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Performance Comparison between Silicon Solar Panel and Dye-Sensitized Solar Panel in Malaysia

N.K. A. Hamed[1], M.K. Ahmad[1,a)], N.S.T. Urus[1], F. Mohamad[1], N. Nafarizal[1], N.Ahmad [1], C.F. Soon[1], A. S. Ameruddin[2], A.B. Faridah[2], M. Shimomura[3] and K. Murakami[3]

[1]Microelectronic and Nanotechnology – Shamsuddin Research Centre (MiNT-SRC) Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia
[2]Department of Science, Faculty of Science, Technology, and Human Development, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia
[3]Department of Engineering, Graduate School of Integrated Science and Technology, Shizuoka University, 432-8011 Hamamatsu, Shizuoka, Japan

[a)]Corresponding author: khairul@uthm.edu.my

Abstract. In carrying out experimental research in performance between silicon solar panel and dye-sensitive solar panel, we have been developing a device and a system. This system has been developed consisting of controllers, hardware and software. This system is capable to get most of the input sources. If only need to change the main circuit and coding for a different source input value. This device is able to get the ambient temperature, surface temperature, surrounding humidity, voltage with load, current with load, voltage without load and current without load and save the data into external memory. This device is able to withstand the heat and rain as it was fabricated in a waterproof box. This experiment was conducted to examine the performance of both the solar panels which are capable to maintain their stability and performance. A conclusion based on data populated, the distribution of data for dye-sensitized solar panel is much better than silicon solar panel as dye-sensitized solar panel is very sensitive to heat and not depend only on midday where is that is the maximum ambient temperature for both solar panel as silicon solar panel only can give maximum and high output only when midday.

INTRODUCTION

A solar cell is a device that converts photon energy into electrical current. In today's world, the mostly used solar cell is silicon based which is currently the most efficient one with approximately 25% of efficiency. Nevertheless, it also has weakneses. The weakness of this type of solar cell is the high production cost which makes it more costly than the source of energy from fossil. Moreover, the fabrication of this type of solar cell itself is difficult due to the need of advanced clean room technology. With the development of nanotechnology, apparently a breakthrough in solar cell technology can be achieved. One of this is the dye-sensitized solar cell (DSSC) technology. This cell is extremely promising because it is made of low-cost materials and can be constructed without any advanced process technology, hence being accessible by researcher from developing countries.

In DSSC type of solar cell, the light absorption and the separation of the electrical charges happens in different process. The light absorption process is performed by dye molecules, and the separation of the electrical charge is done by the nanocrystal inorganic semiconductor that has a wide band gap. Overall DSSC photon to current conversion efficiencies (IPCE) over 10% has been reached [1]. Recent developments in the area of sensitizers for DSSC have led to dyes which absorb across the visible spectrum leading to higher efficiencies. The recent development of an all solid-state heterojunction dye solar cell holds additional potential for further cost reduction and simplification of the manufacturing of dye solar cells [2].

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First, we will summarize the theoretical and experimental work done with high-intensity/high-temperature operation of photovoltaic devices since 1960. The first generation of silicon solar cells was gridless. The better performance of gridded cells was established in 1960 and such cells with various grid geometries were then fabricated by all manufacturers. Theoretical work on the improvement of cell performance showed that the internal series resistance constitutes a major loss factor. Wolf [3] assessed the magnitude of the series resistance (RJ) losses and developed equations for the optimization of grid width and spacing. Wysocki [4] showed that the series resistance can be reduced by using highly doped diffused skins, deep junction depths, and conduction grids. Lamorte [5] also developed expressions for the optimization of grid width and spacing. But, whereas Wolf optimized for minimum series resistance, Lamorte optimized for maximum power per unit cell area. However, Lamorte neglected the resistance of the grid lines and had to introduce certain simplifications in his analysis, making his results valid for special cases only. Experimental work at high light intensities lagged behind the theoretical work. Early high-intensity experiments on silicon solar cells [6].

EXPERIMENTAL

In preparing to achieve the performance between silicon and dye-sensitized solar panel, the silicon solar panel is one of the solar panel that is being studied. The size of the silicon solar panel is a 75cm x 45cm x 3.5cm. The panel is connected directly to the control box to get the output source. These panels mounted on poles as high as 5 feet. Panel faced westward as if faced to the east, there is a roof that blocks the sun rays. Voltage at maximum power is 18.3 volts and open circuit voltage is 22.3 volts. The estimated weight of the module is 8.7 kilograms.

