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Temperature Reduction to Enhancing Solar Panel Performance in Tropical Climate

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Abstract. The characteristics of climate in a region also influences the performance of solar panels, the characteristics are the intensity of solar irradiance, temperature, wind speed and humidity. An evaluation of the performance of solar panels needs to be done regarding the tropical climate in Indonesia. This evaluation is needed to determine how large the resulting energy production that will be used for the benefit of both technical and investment for Solar Power Plant. The purpose of this study was to examine the effect of wood powder composite board material in reducing the surface temperature of solar panels in order to increase the efficiency of energy conversion. The type of solar panel used is 50 Wp Polycrystalline. The results showed that the average of solar radiation is at 690 W/m^2 resulting in an average current value of 1.8 A (with board dampers) and 1.68 A (without the board damper). While the average temperature of a solar panel without a damper is 36.4 ^{o}C while the damping board drops to 34.6^{o}C. Consequently increasing the output voltage level from 20,38 V to 20,55 V, This change also results in an increase in output Solar panel power on average from 47,8 Wp (without damper board) to 48,2 Wp (with damper board), with a reduction in power losses from 2,3 Wp to 1,8 Wp.

Keywords: Solar Cell, Temperature Reduction, Composite Material, Energy Converstion

1. Introduction

The production of solar energy is carried out through the process of converting solar energy into electricity, in which it is very dependent on the climate or environmental parameters of a particular region. These parameters are the intensity of solar irradiance, temperature of solar panels, wind speed and humidity. Solar panel testing is mostly done in subtropical areas, so these results do not necessarily represent tropical conditions in general, including Indonesia. The tropical environment has distinctive characteristics namely [1] :

1. Having high temperatures ranging from 18-40ºC which can cause an increase in solar panel temperatures at 90ºC so it can reduce the performance of solar panels.
2. The high humidity level is 35-85% with low wind speeds ranging from 0.2 m/s.
3. Cloudy tendency and high rainfall. This condition causes the low brightness index which has an impact on the performance of solar panels.

Based on these characteristics, an evaluation of the performance of solar panels needs to be done to see how much energy production is produced because a typical tropical climate will cause deviations from the parameters of the Standard Test Condition (STC) [2].

The aim of this research was to see the effect of wood powder composite board material in reducing heat on the surface of the solar panel so it can increase the efficiency of solar panel energy conversion.

1.1 Solar Energy

The sun supplies energy to the earth in the form of radiation. Without irradiance from the sun, life on earth would not work. Every year there are about 3.9 x 1024 Joules ~ 1.08 x 1018 kWh of solar energy on the surface of the earth, this means the energy received by the earth from the sun is 10,000 times more than the global primary energy demand each year and more than the total available reserve of energy available on earth. The intensity of solar radiation outside the earth's atmosphere depends on the distance between the earth and the sun. Throughout the year, the distance between the sun and the earth varies between 1.47 x 108 km to 1.52 x 108 km. Consequently, irradiance E_0 fluctuated between 1,325 W / m^2 to 1412 W /m^2. The average value of this irradiance is called the solar constant. Solar constant $E_0 = 1367$ W / m^2 [3] .

1.2 Solar Cell Model Circuit

Modules of solar cells are generally made from silicon or gallium arsenide materials, and other building materials. The main part of the solar cell that is the pn junction or equivalent to the Schottky junction is needed for the influence of the solar cell on changes in light rays or solar irradiation.

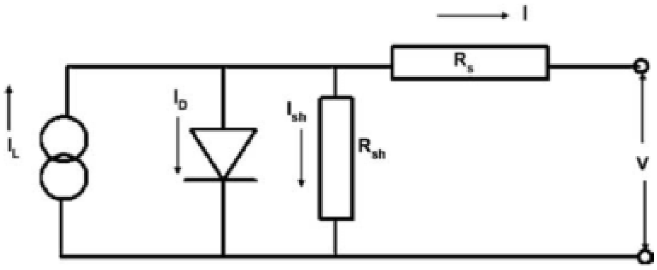

Figure 1. Equivalent Circuit [4]

From the image equivalent, solar cell circuit can be modelled using a block diagram on Simelectronic. The most important component influencing this simulation is the photovoltaic (PV) cell model. Modelling of solar cells includes obtaining the characteristic value curves of VI and VP according to simulations of actual environmental conditions. The approach to the representation of solar cell circuits is a diode. In simelectronic modelling, solar cell blocks have been provided which contain parameters such as Isc, Voc, solar irradiance and other input variables [5].

