RESEARCH ARTICLE

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Comparison of Power Output Between Fixed and Perpendicular Solar Photovoltaic PV Panel in Tropical Climate Region

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This paper discusses the comparison of output power between fixed and dual axis panel, the dual panel manually moved to perpendicular facing the sun. The output power calculated for the fixed panel was 64.26 Watt on 17th March 2016 with the best tilt angle 15° for the latitude of University Malaysia Sabah (6°01'53.73″N, 116°07'14.98″E) and 70.03 Watt output power for dual axis tracking panel on 17th March 2016. Power output measurement was conducted for 13 days from 9 to 21 March 2016. It was found that the highest power output was observed on 17th March 2016 for both systems with 64.26 Watt for fixed system and 70.03 Watt for dual axis tracking system respectively. The corresponding maximum global solar radiation was 1052.9 W/m^2. Therefore, it can be concluded that generally output power for dual tracking panel is higher compared to fixed panel.

Keywords: Solar Photovoltaic, Power Output, Fixed Axis, Dual Axis, Sun Tracking System, Global Solar Radiation, Kota Kinabalu.

1. INTRODUCTION

Development of technology in solar energy becomes more advanced. This can contribute to sustain energy supply and demand, at the same time will benefit to environment.[1] The sun is considered as the only solar energy main source, it's also generate energy continuously, clean and can be converted into electricity through photovoltaic effect. More energy can be produced by incorporating reflections effect. Therefore, the less usage of photovoltaic cells materials which is have a high impact on environment and also limited.[2] The main factor affecting output of the panels are temperature of cell and irradiance intensity. The maximum power change depend on the temperature of the cell, higher temperature will decrease short circuit current and maximum power value. However higher irradiance intensity will result higher value for short circuit current and maximum power output.[3] Installation of azimuth and tilt tracking angle affects the intensity of solar radiation incident, both influence the amount of incident sunlight at PV panel surface.[4]

To receive maximum solar radiation on solar collector, sun tracking system plays an important role.[5] Single axis tracking panel with three different fixed angles which can rotated either eastward or westward can shows significant power output different. This three setting are daily adjusted.[6] Special autonomous tracking mechanism used to align the panel perpendicular to sunlight direction and to get maximum incident beam.[7]

Tilt angle and orientation with the horizontal plane can affected the performance of solar collector.[8] To produces the maximum possible power, the photovoltaic panel must be moved according to sun's position changes and always aimed perfectly at the sun throughout the day.[9–11] According to the simulations calculated, dual tracking system produce 33.8% more electricity compared to the fixed system.[12]

Dual tracking system was able to maintain its orientation without being affected environmental conditions. Solar system equip with tracking system capable to collect about 20–40% radiation or output.[4]

Dual tracking system produce energy 29.3% (radiation) and 34.6% (power) more compared to the fixed system in July.[13] Based on daily data, vertical axis tracking panel also produce 20% higher power than fixed array.[10] In Jordon, maximum electrical gains up to 43.87%, a comparison between sun tracking module compared to fixed module tilted at 32° from the horizon.[11] Overall power increase about 30–45% for north–south axis tracking panel compared to the fixed panel.[14] However many

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ongoing research still investigating on the effect of continues solar tracking system.[15]

It is obviously, fixed system was a simple set-up with easy installation and operation, low maintenance and requirements.[14] To collect more solar energy that aimed the sun with a smaller incident angle was dual tracking system.[16,17]

In this study, the power output between fixed and dual tracking system are compared. The fixed system was positioned with the specific tilt angle and dual axis would track the sun's movement each hour per day. When the amount of solar radiation are higher so does the output power produced by the photovoltaic system.[12]

2. LOCATION AND INSTRUMENTATIONS

Kota Kinabalu situated in Sabah, East Malaysia with the latitude of 5.9714°N and longitude 116.0953°E.[18] The experiment was conducted in University Malaysia Sabah UMS, Kota Kinabalu (6.0367°N, 116.1186°E).[18] This experiment was carried out for 13 days start from 9th of March till 22nd of March 2016. Two of 50 Watt photovoltaic panel Module mono-crystalline SPM050-M was used in this research. Pyronometer model LI-200 was used to record global solar radiation, Fluke 179 True RMS Multimeter to measure the temperature of solar panel, short circuit current and open circuit voltage, HoldPeak HP-720 Infrared Thermometer to measure the temperature of solar panel and KTJ thermometer to measure the environment temperature and also humidity.

