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Performance Photovoltaic for Various Slope (Laboratory Scale)

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ABSTRACT
The purpose of this research is to observe the performance of photovoltaic and observe the current and maximum temperature of photovoltaic. While the other purpose is to calculate the power and the efficiency that produced by photovoltaic with PV slope angle variation of 30°, 35° and 40°. This research is performed by carrying out an experiment on photovoltaic. The trial process is as follows: PV module is heated until a certain time, then the surface temperature, wind speed, current and voltages are measured. PV cell and environment temperatures are measured by a digital anemometer. From this research, a conclusion can be taken that as a whole, slope angle of 30° has higher voltage comparing to the other angle. Whilst for the current, with photovoltaic slope angle of 30°, it is higher comparing to the other slope. Furthermore, when an angle variation is combined, it will be seen, as a whole that the slope angle of 30° has greater temperature distribution comparing to other slope angles. In addition to that, the greatest power is at the slope of the photovoltaic 30^0 when compared to the other angle.

***Keyword*:** Performance, Photovoltaic, Laboratory Scale.

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I. INTRODUCTION

The need for ever-increasing energy will further force people to seek alternative energy sources. Developed countries are vying to make new breakthroughs in searching, exploring and creating new technologies that can replace fossil energy and seek new energy sources.

In the search for new energy sources, it is best to meet the requirements that generate large amounts of energy, economic costs and no negative impact on the environment. Therefore, the search is directed to the utilization of solar energy by using solar cell panels /photovoltaic, which can convert solar energy into electrical energy. Solar cell / photovoltaic is a panel consisting, and several solar cells are connected in series. Solar cells have the function of converting sunlight into electrical energy. Solar cells are generally made of silicon, which is a semiconductor material. The use of solar cell has been widely used in developed countries where the utilization is not only on a small scope but has been widely used for industrial purposes. The existence of solar- energy sources is very abundant, so the application of photovoltaic(PV) technology can meet the needs of electrical energy in areas that have not reached electricity. This PV is quite potential to be developed.

The performance of the solar cell module is directly related to the parameters of the solar cell (e.g. temperature on the cell, efficiency of conversion energy and maximum power point tracking). Solar parameters change, it will affect the efficiency of a solar module [1].

In addition, the most important parameters of the solar cell that describe the operating conditions are irradiation and temperature. The designer of the solar cell assesses the device by evaluating the efficiency under standard test conditions (STC: Illumination at 1000 W / m2, temperature at 25^0C and reference spectrum AM1.5) [2]. However, this condition practically never occurred during normal operating conditions in the outdoor as it does not take into account the geographical conditions and actual meteorological conditions of the installation site.

In this paper, we discuss the effects of temperature variation, ambient velocity of air, variation of photovoltaic angle and radiation on geographical conditions and meteorological conditions affecting photovoltaic performance. This will be explained further.

II. THEORY

A. Operating factors of photovoltaic

In this study, consider the factors that influence the operation of photovoltaic. Operating factors of photovoltaic (PV) are highly dependent on:

1) Ambient air temperature

A photovoltaic can operate at maximum if the cell temperature remains normal (at 25 degrees Celsius), an increase in ambient temperature higher than normal temperature in the cell PV will weaken the voltage (Voc).

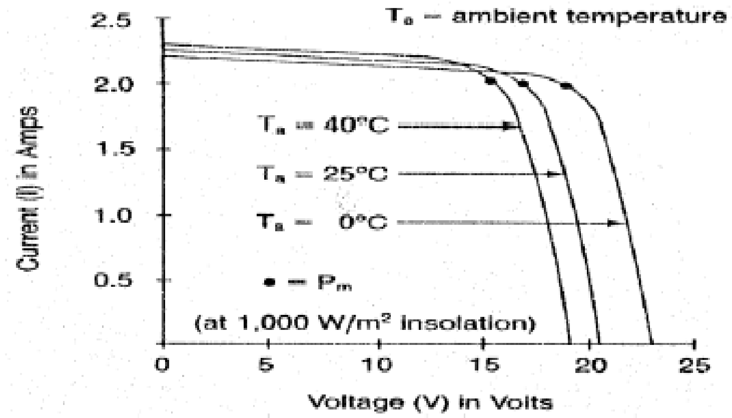

Figure 1. Effect of ambient temperature on voltage [3]

2) Solar radiation

Solar radiation on earth for various locations is highly dependent upon the state of the solar spectrum to the earth. Insulation (Incoming Solar Radiation) will have much effect on the electric current (I) and little effect on voltage.