2. Methodology

2.1. Required Data

The data collection was carried out for 7 days starting from December 23, 2019 until December 29, 2019 with a time span of testing for 10 hours from 08.00 to 17.00 located in Ternate (0° 47'45.0 "N and 127° 22'22.7" E) . The data needed was in the form of environmental data that is solar irradiance, and temperature and electrical parameter data which are current, voltage and electrical power.

2.2. Composite Damper Board

In this research, reducing heat on solar panels was done by using a composite board made from sawdust. Wood dust was mixed with 70% by weight of PVAc in a plastic bath and stirred manually. The mixture was put into a mold with a size of 25 cm x 25 cm which was previously sprinkled with 15% by weight of PVAc. After the core has been sprinkled, then the top surface was re-sprinkled with 15% by weight of sawdust. After the mixture was printed, it was then placed between two aluminum plates. The mixture was pressed at a temperature of 1800ºC with a pressure of 25 kg / cm^2 for 20 minutes. After pressing, the resulting board was left for 30 minutes to make the sheet harden. The conditioning was carried out for one week to release residual stress and achieve water content distribution

Figure 2. The Final result of Composite Damper Board

Next, this damper board was used to reduce heat on the solar panel and during testing is placed on the solar panel as shown in Figure 3.

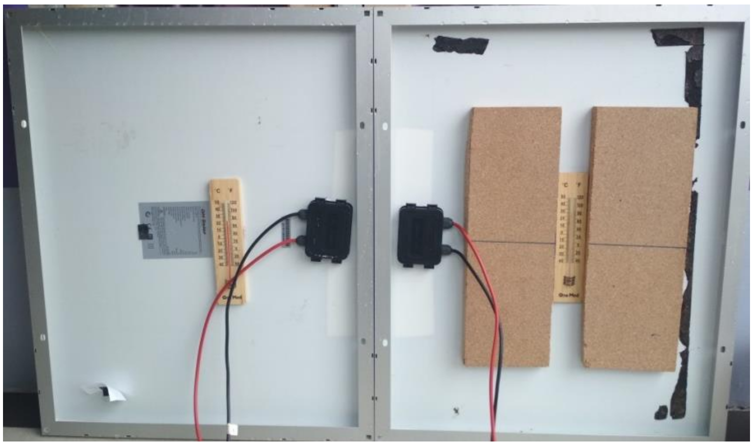

Figure 3. Composite damper board placement in solar panel

2.3. *Solar Panel Specification*

The solar panels used in testing are polycrystalline types with the following specifications:

Table 1. Solar Panel Specification

No	Specification	
1	Model	GH50P-18
2	Rated maximum power (P_m)	50 W
3	Voltage at Pmax (V_{mp})	17,5 V
4	Current at Pmax (I_{mp})	2,86 A
5	Open-Circuit Voltage (V_{oc})	21 V
6	Cuurent-Circuit Voltage (I_{sc})	3,09 A
7	Temperature	-40ºC to+85ºC
8	Coefisien temperature P_{max}	-0,41%

2.4. *Measurement Device*

Measurements done in this study were the *Pyranometer (Meteon)* gauge for solar irradiance measurements and the *EurotestPV* M1 3108 Metrel to measure environmental parameters namely solar temperature and irradiance as well as electrical parameters such as voltage, current and electric power. Besides, it was also used several manual thermometers, and digital and analog multi meters.