3. METHODOLOGY

3.1. Operation of Fixed System

Solar radiation is absorbed effectively when strikes to the solar collecting at the right perpendicular angle which is 90°.[19] When mounting solar collector that relatives to the ground sun moves in 180° arc from east to west and overhead north–south position. Malaysia is placed in Northern of the equator, the sun is usually in the southern portion of the sky and panels should be mounted facing south. Along the equator, the sun's position varies from 23° North to 23° South over the course of the year. Modules should be mounted with 5–15°north or south tilt towards the part of the sky when the sun is during the least sunny months.[19]

Fig. 1. Fixed system.

Fig. 2. Dual axis tracking system.

This experiment was carried out in the University Malaysia Sabah at the latitude of 6.0367°N, 116.1186°E and the tilt angle for sun tracking is at the 15° facing south. Voltage and current output varies according to intensity of global solar radiation on the panels and movement of the sun. Experiment setup of fixed axis systems shown in Figure 1. Data of voltage, current, temperature, humidity, environment temperature obtained manually from Fluke 179 True RMS Multimeter and evaluated using Microsoft excel program meanwhile global solar radiation obtained from LI-200 pyronometer. Single data logger set with Symphonie Data Retriever SDR was used to record average value of global solar radiation every 10 minute.

3.2. Solar PV Panel Setting

The purpose of perpendicular solar PV panel setting is able to track the sun accurately the whole day and was carried manually every hour. Protector used to detect the angle value of the panel every one hour started 6am till 6pm each day when the module rotate from east to west. Meanwhile, compass application was used to identify the trajectory of the sunlight. This dual axis solar tracker system capable moves both directions east to west and north to south as shown in Figure 2. Once the module rotated manually and perpendicular to the sun, the tilt angle of the panels was recorded. This dual axis movement of the panel was achieved and global solar radiation was utilized efficiently within the days.

4. RESULTS AND DISCUSSION

The experiment was conducted for 13 days start from 09th March till 22nd March 2016 and reading taken at 6 am till 6 pm. The result obtained and compared the output power system.

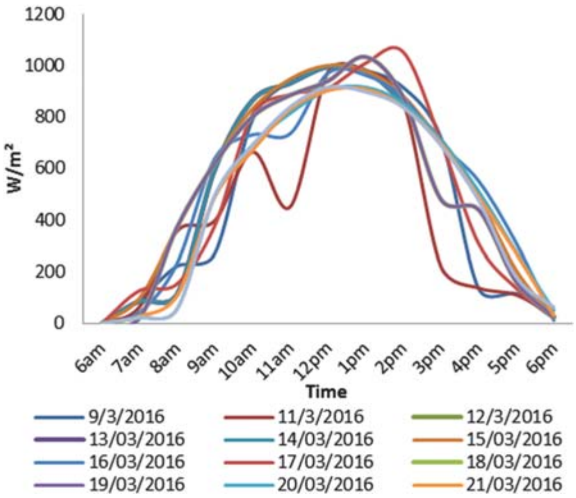

Fig. 3. Global solar radiation.

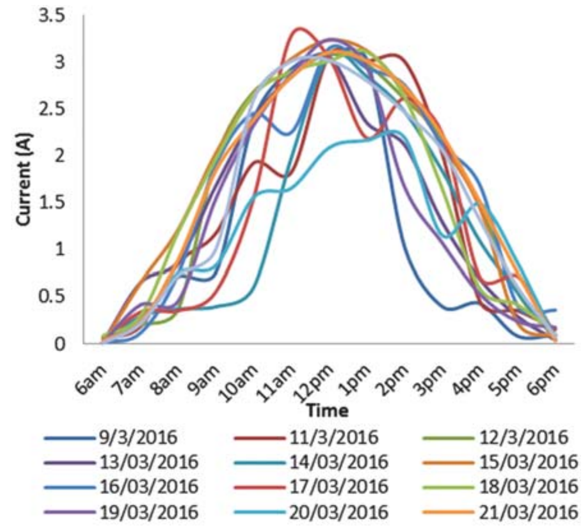

Fig. 5. Daily short circuit current for fixed system.

The sunlight effect changes according to the time and also the geography of the location experiment was conducted. In this study PV array systems was mounted, fixed axis and dual axis tracking system.

From the data in Figure 3, clearly shows the highest global solar radiation captured was 1052.9 W/m^2 on Thursday 17th March 2016 at 2 pm Malaysia time and the environment temperature was 37.1 °C measured by KTJ thermometer. At this time, the sky was clear and the sun hours for this day were 8 hour per day.

The fixed system faced the south with an angle 15° which is the best tilt angle to maximize level of the irradiance received at noon. The angle was taken by considered the latitude of the experiment site was conducted. Meanwhile, the dual axis tracking system was able to track the sun by rotate the stand pod of the module manually each hour throughout the days. The rotation movement is east–west and north–south. The data was compiled and the voltage, current and power for fixed axis and dual axis was compared.

