 1.41																										

Table 12 Project and Equity IRR

Description	Unit	Year																								
		1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5
Project IRR computations																										
Cash outflow																										
fund drawal 1,300.0																										
Cash inflow																										
PBDIT-Tax			2100	274	220	291	196	193	190	187	184	181	178	175	172	169	166	163	160	157	154	151	148	145	142	139
Terminal value																										
Net cash flows (1,300.0)		2100	274	220	291	196	193	190	187	184	181	178	175	172	169	166	163	160	157	154	151	148	145	142	139	136
Project IRR 13.84%																										
Equity IRR computations																										
Equity Cash outflow																										
equity fund drawal (390.0)																										
Equity Cash inflow																										
PAT			2183	353	430	574	641	743	785	852	877	924	959	994	1029	1064	1099	1134	1169	1204	1239	1274	1309	1344	1379	1414
Depreciation		686	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	0	0	0	0	0	0	0

[illegible]

6. SENSITIVITY ANALYSIS OF VARIOUS KEY ASSUMPTIONS

Sensitivity analysis is carried out on the following three variables namely Capacity Utilization Factors, Deretion Factor, Capital Cost and Interest Rate.

6.1 Capacity Utilization Factor : The performance of solar power plants is best defined by the Capacity Utilization Factor (CUF), which is the ratio of the actual electricity output from the plant, to the maximum possible output during the year. The estimated output from the solar power plant depends on the design parameters and can be calculated, using standard software's. But since there are several variables which contribute to the final output from a plant, the CUF varies over a wide range. These could be on account of poor selection /quality of panels, derating of modules at higher temperatures, other design parameters like ohmic loss, atmospheric factors such as prolonged cloud cover and mist.

The variation in 1% of CUF can impact the Generation of Electricity and consequent impacts on revenue realization as explained below:

Table 13 Solar PV

CUF %	Electricity Generation (in Mus)	Tariff (In Rs.)
15	1.31	11.08
16	1.40	10.39
17	1.49	9.78
18	1.58	9.23
19	1.66	8.75
20	1.75	8.31
21	1.84	7.91
22	1.93	7.56
23	2.01	7.23

It is clearly reflected by doing the sensitivity analysis in table above that with 1% change in the Capacity Utilization Factor the tariff has to change in order that the revenue remains unchanged. With 1% increase in CUF the Electricity Generation goes up by 90000 units and the corresponding tariff decreases as shown in table above. CERC has calculated tariff of Rs. 8.75 at 19 % CUF.

Table 14 Solar Thermal

CUF %	Electricity Generation (in Mus)	Tariff (In Rs.)
17	1.34	17.27
18	1.42	16.31
19	1.50	15.46
20	1.58	14.68

21	1.66	13.98
22	1.73	13.35
23	1.81	12.77
24	1.89	12.24
25	1.97	11.75

In case of Solar Thermal on every 1% change in CUF the Electricity Generation changes by 80000 units and tariff changes from Rs. 17.27 for 17% CUF to as low as 11.75 for 25% CUF. CERC has calculated tariff of Rs. 12.77 at 23% CUF.

6.2 Deration Factor:- Another major which affects CUF is duration factor i.e. degradation in the condition of Solar cells and Panels due to natural wear and tear. It is normally taken in the industry that deration factor is between 05.-0.75% per year and around 20% in 25years. CERC has not taken this factor into consideration while notifying the Generic Levellised Tariff. The Electricity Generation will reduce over a period of time due to deration factor.

6.3 Capital Cost: Capital Cost in Generic Tariff inclusive of all capital work including plant and machinery, civil work, erection and commissioning, financing and interest during construction, and evacuation infrastructure up to inter-connection point. The variation in the Capital Cost can affect the Tariff in following manner:

Table 15 Solar PV

Capital Cost(Rs. In Lakhs)	Levellised Tariff (In Rs.)
650	7.33
700	7.80
750	8.27
800	8.75
850	9.22
900	9.70

Table 16 Solar Thermal

Capital Cost(Rs. In Lakhs)	Levellised Tariff (In Rs.)
1000	10.16
1100	11.03
1200	11.90
1300	12.77
1400	13.64
1500	14.51

The reduction in Capital Cost for setting up of Solar Plants is major reason for fall in Generic Levellised Tariff from period 2009-10 when it was first notified to present tariff i.e

during 2013-14. The Capital Cost was drastically reduced as the cost of Solar Cells and modules have reduced significantly over the period. But with the fall in the value of Indian Rupees the effect of the fall during last 1 year has been negated. The prices of Solar Cells and modules have now stabilized and thus the Solar Plant Developers would have to look for other factors as well such as increasing efficiency for reducing the tariff further.

