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"Commercial Viability Analysis of Fixed Mount V.S Single Axis Tracking PV System for 5MW Grid Connected Solar Power Plant at Kolayat"

A Case Study

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Abstract: *The 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 subtropical 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. Thus the objective of this work is to estimate the commercial-viability analysis of fixed mount v.s single axis tracking PV system for 5 MW grid connected solar photovoltaic plant at Kolayat (Rajasthan) and thereby have developed a system based on the potential estimations made for a chosen area of 41524 m2 (present Built-up area). The specifications of the equipment are provided based on the availability of the component in India. Annual energy generation by proposed Grid connected SPV power plant is calculated.*

Keywords: *Solar Photovoltaic (SPV) Energy, Energy Audit, Grid-Connected SPV system.*

1. Introduction

There is a pressing need to accelerate the development of advanced clean energy technologies in order to address the global challenges of energy security, climate change and sustainable development. Solar Photovoltaic is a key technology option to realize the shift to a decarbonized energy supply and is projected to emerge as an attractive alternate electricity source in the future. Globally, the solar PV grid connected capacity has increased from 7.6 GW in 2007 to 13.5 GW in 2008 and was 21 GW at the end of 2009. Similarly, annual solar PV production also jumped from 3.7 GW in 2007 to 10.7 GW in 20091. The growth trend is continuing and is likely to explode once the grid parity is achieved. [1]

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 subtropical 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. [2] 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 R and D efforts. Grid interconnection of photovoltaic (PV) power generation system has the advantage of more effective utilization of generated power. However, the technical requirements from both the utility power system grid side and the PV system side need to be satisfied to ensure the safety of the PV installer and the reliability of the utility grid. For this survey we have gone through different books, journals and papers to get its keen knowledge. [3]

2. Methodology

To find out the commercial-viability analysis for 5MW grid connected solar PV plant in Kolayat (Rajasthan) India, the solar radiation over different months were measured for Kolayat, Rajasthan-India. Then the average monthly outputs are found out and related graphs are plot for showing the variation. We started our project work from January month. So we measured value of solar radiation from January to December month after that we calculated the diurnal variations, average monthly output for twelve months (Jan 2013 to Dec 2013) also took help of NASA website to cross verify the readings. For estimation of solar potential we need reading of solar radiation for our site. For the better understanding of the methodology, the measured radiation data sheet of Kolayat district for the month of January 2013 has been given as a sample.[1] The variation for twelve months is plotted. From that the monthly output are calculated. Input solar radiation means how much amount of solar radiation is coming from sun and Output solar radiation means how much amount of solar radiation we can utilize to generate electricity which is depends upon the efficiency of the PV module. For calculating the output the efficiency of the PV module is taken as 14.2% Chosen area for the estimated plant capacity is considered as 41524 m^2.[2]

3. Energy Audit, Observation & Calculation of Pay-Back period

The energy audit at Kolayat was carried out through the software PVsyst V5.63 and SCADA than the following details were noted down.

1. Rating of transformer is 5000 kVA, step-down of 11kV/0.430kV, 50Hertz, 3 phase.

2. Estimated load for the above transformer rating was 4800kW (approximately) and the present load on the system is nearly 5200kW, which requires 5700Amps of current to run the system at full load. [4]

But from the observations made we can see that the installed transformer has a capability to serve only 5300 Amps of load on 100% loading which is dangerous during system transients and due to overloading, the CLR (i.e. Current Limiting Resistor) connected at HV side of transformer used to fuse out. So to overcome this, engineering staff followed load shedding method which is not advisable especially for the Plants. [5] Then after studying the irradiation level of Kolayat region using NASA metrological website or Metronome data we found that the SPV- Generation as a best method to overcome this overloading problem as well this will help in peak load cutting of the system. [6]

3.1. PV System Cost with Subsidy

	Fixed Mount System		Single Axis Tracking System	
Cost Per MW	Capacity(MW)	Rs.(INR)	Capacity(MW)	Rs.(INR)
Cost of 1 MW Solar PV System	1	51200000	1	61200000
Cost of 5 MW Solar PV System	5	256000000	5	306000000
Subsidy @30%	0.3	76800000	0.3	91800000
Net Cost after Subsidy		179200000		214200000
Accelerated Depreciation @80%	0.8	143360000	0.8	171360000
Tax Rate @35%	0.35	50176000	0.35	59976000