From Figures 4 and 7, it can be seen clearly that voltage for fixed axis and dual axis tracking system are very close. Highest value for fixed axis was 20.14 V on 11th March on 10am and for dual axis was 20.91 V also the same date and time with fixed axis array.

From Figure 5, the highest short circuit current throughout the day most at 12pm except for three days which is 17th, 18th and 20th March. The highest short circuit current was showed on Thursday 17th March 2016 at 11 am which is 3.287 A for fixed axis array. Meanwhile, the highest short circuit current for dual axis array was 3.56 A on 17th March 2016 at 2 pm. The current

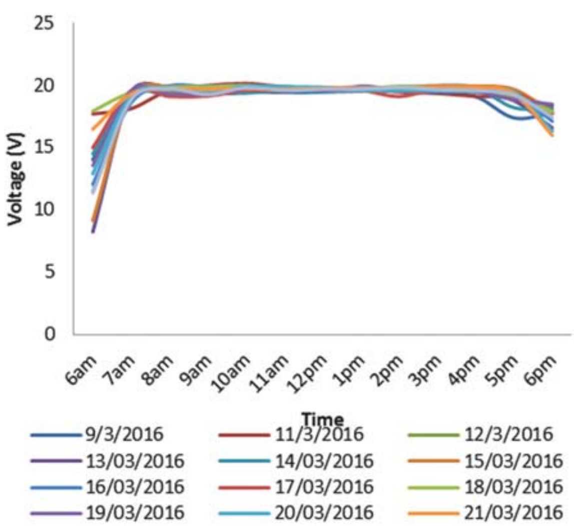

Fig. 4. Daily open circuit voltage for fixed system.

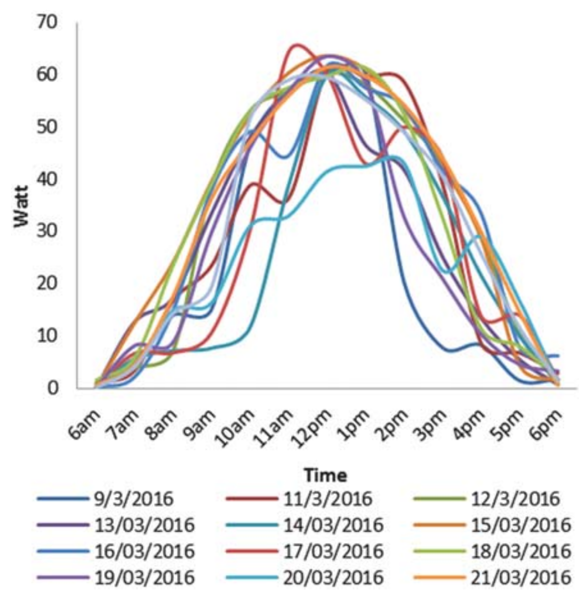

Fig. 6. Power output for fixed axis tracking system.

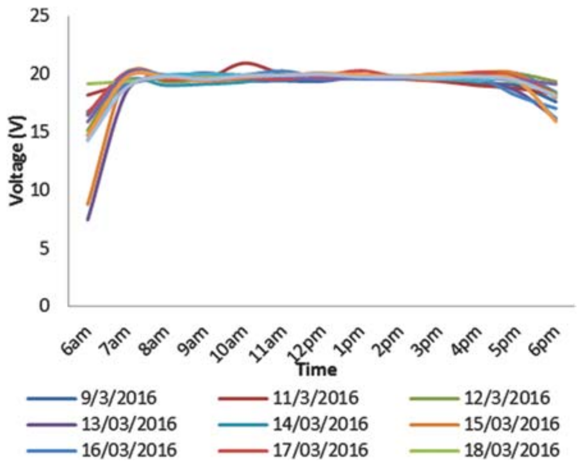

Fig. 7. Daily open circuit voltage for dual axis.

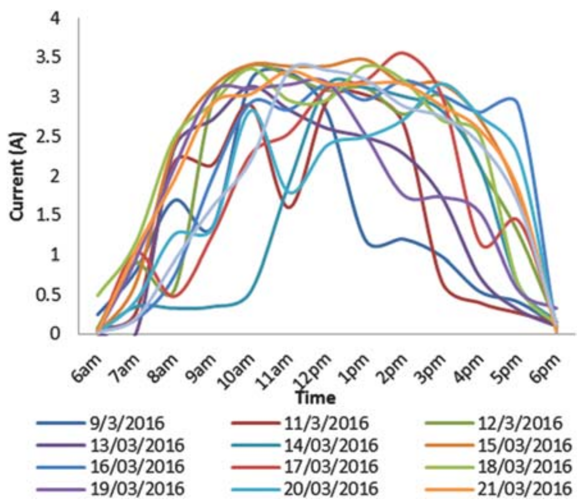

Fig. 8. Daily short circuit current for fixed system.

