Experimental Investigation on Performance Variation of Solar Photovoltaic Module with Respect to Four Different Directions

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Abstract

Harvesting of electrical energy using PV panel is a rising trend. The study is to analyze the electrical efficiency by placing the PV panel at different direction. These experiments were conducted at Saranathan College of Engineering, Tiruchirapalli-12. It is located at latitude of 10.7560°N and longitude of 78.6513°E.From these experiments it is found that the maximum electrical efficiency of 7.21% and power of 37.68W are obtained while the PV panel is facing west direction.

Keywords - *Solar; PV; Four; Directions and Efficiency.*

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I. INTRODUCTION

The trend of harnessing electricity from PV panels is widely applied both for domestic and industrial purposes. In this paper, detailed experimentation of positioning and orientation of PV panel in four different directions is conducted. It is conferred that electrical efficiency of a PV panel is affected by the module temperature. The electrical energy using five different PV modules in a hybrid(PV/T) collectors is cultivated, Crystalline Silicon (C-Si) module is effective in electricity production[1].The increased electrical efficiency of 12.5% is observed when module temperature is maintained at 38**°**C by active cooling technique[2].

A 2D transient model for temperature field and electrical efficiency is used for testing solar thermal absorber, standard plate, thermally enhancing plate have found 7% more in discrepancy[4].The electrical and temperature features of the model are studied and concluded based on metrological features[5]. When the cell temperature increases the output power and electrical efficiency decreases and vice versa [7]. The parameters of solar cell temperature, irradiation intensity, cooling fluid, mass flow rate, humidity and dust affect PV-module performance [6].

II.EXPERIMENTAL SETUP

This system consists of PV panels, Ammeter, Voltmeter, Rheostat and probes. The PV panel is placed at an angle of 22º in all the four direction (East, West, North, and South). To measure the electrical efficiency the PV panel positive terminal is connected to ammeter common from the ammeter negative (range 5A) the probe is connected to voltmeter common from the voltmeter common the connection is fed into variable end of the rheostat.

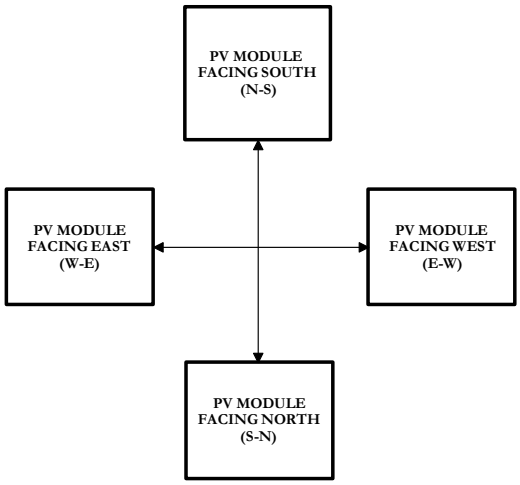

Fig.1. A schematic 2D diagram PV panels in four directions.

The negative terminal of the PV panel is connected to the voltmeter negative (range 30V) and then probe is connected to fixed end of the rheostat. The same connection is applicable for all panels.

A. Formulae

- The fill factor of the module for various time is calculated by the following formula

$$F.F = \frac{I_L * V_L}{I_{SC} * V_{OC}} \quad (1)$$

- The electrical power is determined by the formula

$$P = Isc * Voc \quad (2)$$

- The electrical efficiency for the system can be determined by

$$\eta_e = \frac{I_{SC} * V_{OC} * F.F}{N_m * A_m * I_r} \quad (3)$$

TABLE I TECHNICAL SPECIFICATIONS FOR PV MODULE UNDER THIS STUDY

Components	Specification
PV Module	Poly C – Si
Module Area	610*670 mm^2
Thickness	25 mm
Ammeter	(0-5)A
Voltmeter	(0-30)V
Rheostat	250Ω, 1.8A
Optimum Voltage	18.2 V
Optimum Current	2.2 A
Power	40

III. RESULTS AND DISCUSSION

A. Facing North Direction

Power output from this S-N oriented PV module ranges between a minimum of 18.15 Watts and maximum of 31.5 Watts. Overall power output of this module is 26.61 Watts. Graphical variations in hourly varied electrical power output of this non tracking S-N facing PV module is shown in Fig. 2. Electrical efficiency of this direction oriented PV module varies between a minimum of 4.29 % and maximum of 5.72 %. Overall efficiency of this S-N direction oriented PV module is 4.99 %. Variations in hourly electrical efficiency of this non tracking S-N oriented PV module is plotted in Fig. 5.

B. Facing South Direction

Power output from this N-S oriented PV module ranges between a minimum of 14 Watts and maximum of 38.5 Watts. Overall power output of this module is 29.77 Watts. Graphical variations in hourly varied electrical power output of this non tracking N-S facing PV module is shown in Fig. 2. Electrical efficiency of this direction oriented PV module varies between a minimum of 3.82 % and maximum of 7.75 %. Overall efficiency of this N-S direction oriented PV module is 5.55 %. Variations in hourly electrical efficiency of this non tracking N-S oriented PV module is plotted in Fig. 5.

C. Facing East Direction

Power output from this W-E oriented PV module ranges between a minimum of 6.60 Watts and maximum of 36.75 Watts. Overall power output of this module is 26.42 Watts. Graphical variations in hourly varied electrical power output of this non tracking W-E facing PV module is shown in Fig. 2. Electrical efficiency of this direction oriented PV module varies between a minimum of 2.01 % and maximum of 5.81 %. Overall efficiency of this W-E direction oriented PV module is 4.02 %. Variations in hourly electrical efficiency of this non tracking W-E oriented PV module is plotted in Fig. 5.

