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Performance Evaluation of Grid Connected Solar PV Plant Using PVsyst

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Abstract— *Chandigarh is an emerging Solar City with a target of 50 MW solar PV by 2022.As per CREST data 7.7 MWp of grid connected Solar has already been commissioned by December 2016.In this paper 1 MW gird connected solar plant installed and commissioned at PEC University of Technology which is the largest in 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.*

Keywords— Grid Connected Solar Plant, Pvsyst,Performance ratio,Annual energy yield.

1. Introduction

India has a very huge Solar potential with almost 250-300 clear sunny days in a year. Almost all parts of India receive 4–7 kWh of solar radiation per sq. metre due to its geographical location [1].It receives around 5000 trillion kWh of energy every year. With the increasing demand of power and high solar potential, government of India aims a target of 100,000 MW grid connected solar power projects by 2021-22 under the National solar mission [2].

The Government has set 50 MW as target for Chandigarh administration to be achieved by 2022.Chandigarh has rooftop solar plants installed and commissioned on the buildings of all the government colleges (11) and schools (59) and also at other government buildings accounting to a total of 140 government buildings with total capacity of 7.782 MWp [3].

B. Shiva Kumar et al. [1] studied the performance of a 10 MW solar plant at NTPC Ramagundam. The plant is designed to operate with a seasonal tilt. In this study the solar PV plant design aspects along with its annual performance is elaborated. The various types of power losses (temperature, internal network, power electronics, grid connected etc.) and performance ratio are also calculated. The performance results of the plant are also compared with the simulation values obtained from PVsyst and PV-GIS software. Kanchan Matiyali et al. [4] evaluated the performance of a proposed 400 KW grid connected solar PV plant at Dhalipur. Performance ratio and several types of power losses were calculated. Value of the performance ratio obtained was 78.1% from the results practicality of the solar photovoltaic power plant was discussed. Ali Malek et al. [5] studied the feasibility of photovoltaic power plant situated at an Algerian site. In the study performance of fixed tilt was compared with the seasonal tilt and it was observed that the seasonal tilt gives 5 % more energy as compared to fixed tilt. Mounir Bouzguenda et al. [6] study revealed that even though solar energy resources were abundant in the summer, high ambient temperatures drastically hindered the overall system performance for the given system components and reduced the solar cell efficiency by up to 16%. Shading losses varied between 0.70% and 4.2% according to the panel spacing and field location.

2. Description of solar pv-grid system

2.1. Geographical Location and climatic Resource

The PEC University solar power plant is located at latitude of 30.73 degrees North and longitude of 76.77 East at an altitude of 344 metres.

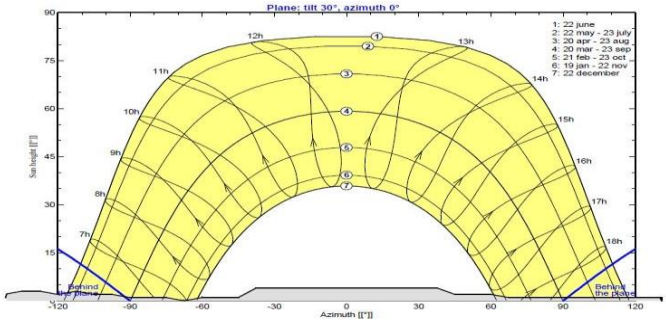

Chart 1. Trajectory of Sun at Chandigarh with Horizon outline

To estimate the Irradiation, temperature and Horizon data of the location, PVGIS solar resource database [7] has been used via internet.

2.2. Plant Layout

The total rating of the plant is of 1 MW and it covers a total rooftop area of about 3 acres. The plant is divided in 13 different buildings of the University. Thus shading losses are not considered in this study. Each building has different solar generation capacity according to the rooftop area available and all of them combine to give total generation capacity of 1 MW.

The plant utilizes a total of 4000 solar panels and 35 three phase inverters which includes 30 inverters of 30 KW and 5 inverters of 20 KW. These inverters are used for DC to AC conversion and the output is fed to the 11 KV grid.

2.3. PV Module

The solar panels used are TITAN M6-60 multi crystalline with open circuit voltage (Voc) of 37.8 V and short circuit current (Isc) of 8.63 A [8]. The efficiency of the solar panel is 15.29 % at STC.

