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Performance Analysis of PV Solar Power System

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Abstract: *The state of Chhattisgarh is blessed with high solar radiation intensity and has capacity for large solar energy generation. With increasing energy demand and rapid use of fossil fuel has made pressure on thermal power generators to fulfill future energy demand, and grid connected PV Solar power system can help to meet this demand. In this paper performance analysis of PV Solar Power System is done with the help of PV SYST Software, in which 10kW$_p$ grid-connected PV Solar Power System is simulated. The energy supplied to the grid and the main performance analysis is done by considering the effect of different global irradiation and temperature, i.e. energy output of PV array, energy output of system including inverter. The annual performance ratio is also considered, with normalized production and loss factor which include collection loss i.e. PV-array losses and various system losses.*

Keywords: *Performance Analysis, Performance Ratio, PV Solar Power System, PV SYST Software, Simulation.*

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I. Introduction

In India, the solar energy is expected to drive the future growth of renewable energy sources. Solar energy is important, yet currently under-utilized, resources in the country. India has an average of 300 sunny days every year and receives an average daily radiation of 5.5kWh/m^2. The government of India launched the Jawaharlal Nehru National Solar Mission (JNNSM) in January 2010, with the objective of achieving 20,000 MW of solar power capacity by 2022. The mission is one of the eight key missions under the National Action Plan for Climate Change (NAPCC). This is major initiative to tap India's naturally available energy sources and contribute to low carbon sustainable growth in the country, while overcoming its ecological and energy security challenges [1].

Problem which I found in considerd 10kW grid-connected photovoltaic system at Dr. C. V. Raman University is Energy produced by it is 20kWh/day but it is designed for 25kWh/day so this difference could be because of (i) climatic factors (incident irradiation and module working temperature), (ii) inverter characteristics (yield, working point and operation threshold, defined as the minimum required power to connect the inverter to the grid) and (iii) the coupling system to the grid, which depends on the characteristics of the energy produced by the inverter and on grid stability and availability.

Previous work of different research journals that have been contributed in the field of performance analysis PV Solar Power System are Deepansh Nirvan et al. (2017) studied the Performance Evaluation of Grid Connected Solar PV Plant Using PVsyst. 1 MW gird connected solar plant installed and commissioned at PEC University of Technology Chandigarh is studied and its Performance is Evaluated using PVsyst software. The average global horizontal irradiation is 5.26 KWh/m2/day and annual average temperature is 20.9 degrees centigrade. The study includes performance evaluation at the tilt angle for which the plant is installed and comparing it with the optimum tilt according to the site with and without the Horizon considerations [2]. Nallapaneni Manoj Kumar et al. (2017) studied Performance analysis of 100 kWp grid connected Si-poly photovoltaic system using PVsyst simulation tool. This study was conducted to evaluate the feasibility of installing a photovoltaic system for supplying the electric load of an educational institute. The simulation results were analyzed for assessing the performance of the photovoltaic system. This includes evaluating the effective energy output of the PV array [3].

The main purpose of this paper is to study the Performance of PV Solar power system in different irradiation and temperature. The amount of power produced by a PV system depends upon the amount of irradiation to which it is exposed. Irradiation fluctuates according to the Sun's location in the sky i.e. changes in both Sun's altitude angle and its azimuth angle. Higher operating temperatures result in lower power outputs and efficiencies, as temperature increases current increases slightly but voltage decreases significantly resulting in a net reduction in power [4].

II. Methodology

2.1 PV Solar System Layout

The 10Kilo Watt grid connected solar photovoltaic system is installed on the roof of Dr. C.V. Raman University's building. It covers total 56sq.m. The PV System utilizes 32 solar panels and 1 inverters of 10 KW. These inverters are used for DC to AC conversion and the output is fed to the 400V grid.

2.2Geographical Location and climatic resources

Dr. C.V. Raman University is located at 22.30° N latitude, 82.03° E longitude and Its elevation is 330meter (1080ft) from sea level.

