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RELATIONS BETWEEN EFFICIENCY OF POLYCRYSTALLINE SOLAR CELLS AND CLIMATIC PARAMETERS IN MALAYSIA

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Abstract The performance of a solar panel is measured in terms of its efficiency in turning sunlight into electricity. This energy is highly influenced by weather variation. This research attempts to find out the relationship between solar efficiency and the Malaysian climate. The output current and voltage of the solar panel had been collected 24 hours non-stop within a week. These data were used to determine the efficiency of solar panel. At the same time, the climate parameters had been recorded using weather station. A correlation test was conducted to establish the relationship between these climate parameters and the solar cells efficiency. Correlation test results showed that the solar irradiance and temperature greatly influence the efficiency of polycrystalline solar cells. However, the humidity and wind speed exerted lesser influence.

KEYWORDS: Climate conditions, efficiency of solar cell, solar energy

Introduction

Solar energy is an energy that is not just clean but it is also a renewable energy, which means it will last forever. Because of these advantages, research and development to improve the usage of this energy have been stepped up. Moreover, it has been proved that solar energy is vital in creating a better and cleaner environment. Photovoltaic (PV) cells are used widely in the process of converting light. The present commercial solar cell converts solar energy into electricity with a relatively low efficiency, less than 20%. More than 80% of the absorbed energy is dumped to the surroundings again after electric energy conversion (Huang *et al.*, 2001). Performance of the PV system is highly influenced by the weather, especially the irradiance and the temperature (Harsono Hadi *et al.*, 2003). To investigate the influence of the Malaysian climate on the performance of solar cells, an outdoor exposure was conducted in at the Faculty of Science and Technology, University Malaysia Terengganu.

Material and Methods

The experiment was conducted during the Northeast monsoon in the middle of January 2005. A 3W peak polycrystalline silicon photovoltaic module was positioned at the top roof of Institute of Oceanography (INOS) building. The latitude of the area where the experiment was conducted is 5°.

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As indicated in (www.oksolar.com), this 3 Wp solar panel should be tilted at 15° from the horizontal to allow greater amount of the direct solar irradiance to fall on the surface of the module.

This PV module was connected to data acquisition (DAQ) card, which was plugged into the PC. The block diagram is shown in Fig. 1. Using MATLAB software, the values of output current and voltage were recorded every 15 minutes for a duration of one week. Fig. 2 shows the connections of reading value were collected. The load is a 7 W fluorescent tube lamp. At the same time, the weather parameters such as relative humidity, air temperature, wind speed and solar irradiance were acquired and recorded every 15 minutes using the weather station.

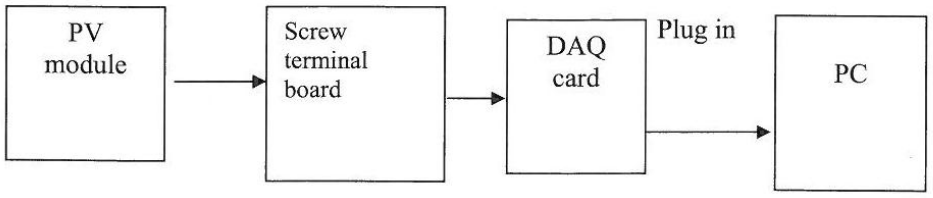

Figure 1. Block diagram shows the connection of the equipments

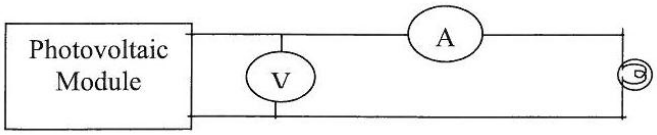

Figure 2. The ammeter and voltmeter show where the reading value of output current and voltage solar panel had been taken

Using the collected current and voltage value from MATLAB and solar irradiation from weather station, the efficiency of the solar panel was determined based on the following formula (Harsono Hadi *et al.*,):

$$\eta = \frac{I \times V\,(W)}{\text{Solar Irradiance}\,(W/m^2) \times \text{Surface Area}(m^2)} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Results and discussion

All the data were collected for 7 days, from 13 to 19 January 2005. The variations of average values for solar irradiance, relative humidity, wind speed, and temperature during the period of experiment with time of the day are shown in Fig. 3. The graph in Fig. 3 shows solar irradiance was 0 Wm^{-2} from 0000 to 0730 hours and from 1930 to 2400 hours. This means that Malaysia receives 12 hours of sunshine per day. The maximum solar irradiance was 162 Wm^{-2} at 1400 hours. The relative humidity, wind speed and ambient temperature were in the range of 32–87%, 3-8 m/s and 24-29°C respectively.

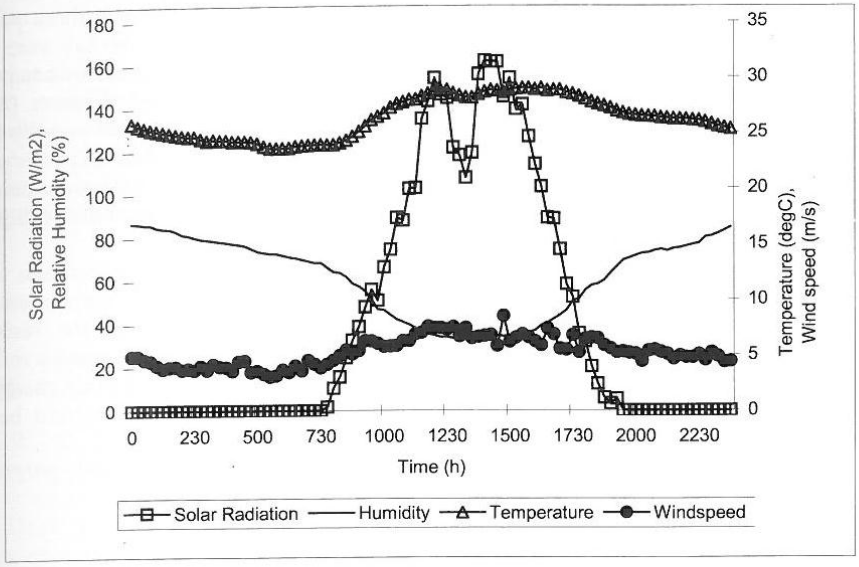

Figure 3. Variations of solar irradiance, relative humidity, air temperature and wind speed opposed to time of the day