D. Facing West Direction

Power output from this E-W oriented PV module ranges between a minimum of 31.45 Watts and maximum of 42.55 Watts. Overall power output of this module is 37.68 Watts. Graphical variations in hourly varied electrical power output of this non tracking E-W facing PV module is shown in Fig. 2. Electrical efficiency of this direction oriented PV module varies between a minimum of 5.73 % and maximum of 10.09 %. Overall efficiency of this E-W direction oriented PV module is 7.21 %. Variations in hourly electrical efficiency of this non tracking E-W oriented PV module is plotted in Fig. 5.

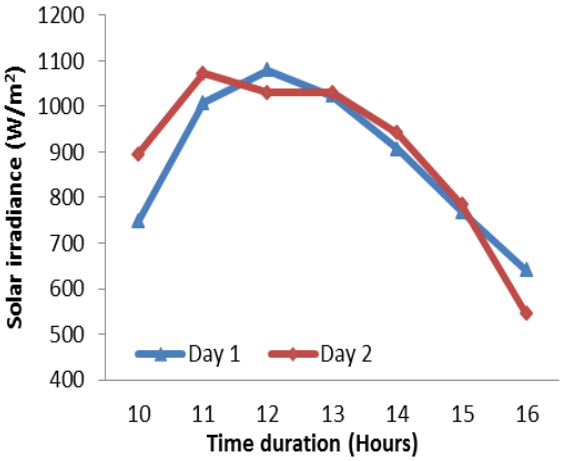

Fig 2. Variation of solar irradiance with time

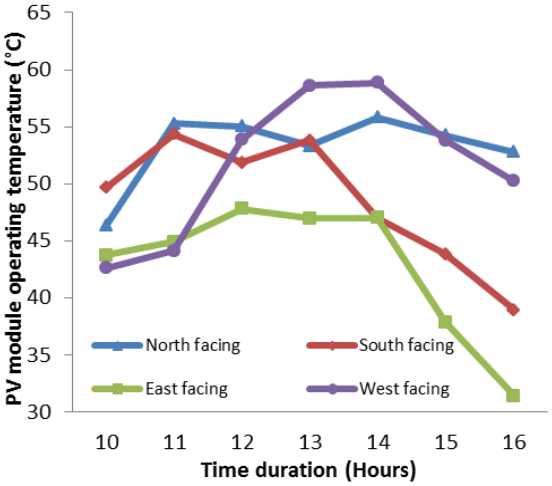

Fig 3. Variation of PV module operating temperature with time in hours

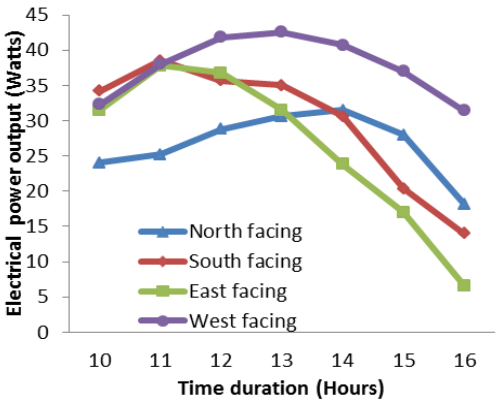

Fig 4. Variation of electrical power output with time

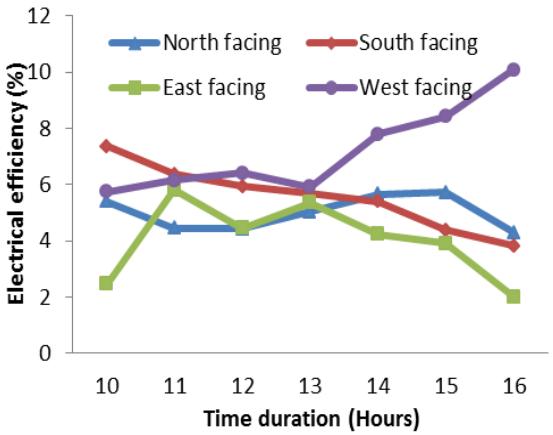

Fig 5. Variation of electrical efficiency with time

IV. CONCLUSIONS

Performance of solar PV module is more sensitive to its operating temperature. It is observed that overall average temperature variation of N-S facing PV module is higher than S-N, E-W and W-E facing module.

T_{N-S} (53.26°C) > T_{E-W} (51.73°C) > T_{S-N} (48.29°C) > T_{W-E} (42.08°C)

From the conducted experiments, it is evident that overall electrical power output produced by E-W facing module is higher than N-S, S-N and W-E module.

P_{E-W} (37.68 W) > P_{N-S} (29.77 W) > P_{S-N} (26.61 W) > P_{W-E} (26.42W)

It is also cleared that overall electrical efficiency produced by E-W facing module is higher than N-S, S-N and W-E module.

η_{E-W} (7.21 %) > η_{N-S} (5.55 %) > η_{S-N} (4.99 %) > η_{W-E} (4.02 %)

V. FUTURE WORK

It is proposed to conduct experiments with various solar based energy conversion devices such as flat plate collector, PV/T collectors etc. with respect to different orientation directions.

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NOMENCLATURE

I_{sc}– Short circuit current (Ampere)
V_{oc} –Open circuit voltage (Volt)
I_L – Line current (Ampere)
V_L – Line voltage (Volt)
P – Electric power (Watt)
I_r– Irradiance (W/m^2)
N – Number of module
Am – Area of module (m^2)
Tavg or T- Average Panel Temperature with reference to three RTD sensors (˚C)
η_e - Electrical efficiency (%)

ABBREVIATIONS

PV- Photovoltaic
S-N – South - North facing
N-S – North – South facing
W-E – West – East facing
E- W – East – West facing