3.2. Cost of 3 Phase Central Inverter in (Rs/Watt)

	Fixed Mount System	Single Axis Tracking System
Cost of 3 phase Inverter in (Rs./Watt)	25	25
Size of Inverter	5000KVA	5000KVA
Total Cost for 3 Phase Inverter Includes	125000000	125000000

3.3. Cost of 3 Phase Transformer (Rs/Watt)

	Fixed Mount System	Single Axis Tracking System
Cost of 3 phase Step-Up Transformer in (Rs./Watt)	20	20
Size of Transformer	5000KVA	5000KVA
Total Cost for 3 Phase Inverter Includes	100000000	100000000

3.4. Cost of the system with all auxiliary and misc cost

	Fixed Mount System	Single Axis Tracking System
Subtotal above by 0.2 (20%) to cover balance of system cost (wire, fuses, switches)	0.2	0.2
Cost Estimated for Balance of System	179200000	214200000
Total Estimated PV system Cost is Rs.	35840000	42840000

Carrying out all the calculations we find that the system cost comes around Rs.215040000 for Fixed Mount System and Rs.257040000 for Single Axis Tracking System.

3.5. Difference in Generation of Units Annually.

The Generation of Units by Fixed Mount System is 9158000 KWh is Injected into grid and the Generation of Units by Single Axis Tracking System is 10806000 KWh Injected into Grid can be calculated by PVsyst software V5.63 by means of simulation analysis.

3.6. Pay-Back Period calculation

As we know,

Pay-Back Period =X/Y

Where: X= Total cost of PV system with all auxiliary equipment's and Y= Total annual Tariff cost after installation of PV System.

Rate per Unit is Rs.5 (actual can be calculated by NVVN policy)

Therefore for Fixed Mount System Annual tariff is Rs. 9158000x5= Rs.45790000

X/Y= 215040000/45790000 = 4.69 years

And for Single Axis Tracking System Annual tariff is Rs.10806000x5=Rs.54030000

X/Y=257040000/54030000 = 4.75 years

3.7. Profit after pay-back period till useful life of SPV

As we know that useful life of PV is 25 years and we calculated the pay-back period of SPV is 4.69 years for Fixed Mount System and 4.75 years for Single Axis Tracking System so by subtracting useful life to Pay-back period and then multiplying by the Tariff.

PROFIT= (Useful life-Pay-Back Period)*annual tariff of units per year.

Therefore Profit for Fixed Axis System = (25-4.69)*45790000.

Profit = Rs.Approx 91 Crore's.

Similarly for Single Axis System = (25-4.75)*54030000.

Profit = Rs.Approx 108 Crore's.