Figure 4 shows the daily average efficiency of the PV panel and solar irradiance during the period of experiment. From the experiment, the polycrystalline solar cell performed maximum at 14.343%. The figure also shows the same trends between solar irradiances and solar cell efficiency. This implies a strong relationship between solar cell efficiency and solar irradiance.

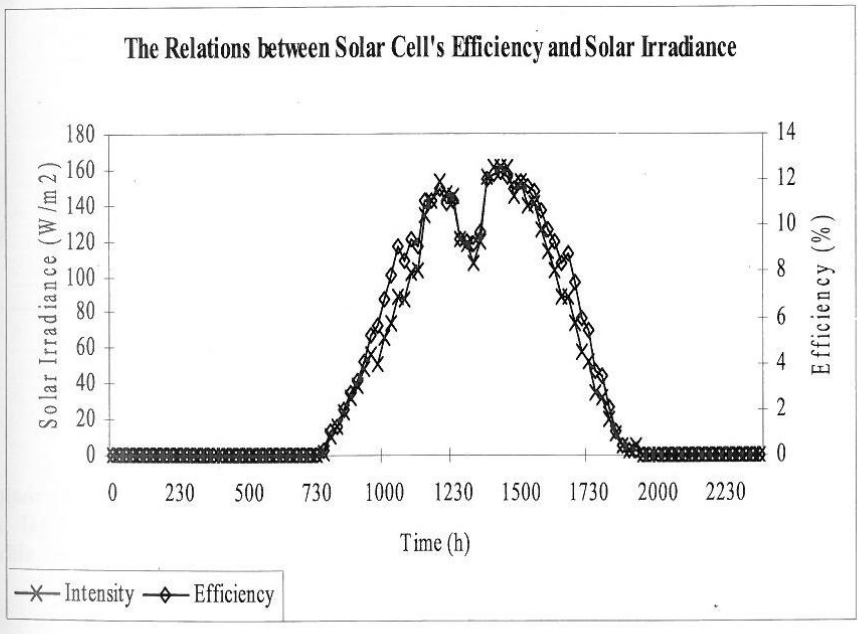

Figure 4. Daily average efficiency of polycrystalline solar cell and solar irradiance

As indicated in Fig. 4, there were two peaks and a drops value between these peaks. This happened because there were two days within that period of experiment where the day were rainy and cloudy and at this time the solar irradiance fell to 6 W/m^2. The curves should have only one peak.

The data were then analyzed using Statistical Package for the Social Sciences (SPSS) for windows to determine the correlation among the interested local climate parameters and the solar cells efficiency. Correlation analysis studies the relationship between the two variables (Neter *et al.*, 1996). Table 1 summarizes the Pearson Correlation Coefficient, *R*, for each relationship between the parameters. Pearson Correlation Coefficient measures the strength of the linear relationship between two variables (http://zlab.bu.edu/~zhangxl/Pearson_correlation.html).

Table 1 shows the efficiency of solar cells has a very strong positive association with solar irradiance. The same trend happens to the air temperature. The positive correlation between temperature and efficiency is positive and quite strong. This is true since the resistance of semiconductor materials decrease from very large values at low temperatures to a smaller resistance at higher temperature. When more valence electrons gain sufficient energy from thermal energy to enter the conduction band, it is clear that semiconductor is a better conductor of current because its resistance decreases with the increase of temperature (Curtis, 2000).

Table 1. A summary of correlation coefficient, *R*

		I (W/m^2)	WS (m/s)	RH (%)	T (^{0}C)	Eff (%)
I (W/m^2)	Pearson Correlation	1.000	.385	-.039	.702	.978
	Sig. (2-tailed)	.	.000	.317	.000	.000
	N	672	672	672	672	672
WS (m/s)	Pearson Correlation		1.000	-.020	.634	.398
	Sig. (2-tailed)		.	.597	.000	.000
	N		672	672	672	672
RH (%)	Pearson Correlation			1.000	-.046	-.076
	Sig. (2-tailed)			.	.236	.049
	N			672	672	672
T (^{0}C)	Pearson Correlation				1.000	.720
	Sig. (2-tailed)				.	.000
	N				672	672
Eff (%)	Pearson Correlation					1.000
	Sig. (2-tailed)					.
	N					672

I - Solar irradiance
RH - Relative humidity
Eff - Efficiency of solar panel
WS - Wind speed
T - Air temperature

The results obtained here support the statement in (Durisch *et al.*, 2000), that the major factors found to cause variations in operational efficiency are ambient temperature and total irradiance intensity. As shown in Table 1, the efficiency is positively correlated with wind speed although the correlation is very weak. Relative humidity has no association with the efficiency at all.

Conclusion

Malaysia has abundant sunshine and thus solar irradiance. From the results, solar irradiance is the most influenced parameter on the performance of the solar cells. Based on the performance of polycrystalline solar cells in the Malaysian climate, the potential of using the solar energy as an alternative energy is great. In the future, the same experiment will be done but in the Southwest monsoon and this dry season expectantly gives better performance on the solar cells and the period of experiment should be extended to at least one year to verify the equation.

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