2.3 System Orientation

To get the maximum solar irradiation the inclination angle of the PV array should be approximately equal to the latitude of the site [4]. Thus, for the optimized study the tilt angle used is 30˚ with azimuth of 0˚ that means facing towards south.

Figure1: PV system installed site on Google Map

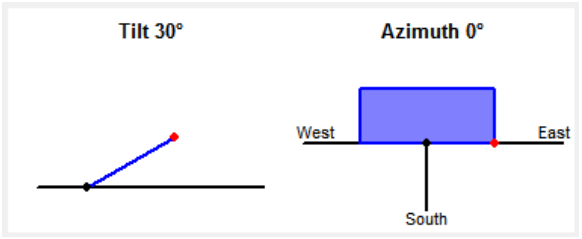

Figure2: Tilt Angle of PV Array

2.4 Solar PV Module Details

The solar photovoltaic module is a packed interconnected combination of solar photo voltaic cells. This module has capability to convert sunlight into electricity without any other intermediate steps. Here, Poly Silicon solar panel is used which offers highest efficiency among all types of panels and it has wattage of 300 Wp. Each module has 108 solar cells. All module offers positive wattage. No modules rating are below 300Watt. Minimum 90% performance efficiency is provided for first 10 year and Minimum 80% efficiency is provided for the remaining 15 years.