2.5. *Calculation Model*

Electric power is the amount derived from the value of voltage and current so that the value of the voltage and current generated is part of the electricity owned by solar cells. Before knowing what the value of the instantaneous power produced, it must be known the received power (input power), where the power is the multiplication of the intensity of the received solar radiation with the area of the PV module with equation persamaan [3] :

$$P_{in} = Ir\ A \tag{1}$$

Where,
P_{in} = Input power due to solar irradiation (Watts)
I_r = intensity of solar radiation (Watt / m^2)
A = Surface area of the photovoltaic module (m^2)

The electrical power provided by solar cells is:

$$Psel = Vsel \times Isel \tag{2}$$

The average solar panel output is:

$$\frac{\sum P_{o\ D1-D7}}{n} \tag{3}$$

with,
$\sum P_{o\ D1-D7}$ = power output PV days 1 - day 7
n = number of Days

Maximum output efficiency (η) is defined as the percentage of optimum output power to the light energy used, which is written as:

$$\eta = P_{out}/P_{in} \times 100\% \tag{4}$$

In addition to efficiency, fillfactor (FF) is another characteristic in which the value of the ratio of voltage and current in the state of maximum power and open circuit voltage (Voc) and shortcircuit current (Isc). The ideal fill factor price is 0.7 to 0.85.

FF = (Vmpp x Impp)/(Voc x Isc) (5)

Pout = Voc x Isc x FF (6)

The equation of power losses as follows [6]:

$T_S = T_{RT} - T_D$ (7)
$P_{losses} \% = T_S \times T_{cpm}$ (8)
$P_{losses} = P_{losses} \% \times P_m$ (9)
$P_{out} = P_m - P_{losses}$ (10)

3. Result and Discussion

3.1. Correlation of Irradiance and Current

Figure (4) shows that the tendency of increasing solar irradiance also influences the changes in current on both solar panels with and without damping boards. This curve shows that with the same amount of solar radiation, a solar panel with a temperature damping board has a higher current value than a solar panel without a temperature damping board. Average of the highest solar irradiance of 530 W / m^2 generates a current value by an average of 1.43 A (with board dampers) and 1.3 A (without the board damper).

The tendency of an increase in current caused by an increase in solar irradiance was also shown in previous studies [3]. This is consistent with the theory as illustrated in the IV curve (Figure 5) that a current short circuit (Isc) depends linearly on irradiation, an increase in irradiation at various levels contributed directly to the increase in the current [7].

