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Studies on Power Output, Fill Factor and Conversion Efficiency of Solar Photovoltaic Panel in Dual Axis Tracking Mode Under Humid Coastal Area

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ABSTRACT: Thaw India, being a tropical country is blessed with plenty of sunshine, the humid coastal region faced the problem of bright sunshine hours. To increase the output from SPV panel, it is necessary to track the panel in perpendicular to sun rays. The studies on power out from SPV panel on dual axis mode in comparison with fixed mode were carried out in humid coastal region (Location-Dapoli, Longitude- 73⁰26'E, Latitude-17⁰45'N, MSL-). The experimental studies on mono-crystalline solar panels of 80 Wp was carried out to find the change in the output power in dual axis tracking and fixed axis mode during the month of March. The output of SPV panels were determined by measuring the electrical parameters using standard test procedures. The study revealed that, the average power out of 80 Wp solar panel for dual axis tracking panel position was found to be 62.75Wp as compared fixed panel position(49.03W).

KEYWORDS: Solar, Photovoltaic, Tracked mode, power.

I. INTRODUCTION

India, being a tropical country, is blessed with plenty of sunshine. The average daily solar radiation varies between 4 to 7 kWh per square meter for different parts of the country. There are on an average 250 to 300 clear sunny days a year in India. Thus, it receives about 5,000 trillion kWh of solar energy in a year, which is far more than the total energy consumption of the country (Sengar *et.al*, 2012).

The photovoltaic cell (PV), is a device that converts light into electric current using the photoelectric effect. The photovoltaic cell is a solid-state device composed of thin layers of semiconductor materials which produce an electric current when exposed to light. Photovoltaic devices are rugged and simple in design requiring very little maintenance and their biggest advantage being their construction as stand-alone systems to give outputs from microwatts to megawatts.

The rapid growth of the solar industry over the past several years has expanded the importance of PV system design and application for more reliable and efficient operation. A major advantage of the coastal areas is the high precipitation level which helps to clean the surface of the solar panel for effective photoemission. Solar energy operators in the coastal areas are faced with challenges ranging from climate change, inefficient solar panel, durability of the solar panel, poor energy budget, and so forth. The estimated solar power reaching the earth is little above 1000 W/m². This means that if solar energy is judiciously harvested, solar option is capable of meeting the energy needs of the whole world. An efficient harvest of the solar radiation within the tropics and specifically coastal areas depends on the efficiency of the solar panel used. The improvement of the solar PV tracking mode is of utmost interest in the quest



of maximizing the utilization of solar energy. The output characteristics of PV module depends on the solar insolation, the cell temperature and output voltage of PV module. The PV system converts solar energy into direct current (DC) electrical energy, their efficiency depending on the degree of use of the conversion of solar radiation. The degree of use of the solar radiation can be increased by the use of solar tracking system. The average solar energy intercepts by fixed collector, during the whole day it is less than the maximum attainable. It is due to the static placement of the collector which limits their area of exposure to direct solar radiation. More energy can be extracted in a day, if the solar collector is installed on the tracker, with an actuator that follows the sun like a sun flower. If the installation and running cost of the system are reasonable, there will be a possibility of increasing the energy yield (Mustafa, 2012).

II. MATERIAL AND METHODOLOGY

The experiment on solar panel (80 Wp) was carried out at the Department of Electrical and other Energy Sources, CAET, Dapoli, (Longitude- 73°26'E, Latitude-17°45'N, MSL) to find the change in the output power when installed in fixed position of solar panel compared with dual axis tracking mode of solar panel. The tests were conducted in month of March on typical mid-day of month. The output current and voltage of solar panel were measured from morning 08:00 h to 18:00 h for 3 consecutive days at an interval of 30 min. The short circuit current and open circuit voltage were measured corresponding to solar intensity. The environmental parameters like wind velocity and ambient temperature were also measured. The I-V Characteristics values mentioned of solar panel are mentioned as below.

Short circuit current (Isc)

This is the maximum current that flows in a solar cell when its terminals at P side and N-side are shorted with each other, i.e., $V = 0$. The short circuit current is usually represented as current density and current per unit area, in terms of mA/cm².

Open circuit voltage (Voc)

It is the maximum voltage generated across the terminal of the solar cell when they are kept open, i.e., $I = 0$. Open circuit voltage depends on the light generated current and reverse saturation current. The Voc is in terms of mV or V.