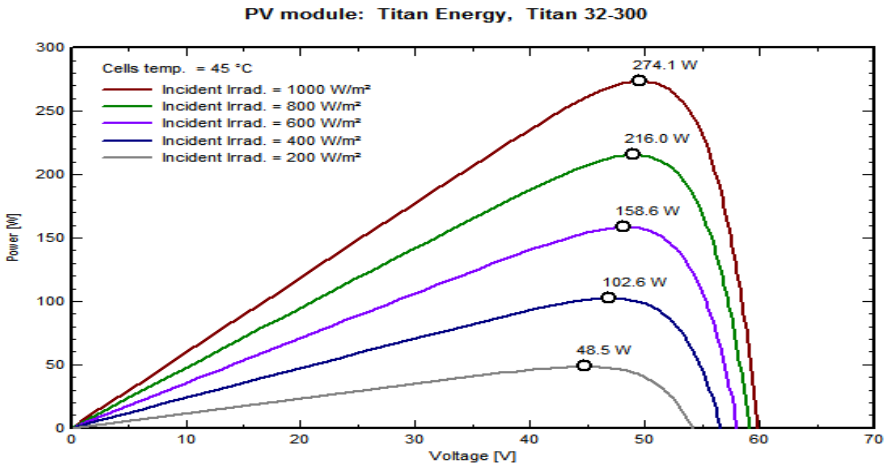

Figure3: PV Curve at different Incident Irradiation

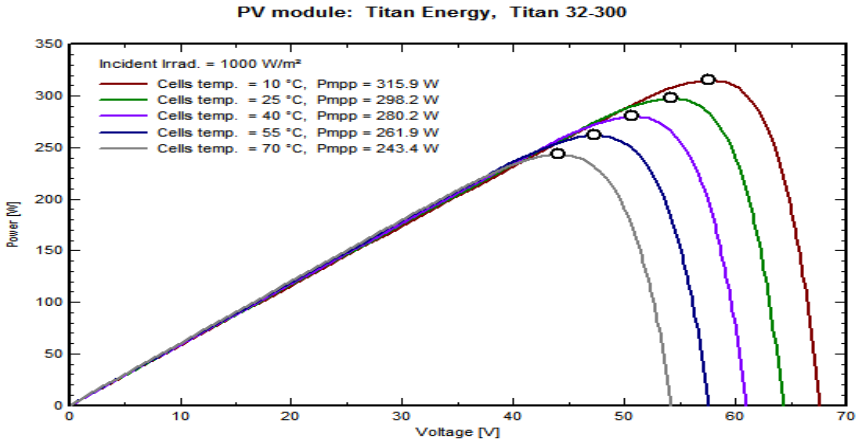

Figure4: PV Curve at different Temperature

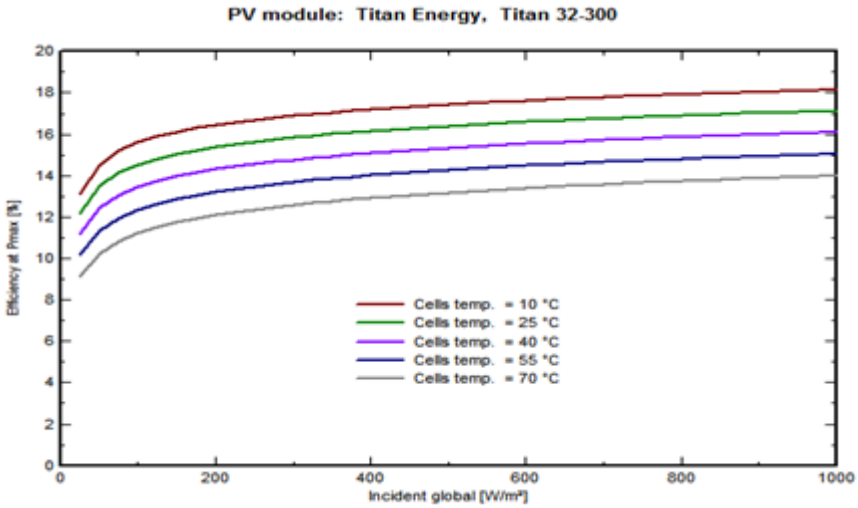

Figure5: Efficiency v/s Incident Irradiation curve of the PV panel at different Temperature

2.5 Inverter

A solar inverter RefuSol_10K_ Three phase 50Hz with nominal power 10kW is used, and it have efficiency of 97.8%

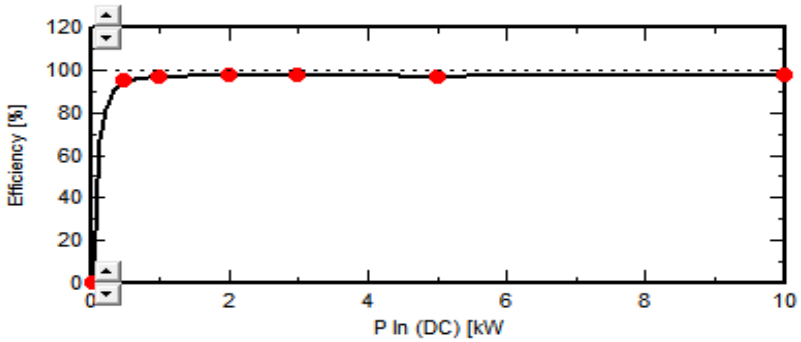

Figure6:- Input Efficiency of Inverter

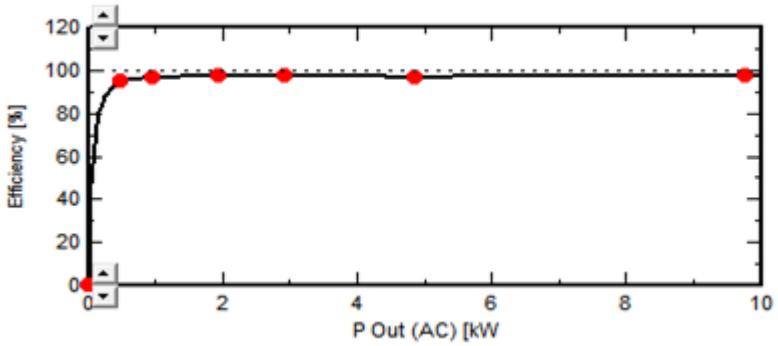

Figure7:- Output Efficiency of Inverter

2.6 PV SYST Software

PV SYST V5.06 is a PC software package for study sizing and data analysis of complete PV system. It deals with grid connected, stand-alone, pumping and DC-grid PV systems, and includes extensive meteo and PV system components databases, as well as general solar energy tools. The software is geared to the needs of architects, engineers, researchers. It is also very useful for educational training [5].