The size of the dye-sensitized solar panel used is a 55cm x 35cm x 1.8cm. The panel is connected directly to the control box to get the output source. These panels mounted on poles as high as 5 feet. Panel faced westward as if faced to the east, there is a roof that blocks the sun rays. Voltage at maximum power is 4.2 volts and the open circuit voltage is 5 volts. The estimated weight of the module is 3.2 kilograms.

There are some components and controller that will be used to build the device apart from solar panel. Which are Arduino Mega 2560, current sensor (AC712), humidity and temperature sensor (DHT11), real time clock (DS1307RTC), temperature sensor (LM35), voltage divider circuit, SD card module, voltage regulator 7805, voltage divider circuit and power supply for controller(5V).

During device architecture phase, software and hardware will be designed and developed. In software development section, the circuit design and coding for the device will be discussed. All the components needed for the device will be recognized and discussed in details at hardware development section. Figure 1 shows the illustration of the project prototype. The design was drawn in order to help in getting better understanding and ideas on hardware development.

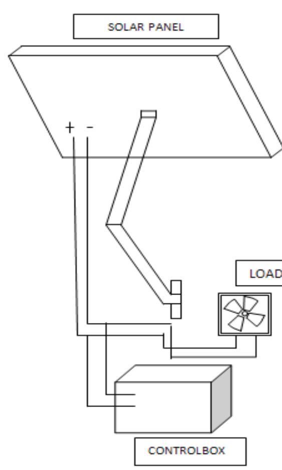


FIGURE 1. Project prototype model

RESULT AND DISCUSSION

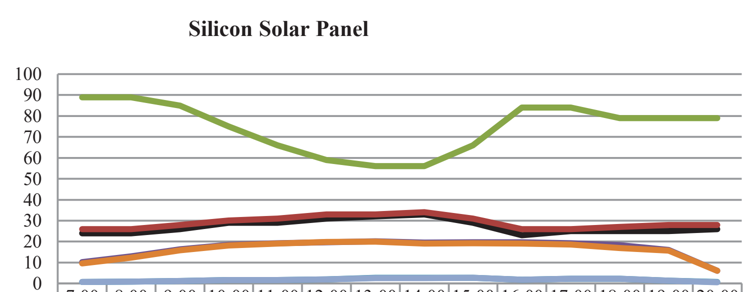
The results obtained and the analysis is performed on seven different characterization patterns which are ambient temperature, humidity, surface temperature, voltage without load, current without load, voltage with load, voltage without load. The performance of the device will be analyzed together in this chapter and the followed by interpretation data on effectiveness of silicon solar panel and dye-sensitized solar panel.

Duration for making these experiments for both the data is on a separate date. This is because the dye-sensitized used was borrowed from SPD laboratory from Japan and can be loaned for one semester only, after the period, dye-sensitized solar panel has been returned to the SPD laboratory. In addition, while conducting experiments on dye-sensitized solar panel, the weather conditions at the MiNT-SRC and throughout Malaysia were normal monsoon.

Silicon solar panel has been purchased and experiment with on the latter semester. Moreover, conducting experiments on silicon solar panel, weather conditions in MiNT-SRCand all over Malaysia has been undergone by haze. Both solar panel experiment was conducted at a time and date separately, therefore, there may be little discrepancy between the performance of both the solar panel.

The variation of the parameters that were used in studying the behavior of parameters and Silicon solar panels has been completed. Solar panels are placed in a relatively open space that is in MiNT-SRC, UTHM. To study the performance of this type of solar panel, some sensors have been placed around the solar panel to get a reading that is based on weather conditions and in accordance with real time clock. A spacious environment allows experiments to get the performance and potential efficiency can be assessed uniformly. Weather also plays a very important role to obtain accurate readings for these researches. During this study for the performance of silicon solar panel, the weather in Malaysia at that time was a haze and the temperature and humidity differences with the dye-sensitized solar panel can be obtained. The coding and circuits used for silicon solar panel also has the distinction of dye-sensitized solar panel based on the output voltage and current of a silicon solar panel. If the same circuits being used for this solar panel, it will cause damage to the device components.