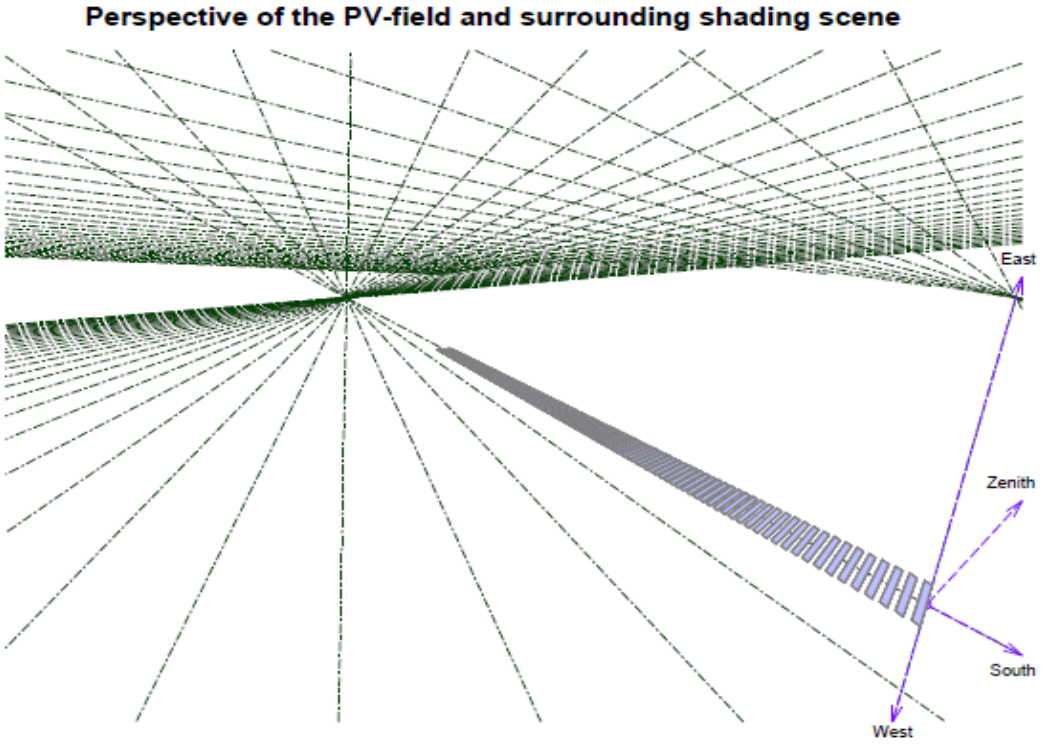

Fig. 1 PV-Field and Surrounding Shading Scene

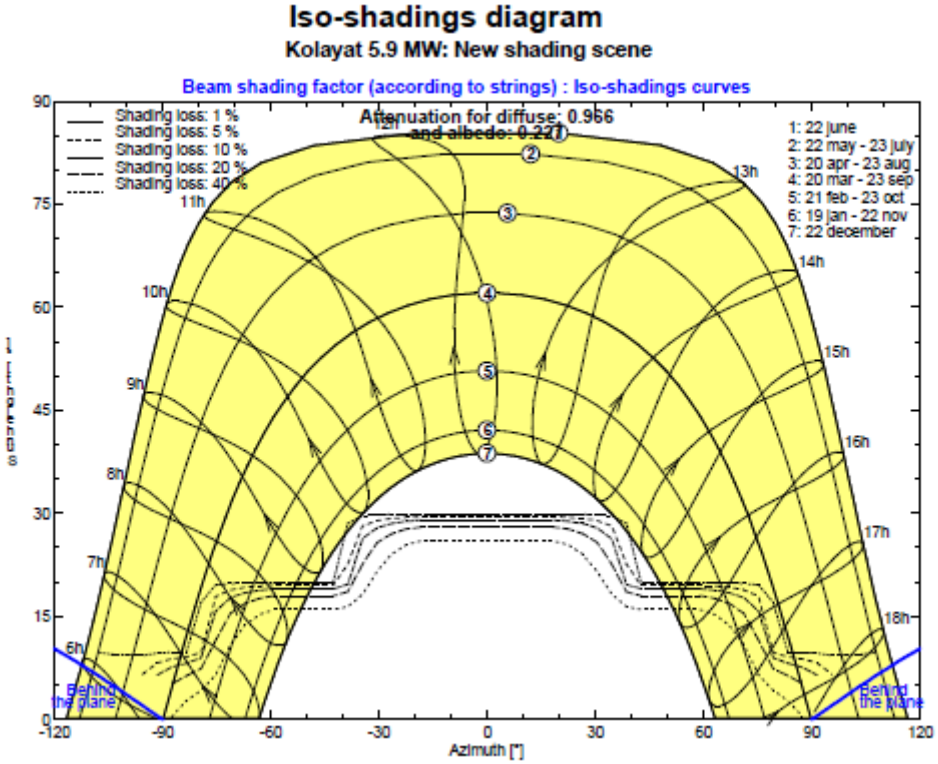

Fig.2 Iso-Shading Diagram of Kolayat 5.9 MW

WS280_JK280_ABB500

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	114.1	14.80	148.9	136.3	725.6	698.3	11.74	11.29
February	122.1	17.30	147.6	139.5	727.8	701.9	11.87	11.45
March	161.5	23.40	178.4	170.7	861.8	832.7	11.64	11.24
April	185.1	28.10	187.7	179.3	883.7	855.2	11.34	10.97
May	204.6	31.30	195.5	186.8	903.6	874.1	11.13	10.77
June	196.8	31.50	183.1	174.4	844.6	816.3	11.11	10.74
July	182.0	30.10	172.2	163.5	803.6	775.7	11.24	10.85
August	170.2	29.00	168.9	161.0	792.3	764.6	11.30	10.90
September	157.8	28.70	167.5	159.9	788.9	762.0	11.34	10.96
October	140.4	26.60	161.1	152.9	766.2	739.0	11.45	11.05
November	116.1	21.60	148.6	138.3	711.3	685.7	11.53	11.11
December	106.0	16.80	140.4	128.1	677.8	652.0	11.63	11.18
Year	1856.7	24.97	1999.9	1890.8	9487.2	9157.5	11.42	11.03

Legends:				
	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

The above statics gives us information about varying sun irradiation level for 12 months in terms of kWh/m2/day, using which we can calculate the amount of electricity generation by SPV panels.