Fill factor (FF)

It is the ratio of maximum power ($P_m = V_m \cdot I_m$) that can be extracted from the solar cell to the ideal power ($P_o = V_{oc} \cdot I_{sc}$). The FF represents the squareness of the solar cell I-V curve. It is represented in terms of percentage.

$$\text{Fill factor(FF)} = \frac{V_m \cdot I_m}{V_{oc} \cdot I_{sc}} = \frac{\text{maximum power}}{\text{Ideal Power}}$$

Where, V_m = Voltage at maximum power, (Volt)

I_m = Current at maximum power, (Amp)

V_{oc} = Open circuit voltage

I_{sc} = Short circuit current

Efficiency (η)

It is defined as the ratio of the power output to power input. The power output is maximum power point P_m of a solar cell, and input power is the power of solar radiation P_{rad} . Thus the efficiency calculated as:

$$\text{Efficiency } (\eta) = \frac{V_{oc} \cdot I_{sc}}{A \cdot SI} * 100$$

Where, A = Solar panel area, (m²)

S.I = Solar intensity, (W/m²)



Fig. 1 Testing of SPV panel with fixed angle

The technical specifications of solar photovoltaic panel under test is summarized in table 1.

Table 1: Technical specifications of solar panel

Sr. no.	Parameter	Specifications.
1.	Make	Su-Kam Power Systems Ltd.
2.	Cell type	Mono crystalline
3.	Maximum Power Pm (Wp)	80 W
4.	Maximum power voltage Vmp (V)	17.70V
5.	Maximum power current Imp (A)	4.55A
6.	Short circuit current Isc (A)	4.85A
7.	Open circuit voltage Voc (V)	21.40V
8.	Maximum system voltage (V)	600
9.	Fill Factor FF	0.785

III. RESULT AND DISCUSSION

The experiments on solar panel of 80 Wp was carried out to find the change in the output power, fill factor and conversion efficiency when installed in fixed position compared with dual axis tracking mechanism of solar panel. The obtained are discussed as under.

Study of effect of tracking on output of SPV panel

The experiment on solar panel (80 Wp) was carried out to find the change in the output power when installed in fixed position of solar panel compared with dual axis mode tracking mechanism of solar panel. The obtained is summarised in fig 1.

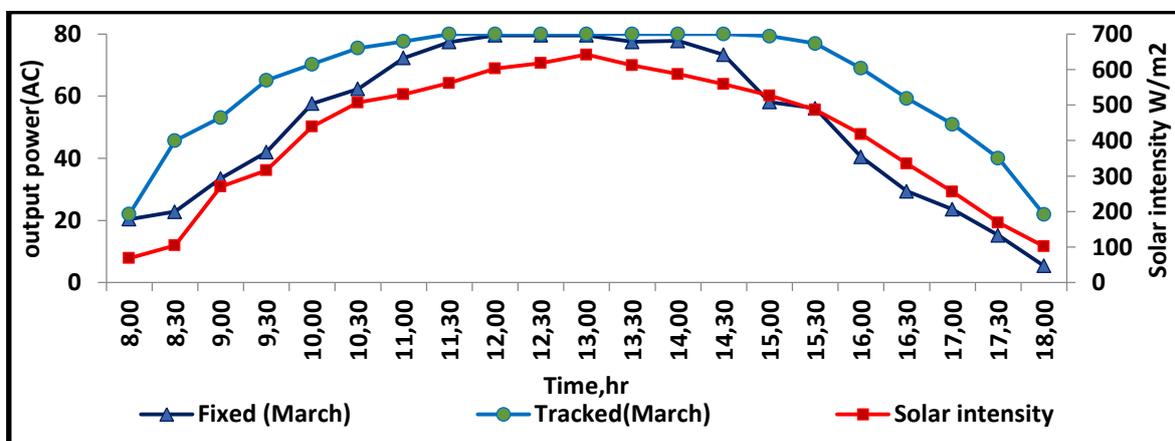


Fig 1 Effect of tracking and solar intensity on output power of solar photovoltaic panel.(80 Wp).



Fig. 1 shows the comparison between outputs power of tracking position and fixed panel of 80Wp. Curve shows that power generated from fixed panel at morning hours and at late evening hours was much lower while for tracking panel it was higher at morning and evening. The output power from fixed system varies between 20.0 Wp to 79.6 Wp whereas from tracking system it was 21 W to 79.6 W. The average power generation for fixed panel was 49.03Wp and for tracking panel it was 62.75Wp respectively. The percentage variation of power output for fixed panel and tracking panel was found to be 13.72%. The corresponding solar intensity and ambient temperature was found to be 423.81 W/m² and 31.08 °C, respectively.

Effect of tracking and solar intensity on fill factor of solar photovoltaic panel.

The effects of tracking and solar intensity on solar panels were studied to determine the change in fill factor with respect to time and solar intensity. The variation of fill factor with respect to time and solar intensity for 80 Wp solar panel in the month of March is shown in Fig 2.