Silicon solar panel is among the most common, solar panel that's being used in industry or residency. The Fig. 2 shows that all the parameters are quite parallel and evenly with each other. The performance has reached the maximum efficiency of silicon solar panel. For the ambient temperature, surface temperature and humidity respect to real time and is affected by the hazy conditions. For output voltage and current without load is balanced. Exactly output from the solar panel for voltage is 22 volts and the output we get is about between 18 volts to 20 volts depending on the weather and time. Output state for current is 3 amperes and we get the output around 2.9 ampere until 1 ampere.



	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Ambient Temp(°C)	24	24	26	29	29	31	32	33	29	23	25	25	25	26
Surface Temp(°C)	26	26	28	30	31	33	33	34	31	26	26	27	28	28
Humidity(%)	89	89	85	75	66	59	56	56	66	84	84	79	79	79
Voltage(V)	10.15	12.89	16.38	18.5	19.27	19.69	20.2	19.53	19.66	19.66	19.24	18.3	16	6.1
Current(A)	0.75	0.9	1.25	1.7	1.65	1.9	2.7	2.7	2.7	1.8	2.23	2.27	1.39	0.76
Voltage(V)with load	9.56	12.3	15.9	18.1	19	19.79	20	19.11	19.26	19.11	18.56	17	15.77	6
Current(A)with load	0.75	0.86	1.24	1.65	1.65	1.9	2.63	2.6	2.7	1.76	2.211	2.23	1.39	0.56

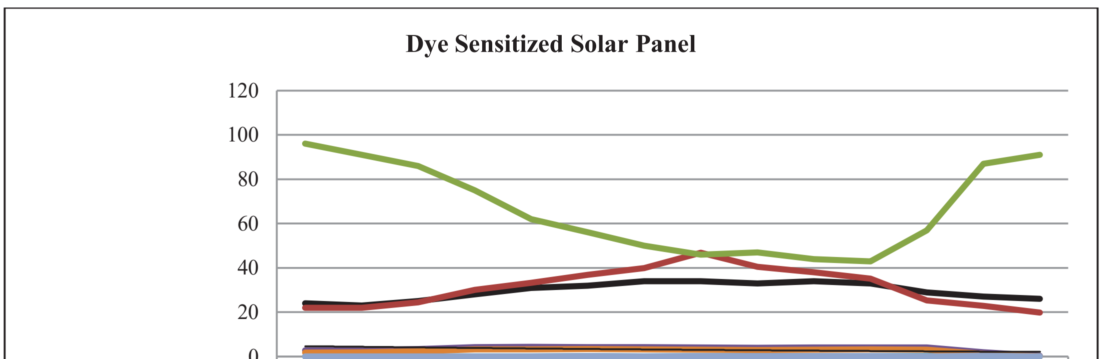
FIGURE 2. Performance Silicon solar panel at different parameter during haze

This shows that the situation around the solar panel does not significantly affect the output of the solar panel, unless there is rain or even no light from the sun. As we can see, the ambient temperature of the main controller device indicates a relatively high reading in the morning and evening. Similarly, the surface temperature on the surface of the silicon solar panel also shows relatively high temperature readings due to haze at that time. The high temperature can be obtained mainly in the afternoon. Humidity in the area has not reached up to> 90%. This clearly shows that the humidity in the morning and sunset are low compared to none during the haze situation. Humidity is very low at midday due to high temperature at that time. Voltage and current that we can take to show performance of this solar panel efficiency is good. But for the early morning, the efficiency of the silicon solar panel to find and process the source of light is a little slow compared to dye-sensitized solar panel. Nearly 21 Volt at noon and the last light of the sun at dusk, silicon solar panels still have a source to generate the output source. In other words, these silicon solar panels have a high efficiency, but quite damp at the start of the operation and can store solar energy much longer than dye-sensitized solar panel.

The variation of the parameters that were used in studying the behavior of parameters and dye-sensitized solar panels has been completed. Solar panels are placed in a relatively open space that is in MiNT-SRC, UTHM. To study the performance of this type of solar panel, some sensors have been placed around the solar panel to get a reading that is based on weather conditions and in accordance with real time clock. A spacious environment allows experiments to get the performance and potential efficiency can be assessed uniformly. Weather also plays a very important role to obtain accurate readings for these researches.