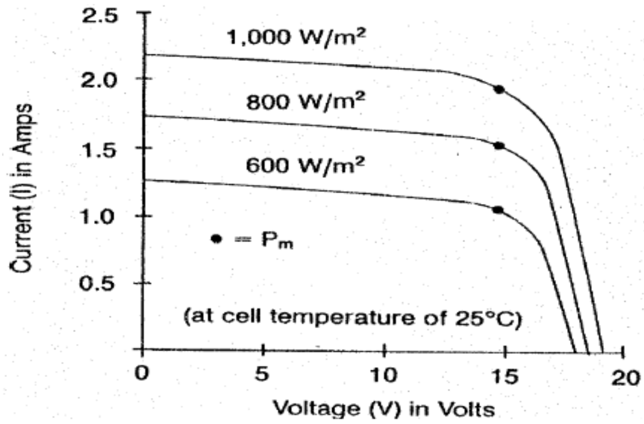

Figure 2. Effect of insulation intensity to current [3]

3) Wind speed

Wind speed around the PV array location, can help cool the surface temperature of PV glass arrays.

4) The circumstances of the earth's atmosphere

The circumstances of the earth's atmosphere such as cloudy, the type of dust particles, smoke, air vapor (RH), fog and pollution greatly determine the maximum amount of electric current from the PV array.

5) Orientation of solar panels/PV array

The orientation of a PV array to the optimum sun's direction is essential in order that the panel can produce maximum energy. In addition to the orientation direction, the angle of orientation of the solar panel also greatly affects the maximum energy yield.

6) The position of the solar cell to the sun (tilt angle)

Tilt Angle in this case is the angle to keep sunlight falling upon a solar panel surface perpendicularly (will get maximum energy ± 1000 W/m2 or 1 kW/m2).

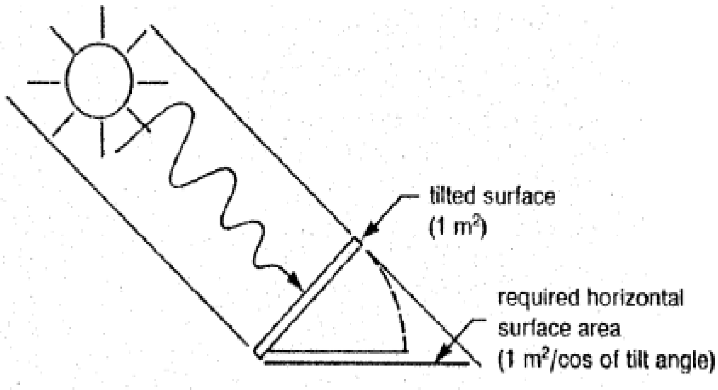

Figure 3. Extra area on the PV panel in a flat position when the light comes perpendicular to the panel [3]

7) Power and Efficiency of Photovoltaic (PV)

By definition, the conversion efficiency of PV is expressed through the ratio between the output energy produced (electrical energy) to the solar energy up to the Photovoltaic surface, so that the maximum energy efficiency is expressed as:

$$\eta = \frac{V_{oc} \, x I_{sc} x FF}{A x S_r} = \frac{P_{out}}{P_{in}} x \; 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where: Voc (V) is the open-circuit voltage, Isc is the short circuit current (A), FF is the Fill Factor present on the photovoltaic surface, Sr is the global radiation from the sun (W/m^2), and A is the surface area of the Photovoltaic module (m^2).

The received power (input power) is using the equation:

$$P_{in} = S_r x \, A \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where: Pin is Input Power due to solar irradiance (Watt), Sr is the intensity of solar radiation (Watt / m²), and A is the surface area of the photovoltaic module (m²).

For power output / power on photovoltaic (Pout) can be calculated by the following formula:

$$P_{out} = V_{oc} \; x \; I_{sc} \; x \; FF \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Pout is power generated by photovoltaic (Watt), Voc is open circuit voltage on photovoltaic (Volt), Isc is short circuit current in photovoltaic (Ampere) and FF is Fill Factor.

The value of FF is obtained from the formula:

$$FF = \frac{Voc - \ln(Voc + 0{,}72)}{Voc + 1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

III. METHOD

A. Time and Place of Data Retrieval

The purpose of this research is to know a photovoltaic can operate maximally. Therefore, data collection includes voltage (V), electric current (I), temperature (T), wind speed (V∞), power (P), and efficiency (η). The research was conducted in the futsal field located at Institut Teknologi Adhi Tama Surabaya-Indonesia starting from in the morning (09.00) until the afternoon (15.00).