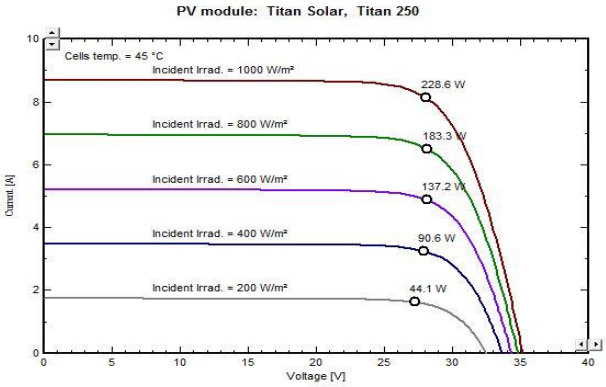

Chart 2. V-I Characteristics of PV panel

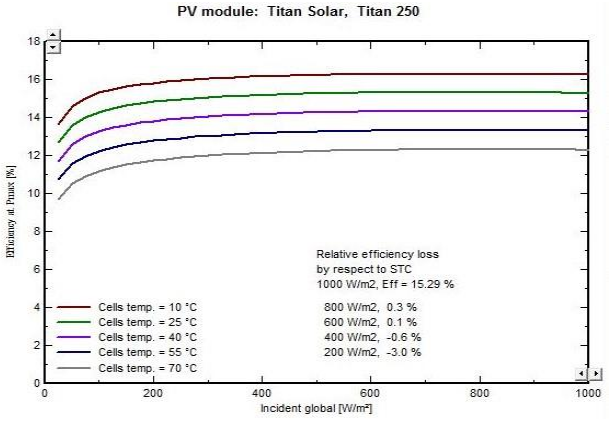

Chart 3. Efficiency curve of the PV panel

2.4. Inverters

Two types of Grid-tied Transformerless solar inverters are used Delta RPI-M20A and Delta RPI-M30 with nominal power of 20 KVA and 30 KVA respectively. The inverters have 2 sets of MPPTs which optimize power harvesting from multiple arrays oriented in different directions and have a maximum efficiency of about 98.3 % [9].

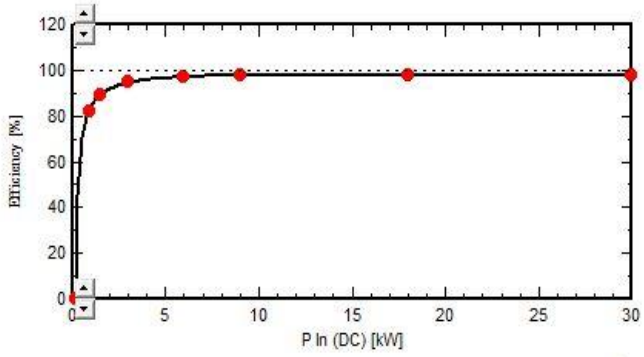

Chart 4. Efficiency curve of 30 KW Inverter

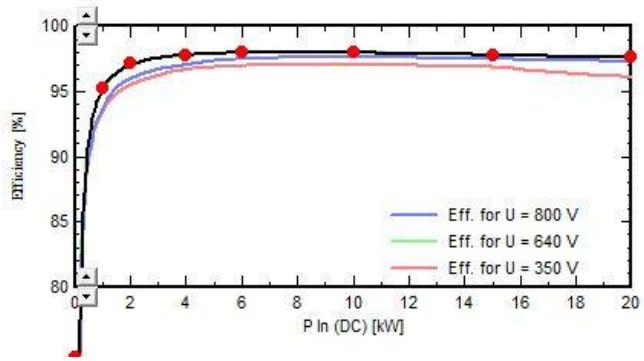

Chart 5. Efficiency curve of 20 KW Inverter

2.5. System orientation

The angle of inclination of the solar panels is 15˚ with an Azimuth of -30˚that means facing towards south-east. To get the maximum solar irradiation the inclination angle of the PV array should be approximately equal to the latitude of the site[10].Thus for the optimised study the tilt angle used is 30˚ with azimuth of 0˚ that means facing towards south.