During this study for the performance of dye-sensitized solar panel, the weather in Malaysia at that time was a normal and the temperature and humidity differences with the silicon solar panel can be obtained. The coding and circuits used for dye-sensitized solar panel also has the distinction of silicon solar panel based on the output voltage and current of a dye-sensitized solar panel. For this solar panel, no additional external circuit as the output in terms of dye-sensitized solar panel is less than 5 volts. Our main controller input source is also 5 volts and will not damage other components.

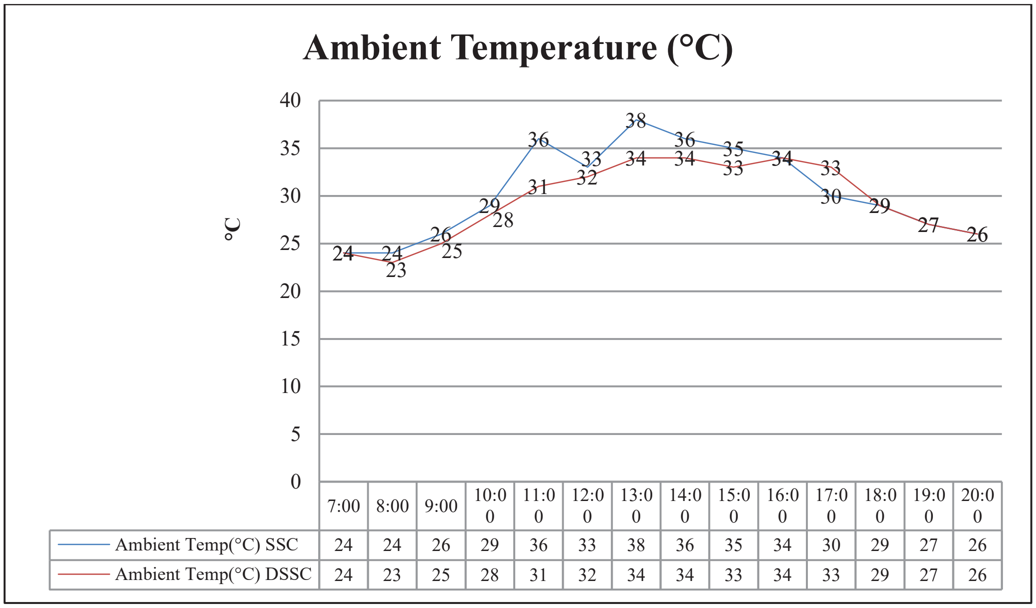
Dye-sensitized solar panel solar panel is developed to produce the output compared to silicon solar panel. The efficiency of dye-sensitized solar panel may be low compared with silicon solar panel. The variation of parameters was tested with a dye-sensitized solar panel which is the same with the silicon solar panel. In Fig. 3, we can see that the low percentage of humidity readings when the surface temperature is at a point of maximum temperature. Ambient temperature readings that clearly showed a relatively uniformly with surface temperature. Output voltage and currents for dye-sensitized solar panel are effectively when there is a heat from the environment. This means, in the morning, the sun has not yet appeared but dye-sensitized solar panel can produce a fairly robust output. Based on figure 4.2, the value reading of voltage and current in the morning is quite high. During the evening and night, dye-sensitized solar panel is unable to store energy in the solar panel itself and at midday, voltage and current can be quite high reading.



	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Ambient Temp(C)	24	23	25	28	31	32	34	34	33	34	33	29	27	26
Surface Temp(C)	22.01	22.08	24.44	30.08	33.2	36.81	39.89	46.83	40.45	38.07	35.13	25.3	22.82	19.89
Humidity(%)	96	91	86	75	62	56	50	46	47	44	43	57	87	91
Voltage(V)	2.75	2.89	3.46	4.26	4.33	4.31	4.26	4.16	3.99	4.17	4.17	4.13	1.98	0.4
Current(A)	0.1	0.11	0.11	0.12	0.12	0.185	0.1	0.18	0.17	0.19	0.18	0.18	0.36	0.04
Voltage(V)with load	1.87	1.9	2.43	3.25	3.3	3.32	3.2	3.1	2.89	3.09	3.19	3.07	1.21	0.1
Current(A)with load	0.1	0.11	0.11	0.12	0.12	0.185	0.1	0.18	0.17	0.19	0.178	0.12	0.32	0