Coordinates: Latitude: -7.2908168055769 and Longitude: 112.77935853058

B. Measurements and Materials Used During Data Retrieval

The equipment and materials used are as follows: Photovoltaic 15 WP, LED Lights, Multimeter, Thermometer, Anemometer, Support and angle change of photovoltaic.

C. Data Collection Procedures

Data collection procedure: Placing photovoltaic and measuring equipment in the field of Institut Teknologi Adhi Tama Surabaya-Indonesia in accordance with the optimal position. Collecting data V, I, Ts, T∞, V∞ starting from 09.00 to 15.00 WIB, The next step analyze the data.

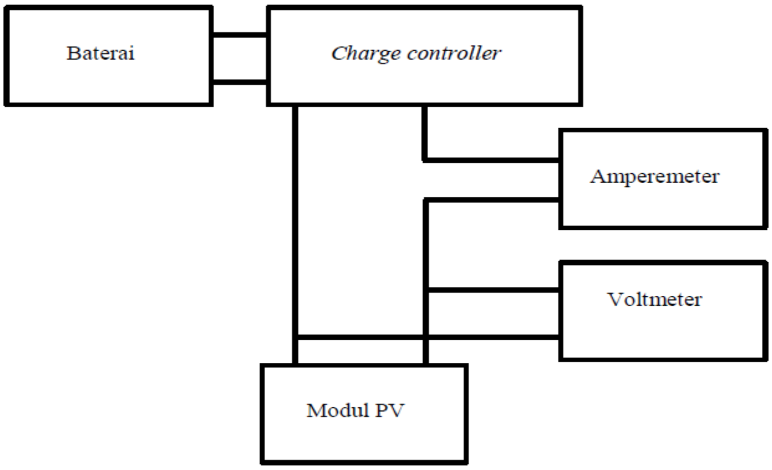

Figure 4. Layout of data retrieval

IV. RESULT & DISCUSSIONS

A. The Relationship Between Surface Temperature Versus Time for Different Photovoltaic Slope

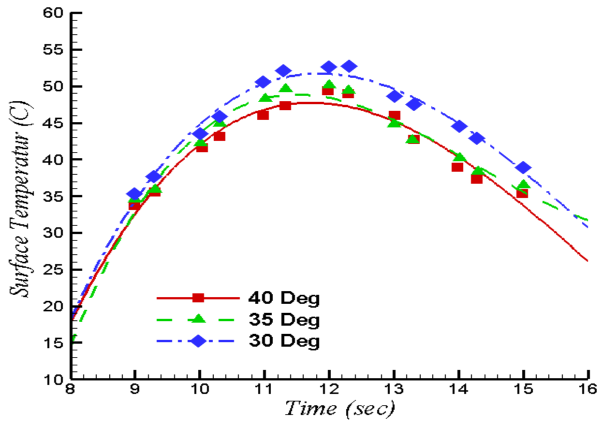

Figure 5. Effect of surface temperature of the module on time for variation of photovoltaic slope

Figure 5 shows the relationship between photovoltaic surface temperature and time. In general, it can be seen that at 09.00 to 12.00 the temperature rises while at 12:00 to 15:00 the temperature is decreasing. When looking at the effect of the slope angle of PV, then overall that the slope angle 30^0 has a larger temperature distribution than the other angle. The results of this study have the same trend in general with research conducted by [4].

B. The relationship between wind speed versus time for different photovoltaic slope

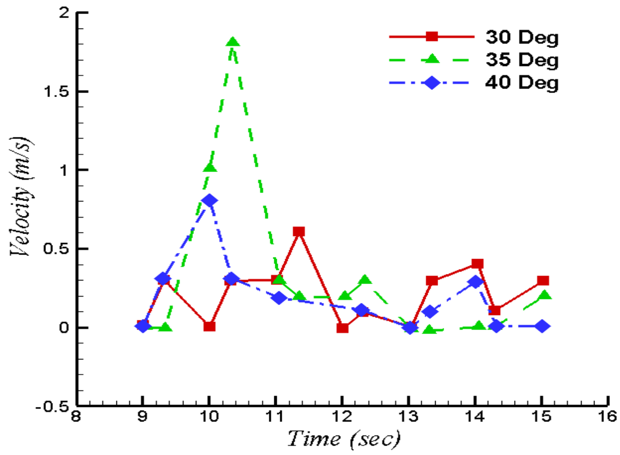

Figure 6. Effect of wind speed on time for various angles of photovoltaic slope

Figure 6 is the relationship between wind speed and observation time. It appears that the wind speed that occurs during the day is fluctuating. The same phenomenon also obtained by previous researchers namely [5] and [6].

