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INVESTIGATIONS ON THE PERFORMANCE OF ROOF MOUNT PHOTOVOLTAIC SYSTEM-A SIMULATED APPROACH

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ABSTRACT

This paper presents the performance investigation of 10 kWp roof mount photovoltaic system. Unlike the most seen PV systems installed on open areas, here a crystalline silicon based PV array is installed on vacant roof space of the buildings at an educational institute i.e., St. Peters Engineering College, Hyderabad, India. As an initial step, simulation study is carried out using PV Watts tool. Results obtained from the study shows that roof mount PV system performed well with capacity factor of 17.5%. Energy generation is observed to be maximum in the March i.e., 1450 kWh, and minimum in July i.e., 1095 kWh. Annual energy is observed as 15371 kWh. This study aims to highlight scope for solar power generation possibility for education institute.

Keywords: PV system, Roof mounts PV, Performance investigation, Photovoltaic.

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1. INTRODUCTION

In recent years, the world has experienced the situations where energy is excessively used. Irrespective of the industry or sectorial type, the increments in the energy use patterns were seen. For example, if it seen in the steel industries, the amount of energy used were seen tremendous increments. On other side, energy usage patterns in the academic and research environments also seemed to be increased. Various reasons for this would be improvements seen in the teaching and learning process. To meet the increased energy demands increasing the energy generation facilities or/and reducing the losses would be two possible options. However, on the other side many awareness activities relating to the energy conservations, and efficient use of energy practices were seen in the universities [1-2]. Also, the energy policies and suggestions are leading to the development of self power generation facilities. Renewable energy power generation facilities would be best suitable for the academic institutes [3-5]. Vacant spaces on the academic buildings are best options for installing the renewable energy based power generation facilities. Among all the available power generation facilities, solar energy is better suitable. Here, the solar energy modules can be erected or installed in different configurations over the available vacant spaces on the buildings [6-14]. Typical installation would be the roof top solar PV. Here, the PV modules were aimed to install over the building roof top at fixed tilt angle. The objective of the paper is to carry out the investigations on the performance of crystalline based PV modules mounted on the building roof top.

2. MATERIALS AND METHODS

This section deals with the various components of roof mount solar power plant along with the performance investigation tool used. The components include the crystalline silicon PV modules grouped into PV array, charge controller, power converter, battery energy storage, and loads. Simulation methodology applied for the performance investigation is discussed in section 2.1, and a case study on the proposed roof mount PV system for educational institute is discussed in section 2.2.

2.1. Simulation Methodology Adopted

PV Watts, a software tool developed by the National Renewable Energy Laboratory (NREL) is used for evaluating the energy performance of the proposed solar power plant for an educational institute i.e. St. Peters Engineering College, Hyderabad, India. In PV Watts, modelling starts with the identification of location, and once the location is identified using the address or the coordinates of the location, then an interactive geographical representation of the location appears. Once after the geographical representation appears, solar radiation data details will be made available. Based on this, one of most suitable data basis is considered stored in Typical Meteorological Year 3 (TMY3) and Typical Meteorological Year 2 (TMY2) solar resource from the Solar and Wind Energy Resource Assessment Program (SWERA) and the ASHRAE International Weather for Energy Calculations (IWEC) on a 10 k gridded dataset. Using this solar radiation data, a PV Watts methodology is applied for determining the system performance. Also, other consideration related to performance

investigation was considered as per the standard given in the PV Watts. Simulation methodology adopted for this investigation is as follows [15-19, 29]:

Enter the location or the site where the PV plant is proposed. (Any location can be assessed) and Select the available solar radiation databases for the selected site or location. (Data is obtained from the nearest satellite and data is in the form of TMY2 or TMY 3 file.) See in Fig. 1 for obtaining the solar resource data.