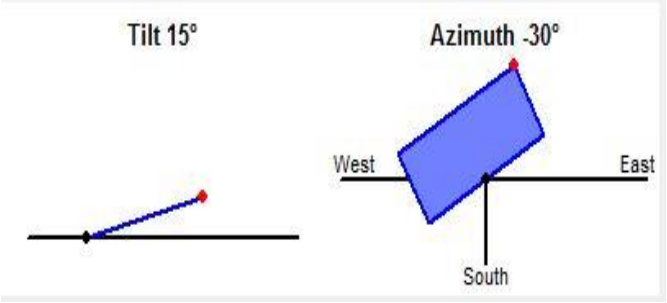

Chart 6. Original Tilt angle of PV array

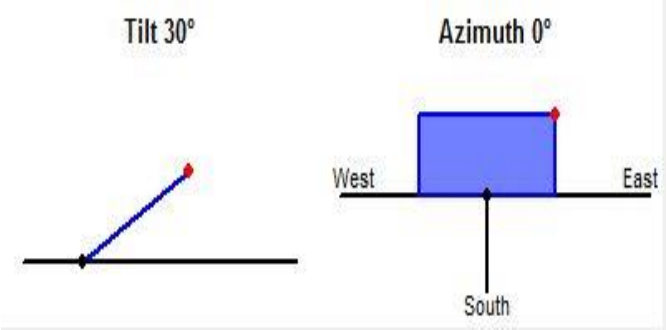

Chart 7. Optimized Tilt angle of PV array

3. Results and Analysis

The Software used is PVsyst which is a simulation based software used for design and performance analysis of solar photovoltaic power plants. It allows the user to import the meteo data from various sources and analyze grid connected, stand alone, dc grid and pumping systems depending on the specifications of the system and characteristics of its components such as PV module , inverters etc. [11]. Details of various losses and near shadings can also be specified for accurate energy yield.

3.1. Normalized production and loss diagrams

The figures 8, 9 shows the normalized production and figures 10, 11 shows the loss diagram for tilt angle of 15˚ and 30˚ respectively.

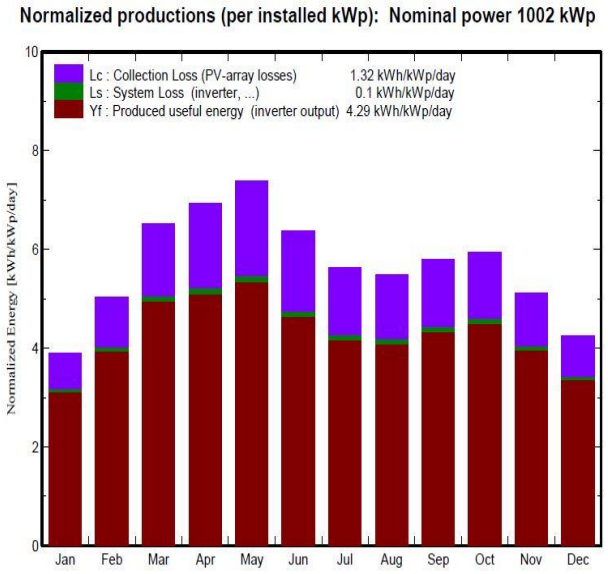

Chart 8. Normalized production for original tilt angle

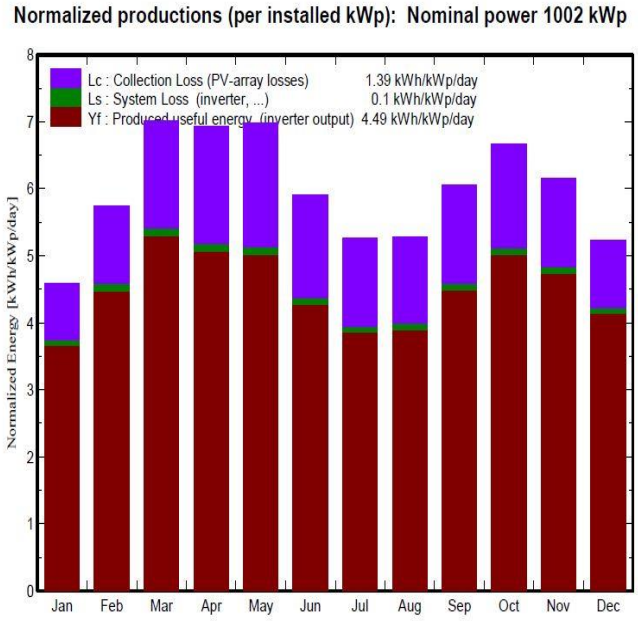

Chart 9. Normalized production for optimized tilt angle

Thus the normalized energy from the optimized 30 degree tilt angle is 4.49 KWh/KWp/day which is more than that from 15 degree tilt angle that is 4.29 KWh/KWp/day. But PV- array losses also increases

from 1.32 KWh/KWp/day to 1.39 KWh/KWp/day for optimized tilt angle of 30 degree.