III. Result And Discussion

Brief result analysis of 10kW grid connected PV Solar Power System is presented in this section.

3.1 Monthly Balances and Main result

Software simulation provide monthly values of parameter which include Horizontal global irradiation Ambient temperature, Global Incident in coll. Plane, Effective global irradiation, Effective energy at the output of the array, Energy injected into grid, Efficiency Eout array and Efficiency Eout system.

Thus, the effective global irradiation is 1791.6kWh/m^2, while average effective global irradiation is 1506kWh/m^2. Average ambient temperature is 26.57 degree centigrade. Effective array energy output is 13.81% and effective energy output of system is 13.43%.

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	%	%
January	129.0	19.70	165.8	161.7	1331	1296	14.42	14.04
February	137.0	22.90	163.2	158.9	1276	1241	14.05	13.66
March	168.0	27.10	177.1	172.0	1359	1321	13.78	13.40
April	192.0	29.80	183.0	177.2	1373	1336	13.47	13.11
May	194.0	29.70	170.0	163.5	1267	1232	13.39	13.02
June	145.0	29.60	125.6	120.5	938	911	13.42	13.04
July	135.0	29.10	119.5	114.7	899	874	13.51	13.13
August	138.0	28.80	128.5	124.0	977	949	13.66	13.27
September	126.0	29.00	125.7	121.7	953	926	13.62	13.22
October	147.0	27.90	165.1	160.5	1270	1235	13.81	13.43
November	132.0	24.70	167.2	163.1	1310	1274	14.06	13.69
December	119.0	20.40	158.1	154.0	1265	1231	14.38	13.99
Year	1762.0	26.57	1848.8	1791.6	14218	13827	13.81	13.43

Table1: Monthly Balances and Main result

3.2 Performance Ratio

Performance ratio is the most important parameter of the photovoltaic system for evaluation of the efficiency of the solar photovoltaic system.

Performance Ratio is defined as the ratio of final system yield to the reference yield.

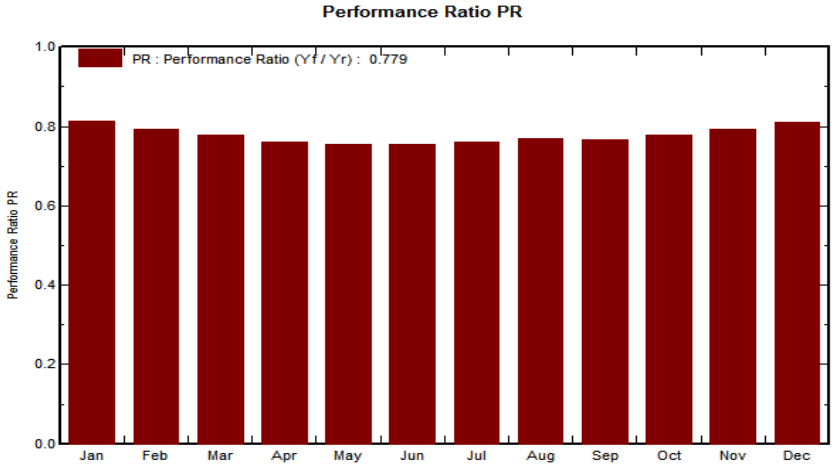

Figure8: Performance Ratio

Performance ratio indicates the overall effect of losses on the array rated output due to the array temperature, incomplete utilization of the irradiation and system component failure or inefficiencies. 77.9% in the simulation environment means 22.1% of insolation not converted into useful energy or we can say that 22.1% losses in the system including system losses and module losses.