FIGURE 3. Performance Dye-sensitized solar panel at different parameter during normal weather

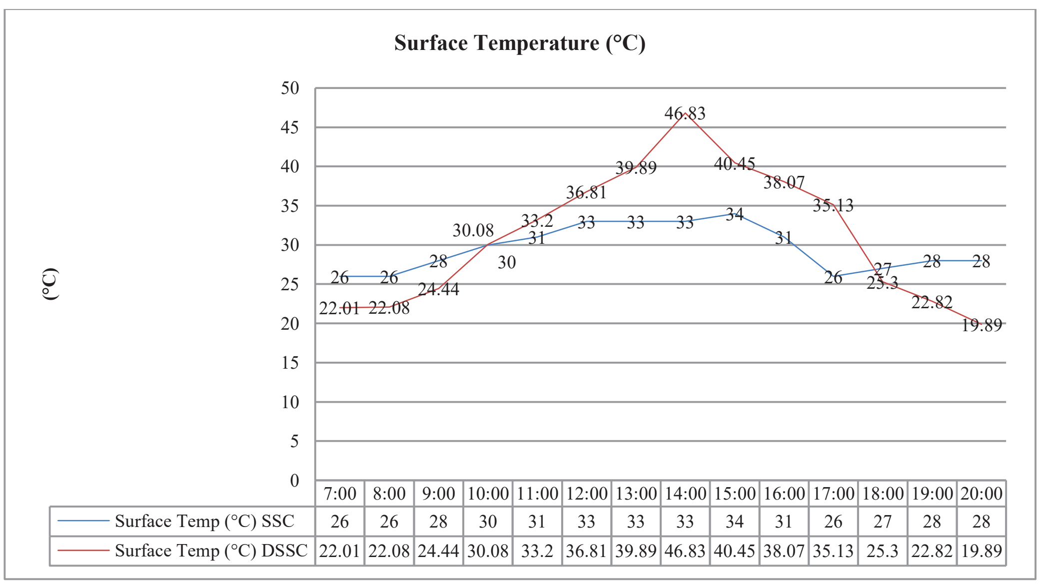
In Fig. 4, we can obtain that ambient temperature is one of the parameters that be observed by this research. The value of ambient temperature readings was obtained using the sensor DHT11. DHT11 is a sensor that can detect ambient temperature with immediate surroundings. DHT11 placed adjacent to the main controller to make sure that the main controller do not heat up so much as to affect their functionality or make the system practically unusable.



	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Ambient Temp(°C) SSC	24	24	26	29	36	33	38	36	35	34	30	29	27	26
Ambient Temp(°C) DSSC	24	23	25	28	31	32	34	34	33	34	33	29	27	26

FIGURE 4. Performance silicon solar panel and dye-sensitized solar panel at different reading of ambient temperature

Figure 5 shows the difference in reading ambient temperature value for silicon solar panel and dye-sensitized solar panel. This difference is clearly noticeable because during experiments conducted on silicon solar panel, the weather at MiNT-SRC and entire nationwide is in hazy condition. Therefore, it is extent affect the ambient temperature around the area. The result shows the readings for silicon solar panel is higher than dye-sensitized solar panel. Maximum readings we can obtain at midday for both the solar panel.