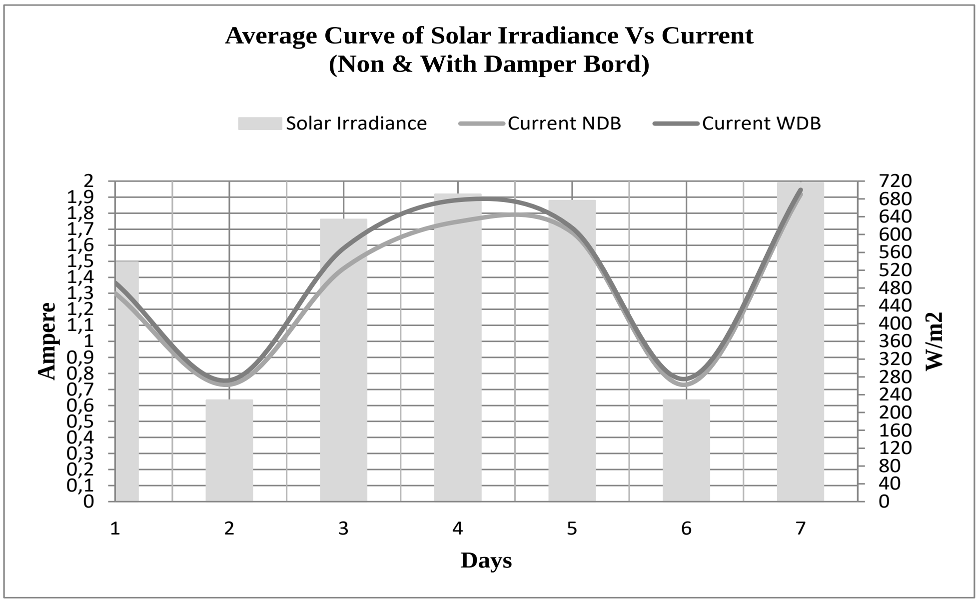

Figure 4. Correlation Curve of Irradiance and Current

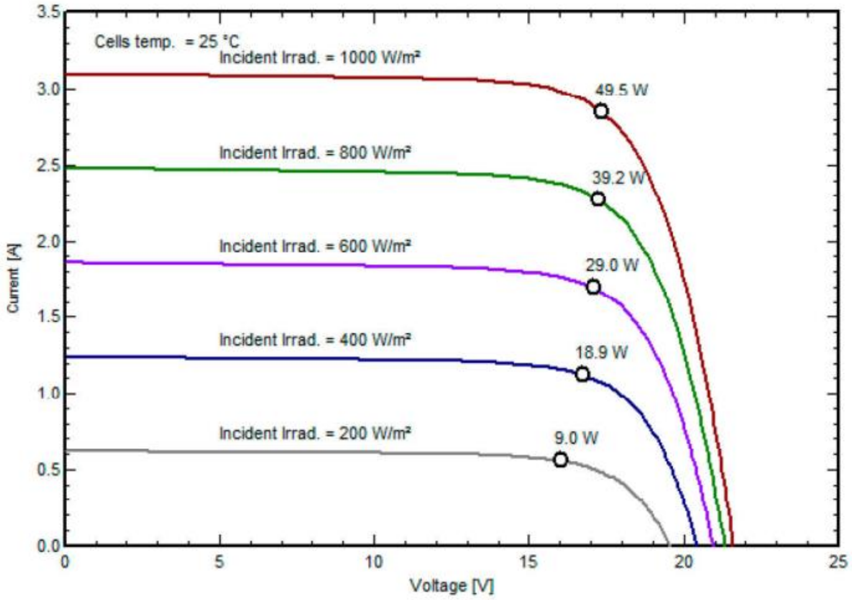

Figure 5. I-V Curves for varying irradiance [8]

3.2. Correlation of Temperature to Voltage

These results indicate that temperature's changes directly affected the voltage produced by the solar panels, as shown in Figure 6. From the graph, it is seen that the solar panel with a silencer boards had the ability in absorption compared to the solar panel temperature without dampening boards. The average temperature of the solar panel without a cushion was 36.4^{o}C with silencer board on the solar panel temperature had fallen to 34.6^{o}C. This directly increased the output voltage levels of 20.38 V to 20.55 V.

This is consistent with the characteristics of solar panels on curve I-V that changes in temperature with constant irradiance cause a decrease or an increase in the level of open-circuit voltage (Voc) [9], as shown in Figure 7.