3.3 Normalized Production and Loss Factor

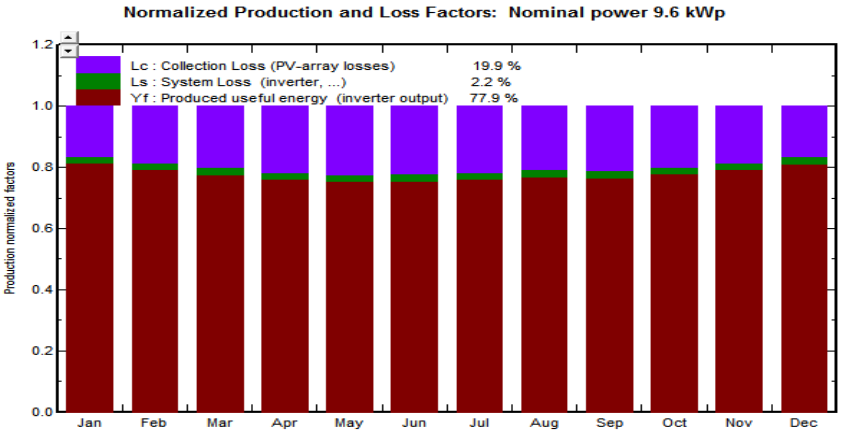

Figure9: Normalized Production and Loss Factor

Normalized production of power from the photovoltaic system given from January to December month, the collection loss which are conversion and thermal losses about 19.9% and system losses i.e. wiring losses, maximum power tracking, inverter and mismatch losses which are 2.2%. The production of the useful energy (inverter output) was 77.9%.