6.4 Interest Rates:- Interest Rate on the Loan Component of the Capital cost funded through borrowings is also a critical factor which can also significantly affect the Tariff Computations. The variation in the Interest Rates can affect the Tariff in following manner:

Table 17 Solar PV

Interest Rate (%)	Levellised Tariff	Total Revenue
1	6.78	112.79
3	7.04	117.22
5	7.34	122.09
7	7.65	127.38
9	8.00	133.07
11	8.36	139.15
13	8.75	145.60
15	9.16	152.39

Table 18 Solar Thermal

Interest Rate (%)	Levellised Tariff	Total Revenue
1	9.79	177.45
3	10.19	184.79
5	10.63	192.83
7	11.12	201.55
9	11.63	210.93
11	12.18	220.93
13	12.77	231.52
15	13.38	242.66

The normal Debt Equity Ratio is 70:30 and CERC has basic its Generic Tariff on the assumption of Interest Rate of 13% and if the Solar Plant Developer is able to source loans at a better rate based on its rating or its balance sheet strength then it can affect the Tariff and Total Revenue as shown in the table above. There are various sources from which the Loans/funding can be taken by the developer as shown below:-

- a) Supplier's Credit:- International Suppliers of components such as modules invertors etc provide suppliers credit at cheap rates which are a Libor + premium which ranges from 2.90 to 3.25%. However, these are foreign currency denominated and carry currency fluctuation risk or have to be hedged.
- b) Loan from International Financial Corporation (IFC) is available at around 11.5% in Indian currency.
- c) Loan from Indian Banks:- Loan from Indian Banks are also available at rates above their Prime Lending Rates. Since Solar Projects are considered to be risky due to technological and commercial reasons therefore these are priced on the higher side.
- d) Loans from domestic Financial Institutions : Domestic financial Institutions such as IREDA, PFC Green Energy, REC etc provide loans for funding the Renewable Energy Sector. These are comparably costlier in 12.5%-13% range.
- e) Loans from Multilateral and Bilateral Agencies such as ADB, World Bank, KFW, JICA etc. are also available at low cost compared to domestic loans. These are based on sovereign guarantee given by Govt. Of India at very cheap prices or on commercial lending basis at higher prices. However, these are foreign currency denominated and carry currency fluctuation risk or have to be hedged.
- f) Apart from this Viability Gap Funding is also provided by Government of India out of its budgetary resources or National Clean Energy Fund (NCEF) to make the tariff for energy generated from Renewable Energy Sources to be viable in comparison with conventional power plants.
- g) Various Tax Benefits such as Customs and Excise Duty Benefits, Income Tax Benefits under Section 80IA, Accelerated Depreciation benefits, Interest subsidy, Capital Subsidy, Sales Tax benefits, Generation Based incentives are also available.
- 6.5 Return on Equity: The Return on Equity is return expected by the Shareholders from the project. The residual returns goes to the shareholders. For the purpose of Generic Levellised Tariff CERC has taken ROE to be 20% for first 10 years and 24% for the balance project life of 25 years. This is based on assumption that the pre-tax rate of return of 16% and the applicability of MAT.
- If the investor is ready to compromise his returns as a result of competition or he has got some innovative funding from PE investors, foreign institutional investors, or is ready to take higher risk and lower returns on his investments than this may also result in lower tariff as shown below:-

Table 19 Solar PV

ROE Rate	Tariff	ROE Value	Total Revenue
10	7.09	24.00	118.08
12	7.39	28.80	122.99
14	7.68	33.60	127.91
16	7.98	38.40	132.82
18	8.27	43.20	137.73
20	8.57	48.00	142.64
22	8.86	52.80	147.55
24	9.16	57.60	152.46