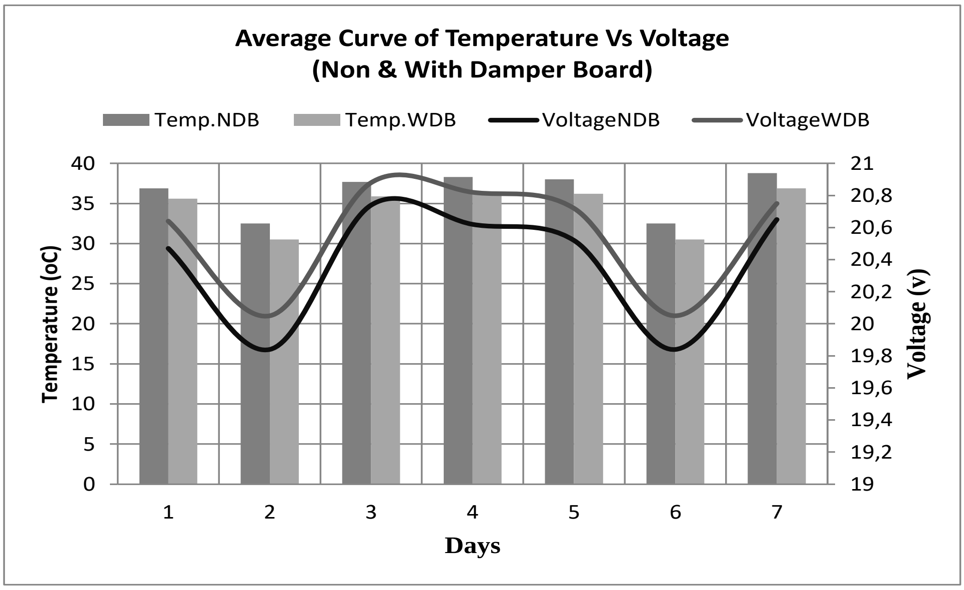

Figure 6. Correlation Curve of Temperature and Voltage

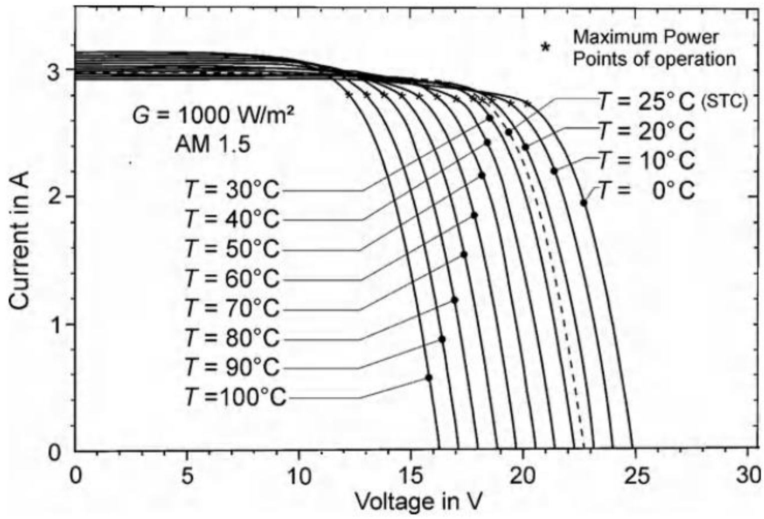

Figure 7. I-V Curve at different level temperature [9]

3.3. Losses Power and Output Power

The performance of solar panels is greatly influenced by temperature factors. If the temperature is higher than the standard temperature (STC) which is 25^{o}C, then this solar panel will experience a loss in maximum output power [6], as the purpose of this study is to reduce solar panel heat by using a damping board. Based on this study, solar panel with board reducer has a lower temperature which can reduce the losses compared to solar panels without temperature damper. The test results can be seen in Figure 8. In this graph, it shows that the temperature's average was 35.6^{o}C then the losses generated by the solar panels without damper was 2.3 Wp, while solar panels with a dampening board was lower which was equal to 1.8 Wp. Reduction of losses due to a decrease in the temperature of the solar panel is reduced by the damping board, directly increases the power output of the solar panel. Figure 9 shows that a solar panel with a damping board is able to increase solar panel output on average from 47.8 Wp (without a damping board) to 48.2 Wp.