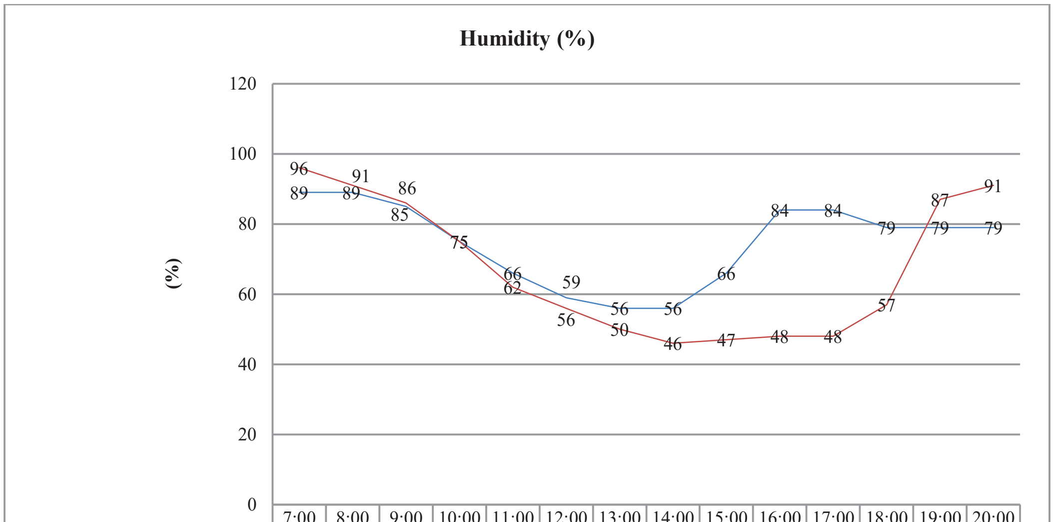


	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Surface Temp (°C) SSC	26	26	28	30	31	33	33	33	34	31	26	27	28	28
Surface Temp (°C) DSSC	22.01	22.08	24.44	30.08	33.2	36.81	39.89	46.83	40.45	38.07	35.13	25.3	22.82	19.89

FIGURE 5. Performance Silicon solar panel and Dye-sensitized solar panel at different reading of surface temperature

Temperature sensors used during this study are the LM35. LM35 is a precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. LM35 are placed above the surface of the solar panel to determine the real time temperature readings for solar panels. The difference between the silicon and dye-sensitized solar panel is, while carrying out experiments on silicon solar panel, the weather was hazy. Therefore, it has an impact on temperature readings at the surface of the solar panel. Wherein the temperature reading of silicon solar panel is lower than the reading of dye-sensitized solar panel. Because of the haze, sunlight cannot penetrate the layer of haze. Only the environmental temperature becomes higher when the haze. Maximum readings for both the solar panel is at midday. Errors also occur because LM35 low efficiency in terms of durability. This is because the solar panels are placed in areas that are not covered and are regularly exposed to sunlight and rain.

In Fig. 6, we can see the graph for humidity. A humidity sensor senses relative humidity. This means that it measures both air temperature and moisture. Relative humidity, expressed as a percentage, is the ratio of actual moisture in the air to the highest amount of moisture air can hold at that temperature. The warmer the water is, the more moisture it can hold, so relative humidity changes with fluctuations in temperature.



	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
Humidity(%) SSC	89	89	85	75	66	59	56	56	66	84	84	79	79	79
Humidity(%) DSSC	96	91	86	75	62	56	50	46	47	48	48	57	87	91

FIGURE 6. Performance Silicon solar panel and Dye-sensitized solar panel at different reading for humidity

Humidity readings in the early morning for both solar panel is quite high but the humidity readings for silicon solar panel it is relatively low compared dye-sensitized solar panel due to hazy conditions. At midday, the reading for both solar panel are low due to high temperature at that time. In the evening, graph showing that the readings for humidity is increased back because temperature surrounding is decreased. But the reading of silicon solar panel it is relatively low compared to dye-sensitized due to haze condition.

CONCLUSION

In this research study, dye-sensitized solar panel and silicon solar panel are used to obtain data for the purpose of reviewing the performance of both the solar panel. Arduino Mega 2560 was used as the main controller to obtain the measuring data of the dye -solar panel and silicon solar panel. Therefore, the performance of the dye-sensitized solar panel and silicon solar panel can be obtained by comparing the output between these two solar panels. From the results obtained in silicon solar panel analysis, the results can be concluded that reading range that suitable to obtain the best performance in silicon solar panel is between 29°C until 33°C for reading of ambient temperature, for surface temperature, the suitable data are from 33°C until 34 °C and humidity must maintain low in range of 56% until 66%. With this controlled variable, high performance result can be obtained in voltage without load, current without load, voltage with load and current with load. The maximum data of high performance can be found between 1:00pm until average 3:00pm.

For the result of dye-sensitized solar panel, the conclusion can be made as dye-sensitized solar panel can react effectively when there is heat source not only depending on sun or surface temperature. The data prove that reading of voltage and current fluctuate and quite high even in the morning as the panel reacts to heat.

A conclusion also can be concluded that in based on data populated on graphs, we can see the distribution of data for dye-sensitized solar panel is much better than silicon solar panel as dye-sensitized solar panel is very sensitive to heat and not depend only on midday where is that is the maximum ambient temperature for both solar panel as silicon solar panel only can give maximum and high output only when midday.

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