Figure 1 Solar resource database selection window

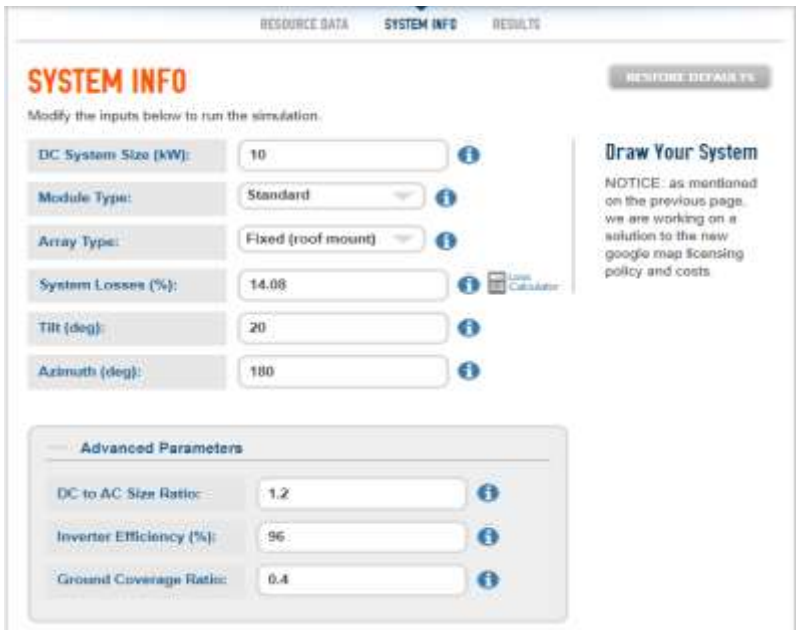

Figure 2 Photovoltaic system sizing window

Enter the PV plant sizing details: PV Technology used (standard crystalline, premium crystalline, and thin film), type of installation (open rack, roof mount, tracking), tilt angle (user can vary from 0° to 90°), azimuth angle (Can vary from (0° to 360°), PV system DC size (1 kWp to 50000 kWp), electrical parameters (DC-AC size ratio as 1.2, Inverter

efficiency as per the user needs, cost of unit electricity. The simulation window for sizing the PV system is shown in Fig. 2.

Simulate the sized PV system and analyse the results (Annual energy yield, Monthly energy yields, Solar radiation, Capacity Factors, Annual energy cost, monthly energy cost) [20-28]. Then analyse the output data in visual representations as per the performance investigation parameters.

2.2. Case Study-10 kW Roof Mount Photovoltaic System

A 10 kW peak roof mount PV system is proposed for the St. Peters Engineering College in Hyderabad. Here, the proposed solar power plant is aimed to install on the vacant space available in the academic buildings. Schematic view of the plant is shown in Fig. 3.

The various components used for the solar power plant were [20, 26]:

- PV modules installed over the building roofs
- Charge controller
- Battery for electrical energy storage
- Inverter for converting the DC electricity to AC electricity.
- Load

Figure 3 Schematic view of the proposed photovoltaic system

The technical specification of the photovoltaic system sized for the education building is shown in Table. 1. These specifications would include the module type, type of the installation, angle of the PV module placement, orientation of the module, systems losses. Here system losses include the cable losses, conversion losses, thermal losses, losses due to dust etc.

Table 1 Roof Mount photovoltaic system specifications.

Parameter	Value
Location name	St. Peter's Engineering College, Hyderabad
Solar data resource	NREL
Latitude	17.55 °N
Longitude	78.45 °E
DC system size	10 kW
Module type	Crystalline Silicon
Array type	Roof mount
Array tilt	20 degree
Array Azimuth	180 degree
System losses	14.08 %
Inverter efficiency	96 %
DC to AC size ratio	1.2

3. RESULTS AND DISCUSSION

Studies related to the performance analysis of PV system at any location requires long term solar radiation data. In this study, long term monthly average solar radiation data provided by PV Watts (Solar and Wind Energy Resource Assessment Program (SWERA), The ASHRAE International Weather for Energy Calculations (IWEC)) have been utilized for estimating the feasibility analysis of PV system at St. Peters Engineering College, Hyderabad. The obtained data from the PV Watts tool is exported into eh excel for carrying out the performance analysis. While in the performance analysis, the major parameters are the energy generations, PV plant capacity factors, hence a concentration is made on the monthly energy generations, annual energy generations and capacity factor estimations.

In Fig. 4, the possible solar irradiance for the study location is given. If carefully observed, the solar irradiance also seems to be varying as per the seasons, especially a considerable variation is observed on monthly basis also. On an average, the variation of solar irradiance seems to be in the range of the 4.72 kWh/Sq. m/day to 6.95 kWh/Sq. m/day. On other side, the highest irradiance was observed to be in the month of March and the lowest is observed to be in the month of July. This is due to the weather condition available in the study location.

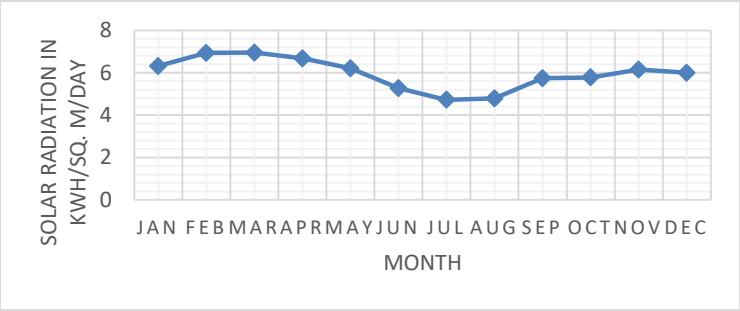

Figure 4 Solar radiation potential at the PV plant proposed location

Table 2 Energy performance of the proposed PV plant

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	6.31	1,397
February	6.93	1,356
March	6.95	1,450
April	6.68	1,322
May	6.21	1,311
June	5.27	1,160
July	4.72	1,095
August	4.79	1,107
September	5.74	1,254
October	5.78	1,266
November	6.15	1,324
December	6.00	1,329
Annual	5.96	15,371