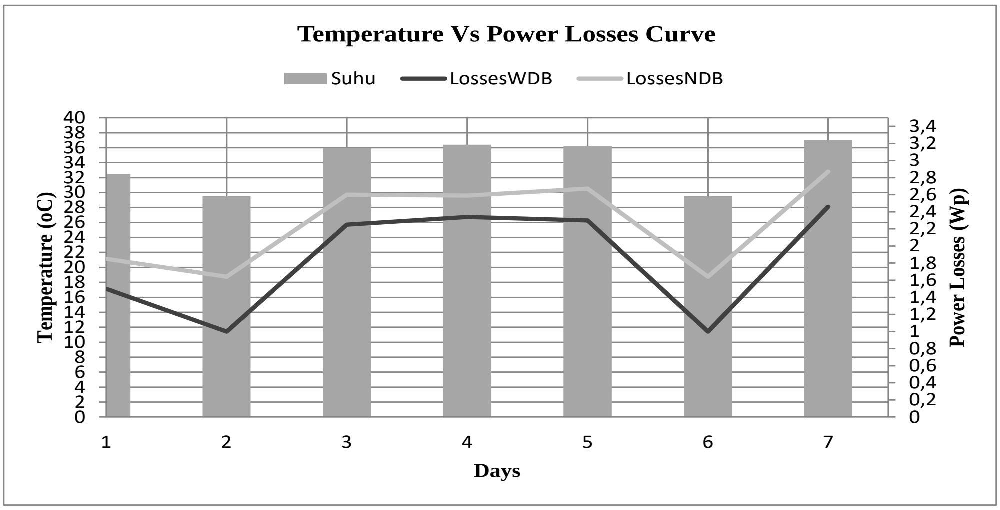

Figure 8. Losses Power Curve

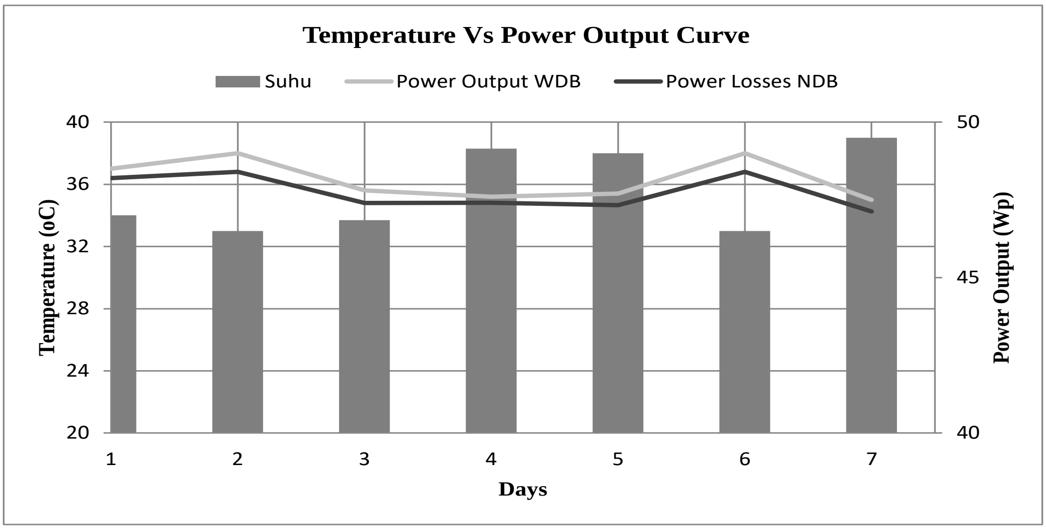

Figure 9. Output Power Curve

4. Conclusion

The use of composite damping boards to reduce temperatures can improve solar panel performance. The average solar radiation of 690 W/m^2 resulted in an average current value of 1.8 A (with board damper) and 1.68 A (without board damper). Meanwhile, the average temperature of the solar panels without damper reached 36.4^{o}C while with damper board fell to 34.6^o C. Consequently, there was an increase in the level of output voltage on the solar panels of 20.38 V to 20.55 V. This change resulted in an increase in average power output from 47.8 Wp (without damping boards) to 48.2 Wp (with damping boards), with a reduction in losses power from 2.3 Wp to 1.8 Wp. This result was confirmed by the I-V characteristic curve approach either for constant temperature and constant irradiation

5. References

[1] S. Petrana, E. A. Setiawan, and A. Januardi, "Solar panel performance analysis under indonesian tropic climate using sandia PV array performance model and five parameter performance model," vol. 02048, pp. 1–11, 2018.

[2] O. O. Ogbomo, E. H. Amalu, N. N. Ekere, and P. O. Olagbegi, "A review of photovoltaic module technologies for increased performance in tropical climate," *Renew. Sustain. Energy Rev.*, vol. 75, pp. 1225–1238, 2017.

[3] Muchammad dan Eflita Yohana, "Pengaruh Suhu Permukaan Photovoltaic Modul 50 Watt Peak Terhadap Daya Keluaran yang Dihasilkan Menggunakan Reflektor," *Rotasi*, vol. 12, pp. 14–18, 2010.

[4] W. De Soto, S. A. Klein, and W. A. Beckman, "Improvement and validation of a model for photovoltaic array performance," vol. 80, pp. 78–88, 2005.

[5] S. Yuliananda, G. Sarya, F. Teknik, and F. Teknik, "Pengaruh perubahan intensitas matahari terhadap daya keluaran panel surya," vol. 01, no. 02, pp. 193–202, 2015.

[6] Sinovoltaics, "Measuring the temperature coefficient of a PV module," 2016. .

[7] The German Energy Society (Deutsche Gesellschaft Für Sonnenenergie (Dgs)), *Planning & Installing Photovoltaic Systems*, 2nd Editio. 2012.

[8] David A. Quansah et al, "I-V Curves for varying irradiance and constant temperature," p. 2984, 2017.

[9] S. C. W. Krauter, *Solar Electric Power Generation*. .