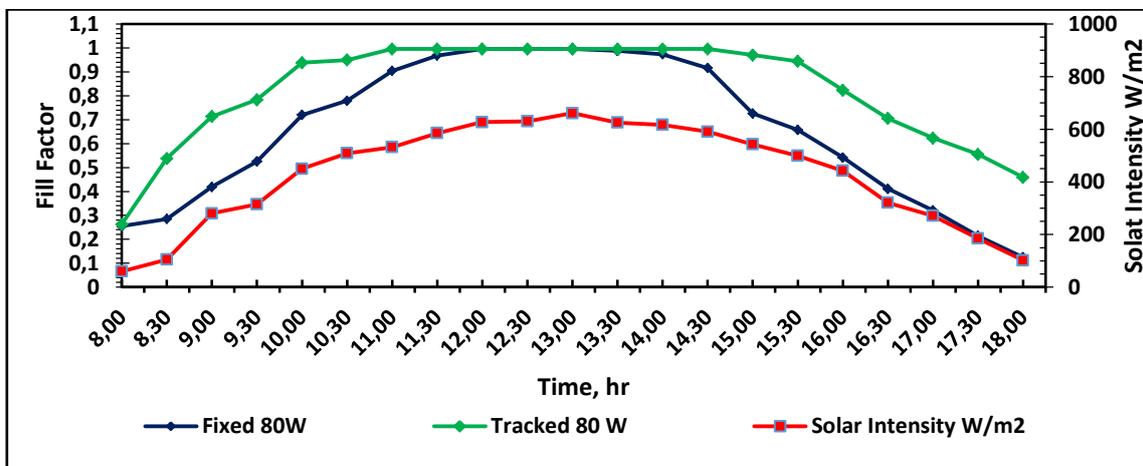


Fig. 2 Variation of fill factor with respect to time and solar intensity (March).

Fig 2 revealed that, the maximum solar intensity of 640 W/m² was recorded during 13:00 with maximum fill factor of 1 in the month of March. It also showed that the constant fill factor was achieved during 10:00 to 16:00 for tracking and fixed positions of 80 Wp solar panel. The average range of fill factor were found to be 0.625 and 0.769 for fixed and tracked position, respectively. The solar panels with tracking positions achieved more fill factor compared to solar panels with fixed positions.

C. Effect of tracking on conversion efficiency of solar photovoltaic panel

The effects of tracking and solar intensity on conversion efficiency of solar panels were studied with respect to time and solar intensity. The variation of conversion efficiency with respect to time and solar intensity of 80 Wp solar panel are shown in Fig 3.

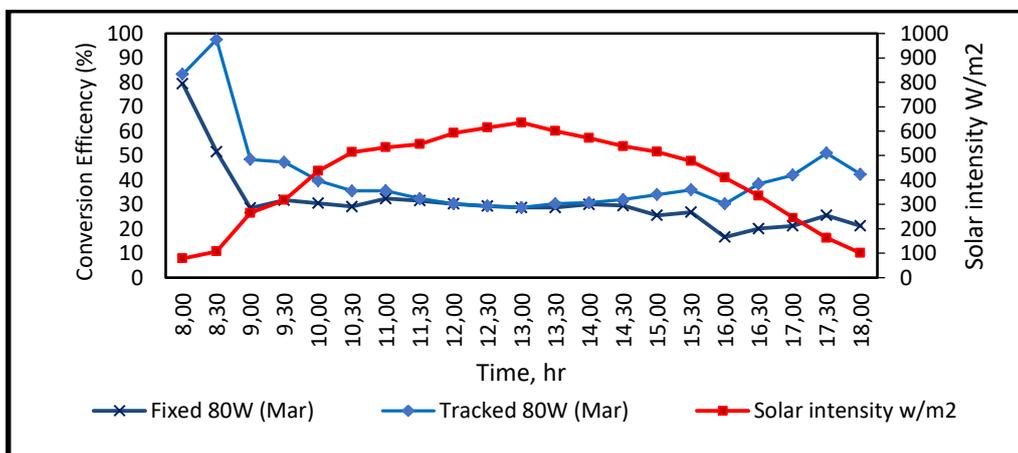


Fig 3 Effect of tracking and solar intensity on conversion efficiency of solar photovoltaic panel.(80 Wp, March).



Fig. 3 revealed that, the maximum conversion efficiency was obtained in the tracking position of solar panel compared to fixed position of 80 Wp solar panel. The average conversion efficiency of 80 Wp was found to be 34.5 % on tracking mode as compared to 26.3 % at fixed position during month of March for tracking and fixed position, respectively.

IV. CONCLUSION

The experiment on solar panel of 80 watt was carried out to find the change in the output power, fill factor and conversion efficiency when installed in fixed position of solar panel compared with dual axis tracking mechanism of solar panel. The percentage variation power output was found to be 13.72% more in dual axis mode as compared to fixed position in humid coastal region. The average fill factor of solar photovoltaic panel were found to be 0.625 and 0.769 for fixed and tracked position. The average conversion efficiency of 80 Wp was found to be 34.5 % on tracking mode as compared to 26.3 % at fixed position

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