3.4 Losses over Whole Year

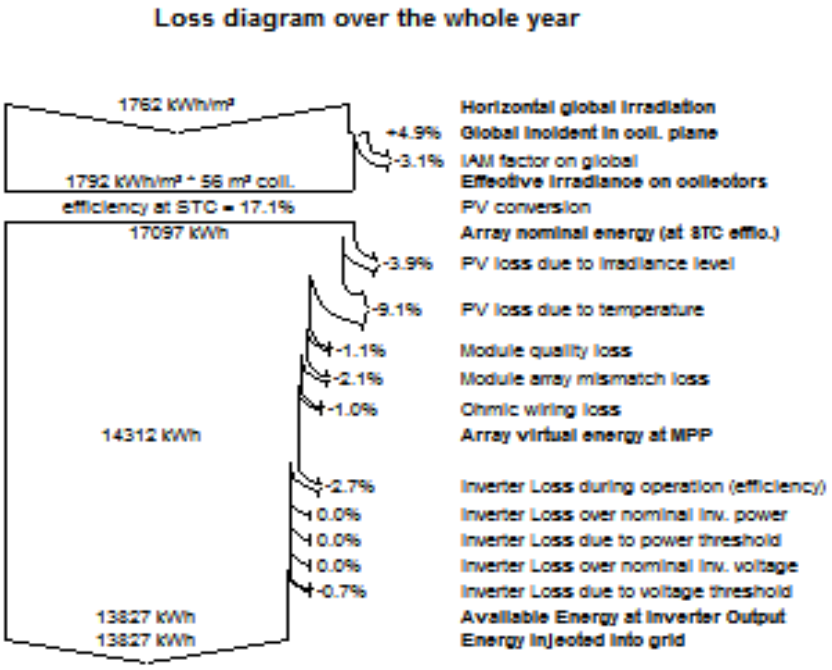

Figure10: Loss Diagram over the whole year

The loss diagram represents the various losses in the system. Global irradiance on horizontal plane is 1762kWh/Sq. m. But the effective irradiance on collector is 1792kWh/Sq. m. This results in the loss of energy i.e. 0.5 % due to irradiance level. When this effective irradiance falls on the surface of a photovoltaic module or array, electrical energy is produced. After the PV conversion, array nominal energy at standard testing conditions (STC) is 17097kWh. The efficiency of the PV array at STC is 17.1%. Annual array virtual energy at MPP is 14312kWh. The various losses occurs in this stage are 3.9% due to irradiance level, 9.1% losses due to temperature, 2.1 % loss due to module array mismatch and 1.0 % is the Ohmic wiring losses. Available energy on annual basis at the inverter output facility is 13827 kWh and the same is injected to grid. Here two losses were possible, one is inverter loss during inverter operation i.e. 2.7 % and inverter loss due to voltage threshold is 0.7%

3.5 Array Output

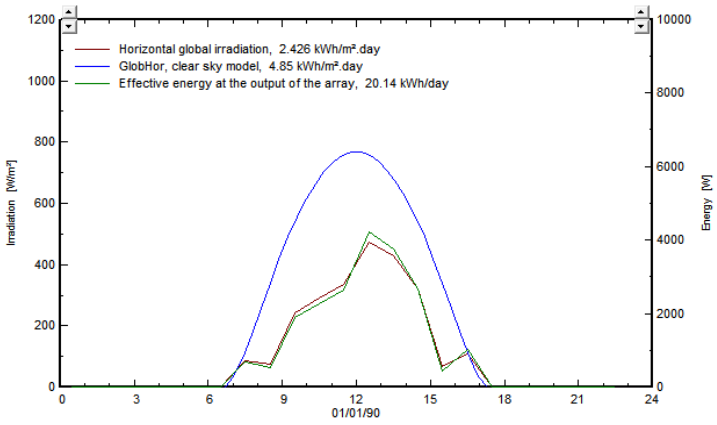

Figure11: Hourly array Output with Irradiation

The above graph shows that the effective energy at the output of the array is 20.14kWh/day. It is increases first up to 12pm than decreases after 12pm. The average Horizontal global irradiation is 2.426kWh/m^2.
The Energy output of array is directly proportional to the Irradiation.

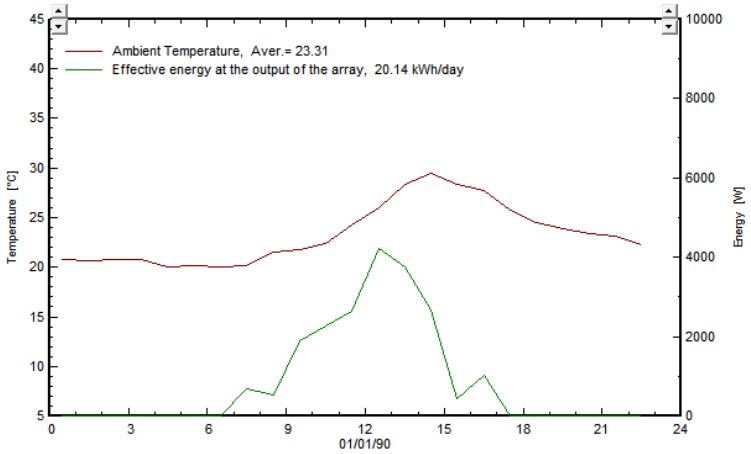

Figure12: Hourly array Output with Temperature

The above graph shows that the effective energy at the output of the array is 20.14kWh/day, with average ambient temperature 23.31 ˚C**.** Initially the energy output is increases with increase in temperature but thereafter approximately 30 ˚C the energy output decreases even there is increase in temperature.

IV. Conclusion

Simulation of 10kW grid-connected PV Solar Power system is done by using PV Syst software. In which the performance of 10kW grid-connected PV Solar Power system is analyzed, Effective energy output is 20.14kWh/day. Annual performance ratio is 77.9%. Array output is directly proportional to irradiation but even increase in temperature beyond 30 ˚C the energy output decreases.

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