If we see the solar resource potential for the studied location, month wise analysis can be made. This potential is shown in Table. 2. A solar radiation of 6.31 kWh/Sq.m/day is observed in the month of January, 6.93 kWh/Sq.m/day in the month of February, 6.95 kWh/Sq.m/day in the month of March, 6.68 kWh/Sq.m/day in the month of April, 6.21 kWh/Sq.m/day in the month of May, 5.27 kWh/Sq.m/day in the month of June, 4.72 kWh/Sq.m/day in the month of July, 4.79 kWh/Sq.m/day in the month of August, 5.74 kWh/Sq.m/day in the month of September, 5.78 kWh/Sq.m/day in the month of October, 6.15 kWh/Sq.m/day in the month of November, and 6.00 kWh/Sq.m/day in the month of December.

In Fig. 5, the energy performance of the proposed PV system on monthly basis is shown. From the observations, it is noted that the PV system performed better in generating energy. A slight variation seems to exist in the monthly scale. However, maximum energy generation possibility seen in the month of March i.e. 1450 kWh, and the minimum energy generation is seen to be in the month of July i.e. 1095 kWh.

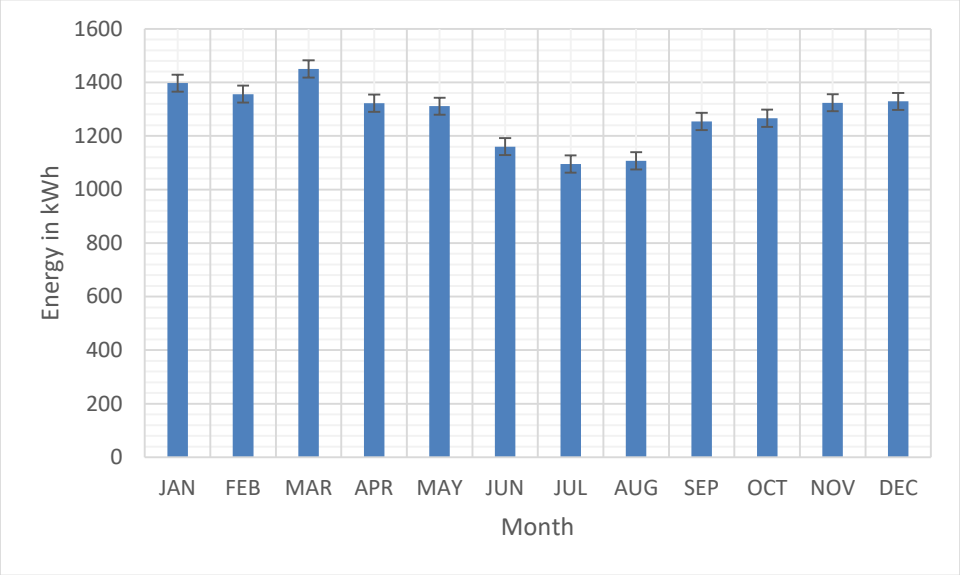

Figure 5 Possible monthly energy generations from the proposed PV plant

If we see the energy generations on month wise, 1397 kWh is generated in the month of January, 1356 kWh in the month of February, 1450 kWh in the month of March, 1322 kWh in the month of April, 1311 kWh in the month of May, 1160 kWh in the month of June, 1095 kWh in the month of July, 1107 kWh in the month of August, 1254 kWh in the month of September, 1266 kWh in the month of October, 1324 kWh in the month of November, and 1329 kWh in the month of December.

In Table. 3, overall summary of the proposed roof mount PV system is shown. The average annual solar irradiance is around 5.96 kWh/Sq. m/day. With this solar irradiance, the generated power is 15371 kWh. The overall performance of is seem to better with a capacity factor of 17.8%, which is quite high when compared to the open rack PV installation.

Table 3 Summary of the proposed PV plant performance

Parameter	Value
Annual Average Solar Radiation	5.96 kWh/Sq.m/day
Annual Energy generation	15371 kWh
Capacity factor	17.5 %

4. CONCLUSION

In this paper, an attempt has been made to investigate the performance of 10 kW roof mount photovoltaic system for St. Peters Engineering College located having latitude and longitudes as 17.55° N and 78.45° E respectively. Here, the applied methodology based on NREL PV Watts® Software tool seems to be best suitable. On other side, the scope for the applicability of the tool is much more appreciated in analysing the performance of the proposed PV plant. Performance of roof mount PV system is elucidated based on the annual AC energy predicted and capacity factor. This study helps the academic institutes to make the best decisions on the proposing the solar power systems for the academic institutions.

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