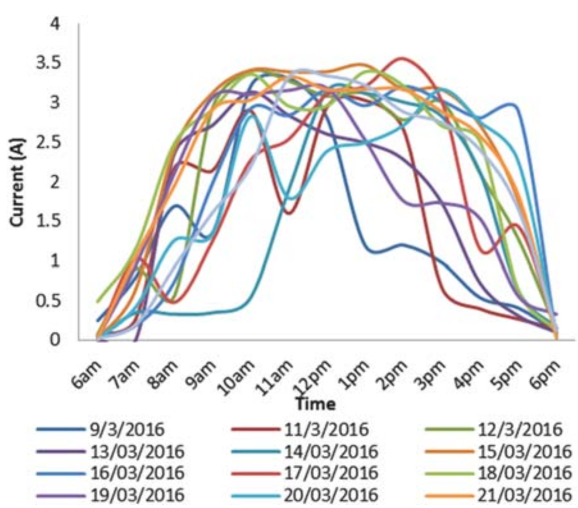

Fig. 9. Power output for dual axis tracking system.

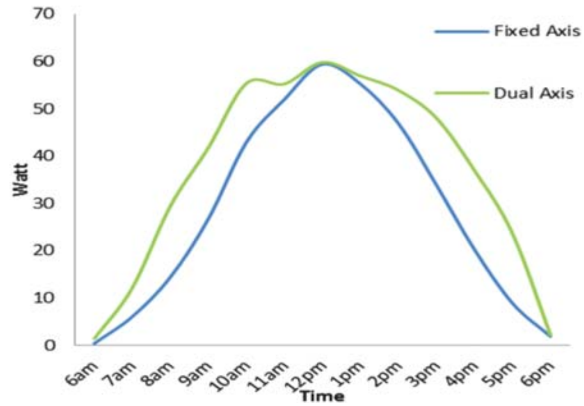

Fig. 10. Average output power between fixed and dual axis tracking system.

values of the fixed axis are lower than dual axis tracking. So, the output power of dual axis tracking system increases.

Figures 6 and 9 show that the highest output power for fixed axis array was 64.26 Watt on 17th March 2016 at 11am meanwhile for dual axis tracking system showed 70.03 Watt on 17th March 2016 at 2 pm and the global solar radiation on that time was 1052.9 W/m^2 is the highest throughout the measurements. The difference output power between two arrays was 5.77 Watt. It's more obvious that the fixed axis system generates low power than dual axis tracking system.

Figure 10 shows the average output power between fixed axis and tracking panel system throughout the 13 days start 9th March till 22nd March 2016, obviously that the output power dual axis tracking system is always higher than the fixed. Referring from the figure that dual axis tracking system is more advantageous compared to the fixed system in terms of power output.

Table I shows the averaged power output from the solar panel with dual and fixed axis Sun Tracking System for Kota Kinabalu, Sabah. For Kota Kinabalu output power for 17th March 2016 was picked because have a higher output power throughout the 13 days that is 70.03 Watt at 2 PM and 64.26 Watt at 11 AM for dual axis and fixed axis respectively. As a comparison with other available published work, Perlis, a state in the Peninsular of Malaysia have a lower output power which is 25.56 Watt at 12 PM for dual axis and 16.58 Watt for fixed axis during sunny day.[20] This advantage could justify the work carried out in this paper.

Table I. Averaged power output from the solar panel with dual and fixed axis Sun Tracking System for Kota Kinabalu, Sabah.

Time	Dual axis	Fixed axis
6.00 AM	0.51	0.28
7.00 AM	20.61	6.65
8.00 AM	9.34	6.78
9.00 AM	24.60	10.62
10.00 AM	44.60	30.34
11.00 AM	49.63	64.26
12.00 PM	61.52	59.98
1.00 PM	65.05	42.92
2.00 PM	70.03	49.95
3.00 PM	58.86	44.02
4.00 PM	23.13	13.80
5.00 PM	28.26	13.97
6.00 PM	2.54	1.63
Average	35.28	26.55

5. CONCLUSIONS

The performance of the output power between fixed axis and dual axis tracking system was analyzed. From the data obtained it can be summarized that dual axis tracking system works more efficiently than the fixed axis. Dual axis panel adjusted correlate with the position of the sun and makes it always perpendicular to the panel. The maximum output power for fixed axis was 64.26 Watt and 70.03 Watt for dual axis tracking system. Although dual axis tracking system is more expensive, this tracking system produces higher output power that can supplies electricity and has a good performance than fixed axis system.

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