C. The relationship between power over time for various angles of photovoltaic slope

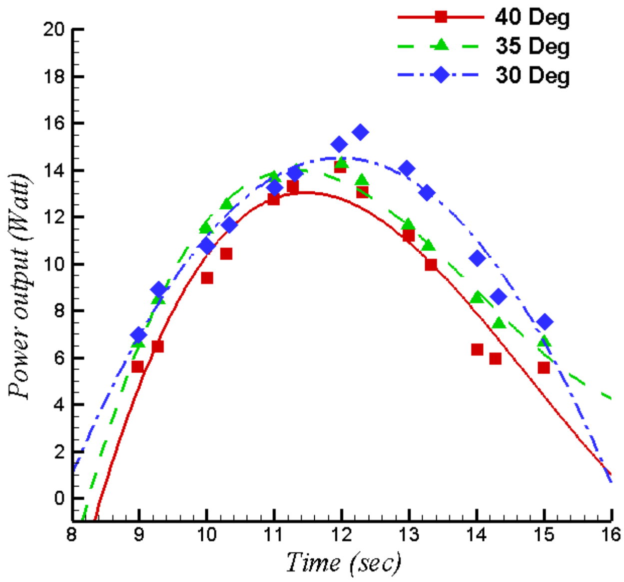

Figure 7. Effect of power on time for various angles of photovoltaic slope

Figure 7 is a graph of the relationship between power and time of observation. Generally, it is seen that the power has increased from 09.00 to 12.30 and the power has decreased from 12.30 to 15.00. When viewed from the side of various angles of the photovoltaic slope, the greatest power is the power at the angle of the photovoltaic 30^0 when compared to the other angle.

D. The relationship between the efficiency against time for various angles of the photovoltaic slope

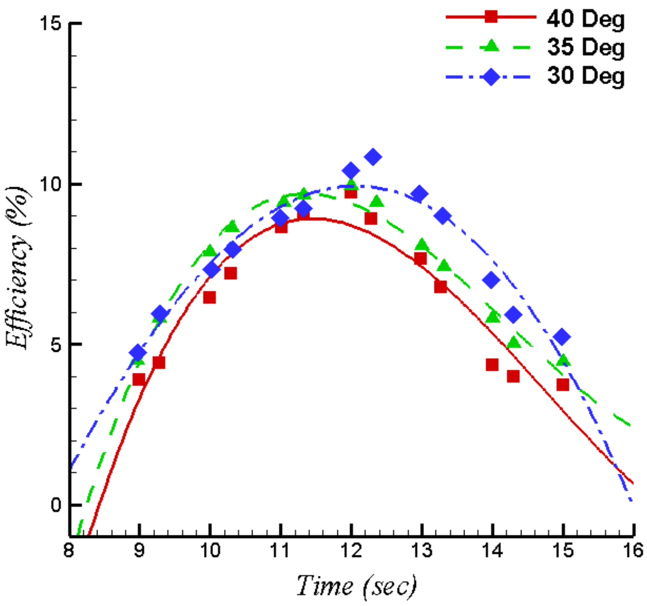

Figure 8. Effect of efficiency on time for various angles of photovoltaic slope

The above figure is Figure 8 which is a graph of the relationship between the efficiency, on, time for different angles of photovoltaic slope. In general there is an increase in efficiency starting at 9:00 to 12:00 and then decreased at 12:30 to 15:00. If the efficiency of the various slope angles is combined, then it appears that the highest efficiency is at 30^0 slopes.

V. CONCLUSIONS

From all the results of experiments and data retrieval, it can be obtained some conclusions as follows:

1. The relationships between the surface temperature of the photovoltaic to the time of measurement are generally it can be seen that at 09.00 to 12.00 the temperature rises while at 12:00 to 15:00 the temperature is decreasing. Overall, the slope angle 300 has a larger temperature distribution than the others.
2. The relationships between the ambient wind speed and the observation time are it is seen that the wind speed that occurs during the day is always fluctuating. The same phenomenon is also shown by other researchers.
3. The greatest power is at the slope of the photovoltaic 30^0 when compared to the other angle.
4. If efficiency is seen from various angles, it is seen that the highest efficiency is at 30^0 slopes.

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