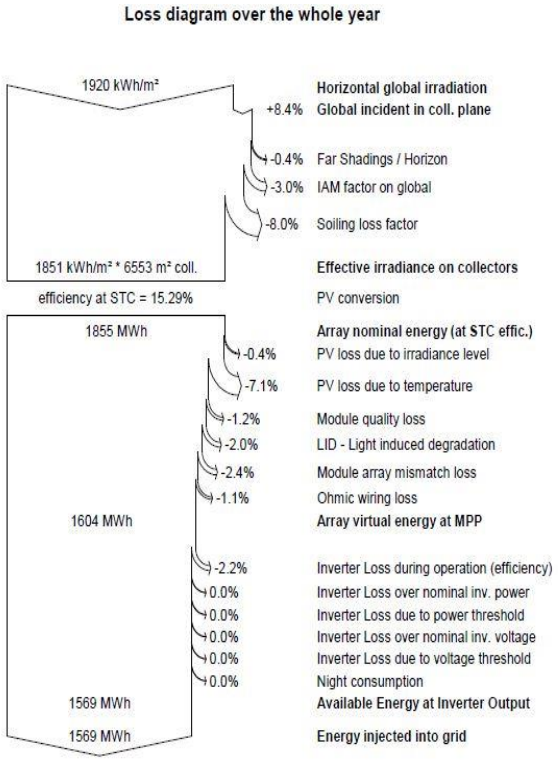

Chart 10. Loss diagram for original tilt angle

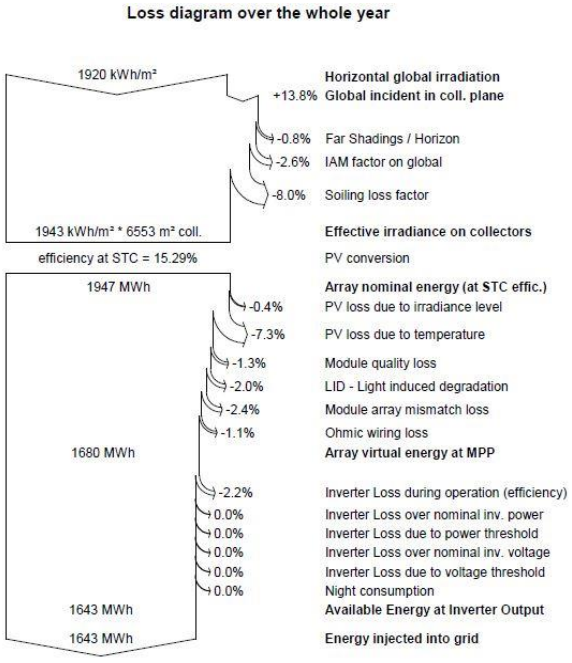

Chart 11. Loss diagram for optimized tilt angle

The energy injected into the grid is 74 MWh more for optimized angle of 30˚ than that of original 15˚ tilt angle.

3.2. Comparison of simulations

Four simulations were done for the same plant and the results are summarized in the table below.

Table- 1: Comparison of main Results

Parameters	15˚ without horizon	15˚ with horizon	30˚ without horizon	30˚ with horizon
Global Horizontal Irradiation (kWh/m^2)	1919.7	1919.7	1919.7	1919.7
Ambient Temperature (°C)	20.90	20.90	20.90	20.90
Global incident Irradiation (kWh/m^2)	2081.4	2081.4	2185.3	2185.3
Effective Global ,corr. for IAM and shadings (kWh/m^2)	1855.6	1851	1957	1943.2
Energy at the output of the array (MWh)	1607.9	1604.2	1691.1	1679.9
Energy injected into grid (MWh)	1572.9	1569.1	1654.3	1643.3
Performance ratio (%)	75.4	75.3	75.6	75.1

3.3. Economic Analysis

The total energy fed to the grid by the solar plant is 1569 MWh which is 1569000 units per year. The cost per unit of solar power as per Joint Electricity Regulatory commission for UTs is Rs 8.51 without subsidy and Rs 6.14 with capital subsidy of 30 % [3]. The total cost of the plant is Rs 8 crores .

Thus by using above data we get the payback period as 6 years for 15° tilt angle.

4. Conclusion

The study of the solar photovoltaic power plant using PVsyst shows that the 1 MW plant produces more energy for optimized tilt angle equal to the latitude of the site i.e. 30 degree as compared to the energy produced at original tilt angle of 15 degree. The energy produced is 4.71 % more in case of optimized tilt and thus while designing the plant this factor should be considered.

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