Table 20 Solar Thermal

ROE Rate	Tariff	ROE Value	Total Revenue
10	10.30	39.00	186.80
12	10.74	46.80	194.78
14	11.18	54.60	202.76
16	11.62	62.40	210.74
18	12.06	70.20	218.72
20	12.50	78.00	226.70
22	12.94	85.80	234.68
24	13.38	93.60	242.66

7. CONCLUSION

The paper analyses the Investment Decision and financial feasibility of solar power plants in India. The analysis is carried out on the basis of financial Parameters based on CERC Generic Tariff Model 1. Assumption of solar PV power projects and 2. Assumption of solar thermal power projects. Assumptions are related to Cost of Generation over the life of the Project consisting of various costs factors such as Operation and Maintenance Expenses, Interest on Term Loan, Interest on Working Capital, and Return on Equity & Depreciation.

In case of solar PV project the total fixed cost shows a decreasing trend from year one to 15 thereafter it shows an increasing trend till year 25. The depreciation of power plant for the first 12 years is rupees 46.64 lakhs per year and for year 13 to 25 it is rupees 12.33 lakhs per year. ROE turns out to be 48% for year 1 to 10 thereafter it increase to 57.60% till year 25. Interest component shows a decreasing trend as there is repayment of rupees 46.67 lacks per year. PAT shows an increasing trend for year 1 to 10 and thereafter there is no trend. Net equity cash flows shows an increasing trend for year 1 to 15 and thereafter it shows a decreasing trend. The trend in working capital is just the reverse of net equity cash flows. It shows decreasing trend for year 1 to 15 and thereafter it slightly shows an increasing trend. Operating and maintenance expenses shows a decreasing trend for year 1 to 6 and after that it increase till 25 years. Project IRR post tax without tax shelter is 10.02%. Project IRR post tax with tax shelter is 12.05%. Equity IRR post tax without tax shelter is 11.31% and with tax shelter turns out to be 17.40%.

In case of solar thermal project the total fixed cost shows a highly decreasing trend from year one to 15 thereafter it shows an increasing trend till year 25. The depreciation of power plant for the first 12 years is rupees 75.79 lakhs per year and for year 13 to 25 it is rupees 20.02 lakhs per year. ROE turns out to be 78% for year 1 to 10 thereafter it increase to 93.60% for year 11 to 25. Interest component shows a decreasing trend and it comes to zero in 13th year as there is repayment of loan to the extent of rupees 75.83 lacks per year. PAT shows a highly increasing trend for year 1 to 15 and thereafter it shows a slightly decreasing trend. Net equity cash flows shows an increasing trend for year 1 to 14 and thereafter it shows a decreasing trend. The trend in working capital is just the reverse of net equity cash flows. It shows decreasing trend for year 1 to 11. It falls down in year 13 to rupees 32.03 lack per year. There after it shows an increasing trend. Operating and maintenance expenses shows a decreasing trend through out the period. Project

IRR post tax with tax shelter is 13.84%. Equity IRR post tax with tax shelter is 14.16. The paper concludes that power purchase costs constitute the largest cost element.

The sensitivity analyses on various key parameters like capacity utilization factor, Capital cost, interest rate and return on equity and depreciation were analyzed both in Solar Thermal and Solar PV power plants.

The sensitivity analysis in solar PV shows that with 1% increase in CUF the Electricity Generation goes up by 90000 units and the corresponding tariff decreases as shown in table above. CERC has calculated tariff of Rs. 8.75 at 19 % CUF. In case of Solar Thermal on every 1% change in CUF the Electricity Generation changes by 80000 units and tariff changes from Rs. 17.27 for 17% CUF to as low as 11.75 for 25% CUF. CERC has calculated tariff of Rs. 12.77 at 23% CUF.

The Capital Cost was drastically reduced as the cost of Solar Cells and modules have reduced significantly over the period. Interest Rate on the Loan Component of the Capital cost funded through borrowings is also a critical factor which can also significantly affect the Tariff Computations.

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