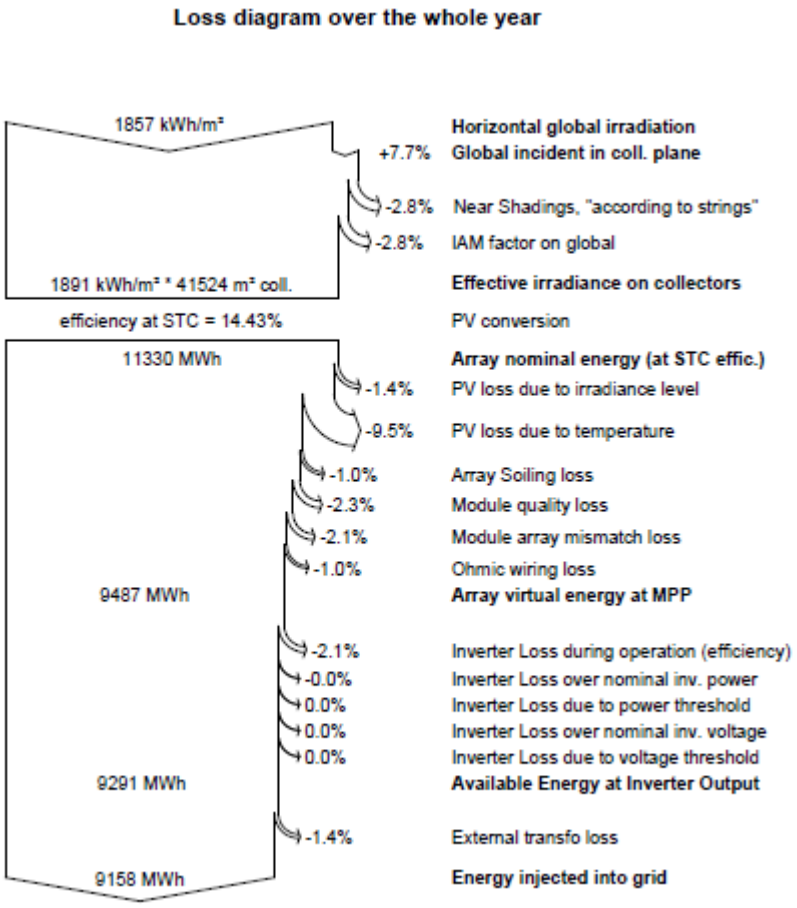

Fig.3 Loss diagram over the whole year

7. Conclusions

The design described is based on the potential measured & the system is connected to state electricity grid under state nodal policies of NVVN. System sizing and specifications are provided based on the design made. Finally, commercial-viability is carried out for the proposed design. Estimated PV System Cost is Rs. 21.5 Crore's for fixed mount system and Rs. 25.7 Crore's for single axis tracking similarly payback period for fixed mount system is 4.69 years and for single axis tracking system is 4.75 years as calculated. Thus methodology adopted seems satisfactory for determining the rate of return for Fixed Mount System = (25-4.69)*45790000.

Profit = Rs.Approx 91 Crore's.

Similarly for Single Axis System = (25-4.75)*54030000.

Profit = Rs.Approx 108 Crore's.

For a calculated area of 41524 m2.

Thus we can say that single axis tracking PV system is commercial viable as compared with fixed mount system PV system for a grid connected solar power plant.

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