

Experimental study on the performance of solar collector at angle 0° and 5° at Medan city.

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Abstract. Utilization of photovoltaic has been widely used in order to reduce dependency on unrenueable natural resources. In order to maximize solar radiation as down to earth surface, the use of photovoltaic needs to be varied. These varied Photovoltaics are to measure each of the efficiency of the work performance and charging rate stored into batteries. Typical Photovoltaic that is used in this measurement is 3 Photovoltaics with 50 Watt Peak in variation angle of 0° , 5° , Solar Tracker based Real-Time Clock. The efficiency of work performance of each varied angle 0° , 5° , Solar Tracker are 13.21 %, 14.1 %, dan 15,26 %, meanwhile the results of charging rate of each batteries within 6 hours conduct 17,42%, 21,71%, 25,14 %. Work performance can be improved further with varies Solar Tracker base LDR sensor to be more accurate.

1. Introduction

As we know, sun is a major source of inexhaustible energy (i.e solar energy) for the planet earth, currently new technologies are employed to geneerate electricity from harvested solar energy. These improvements have been widely throughout the world as renewable alternatives to conventional non-hydro technologies. Nearly four million exajoules ($1 \text{ EJ} = 10^{18}$) of solar energy reaches the earth annually, ca. 5×10^{18} EJ of which is claimed to be easily harvestable. Therefore the purpose of this paper is to maximilise the use of Photovoltaic by comparing the performance and the charging rate using Solar Charge Controller. [1], [2]

The maximum output energy from Photovoltaic cell can be obtained when the surface of Photovoltaic is directly perpendicular to the sun's rays, this sun's rays produces photons. Photons are partucle of light. The fact that we can also describe light as an electromagnetic wave is no way contradictory [3,4]. Adjusting tilt angle is important for maximizing the output power. The optimum tilt angle vaires with the latitde and depends on the climate conditions [5] maximum Photovoltaic output power with a tile angle varies from season to another [6] specific optimum tilt angle for Photovoltaic should have a specific tilt anglefor each city (i.e Medan city) has the latitude of $3,43^\circ \text{LU}$ and $98,44^\circ \text{BT}$, in this correlation the tilt angle that adjusted is 5° based on latitde of the region.

Performance of Photovoltaic can be enhanced based methods tilt angle and depends on types of the microstructure. Types of microstrcture conduct different amount of efficiency [7], on the other hand, assembling Photovoltaic to Solar Charge Controller has its role to connect Photovoltaic to battery bank and it controls the over-charging and discharging battery to enhances the life time of battery [8] the integrated PV-battery system approach is still in the



early research and development stage. Reports to date focus on the feasibility of innovative development and new device designs, and should continue in that direction, designs that incorporate high-capacity, efficient, and stable materials could be emphasized in coming days [9].

Recently, our laboratory is developing optimum design for solar collector that suitable for Indonesia climate. Several related studies have been reported in literature [10 – 24]. One of the important parameters for solar collector is tilt angle. The objective of this study is to explore the effect of tilt angle of a solar collector. The solar collector will be tested by exposing to solar irradiation in Medan city of Indonesia. The results are expected to provide the necessary information for development high performance solar collector that suitable for Indonesia climate.

2. Methods

The experiments are divided into two methods. The first solar collector without applying solar charge controller. Here, the solar collector is fixed and the performance is measured directly. The experimental set-up of the first method is shown in Figure 1.

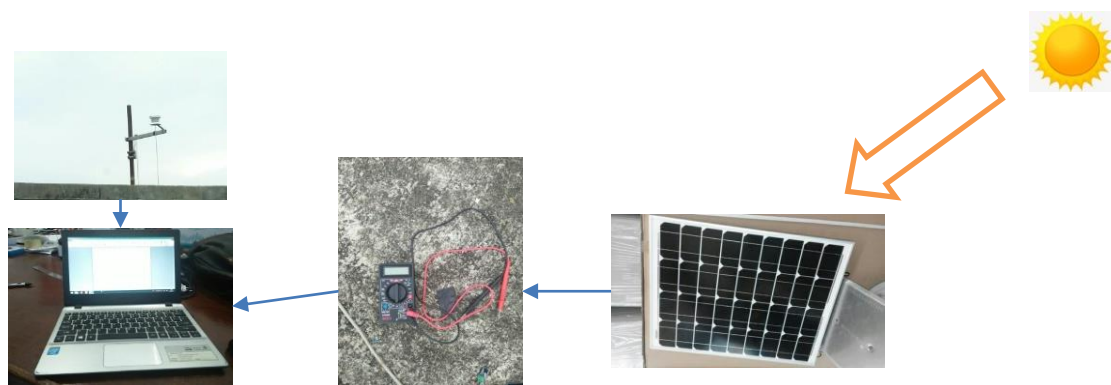


Figure 1. Experimental set-up for the first method

The second method, the solar collector is installed with controller. Figure 2 shows the experimental set-up of the second method. In this method, the solar PV is employed to charge the battery.

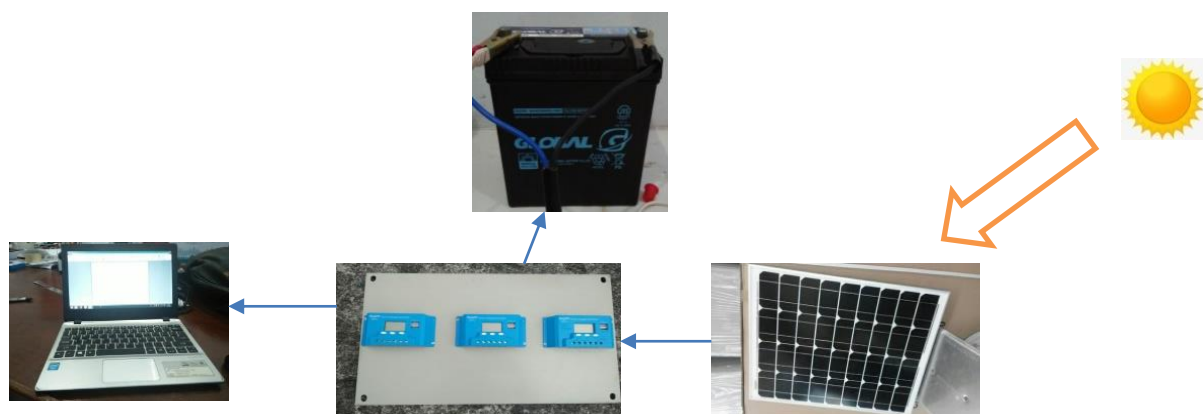


Figure 2. Experimental set-up for the first method

The purpose of this set-up is to measure the efficiency of each Photovoltaics, as a multimeter is unable to measure the current and voltage of photovoltaic when connecting the PV into solar charge controller due to high current of solar charge controller is above 10 A. This set-up exploits solar radiation spread into PV surface to conduct electricity, Hobo Data logger was prepared to measure the amount of solar radiation. The generated outputs are inserted into PC. Efficiency of PV is countable in the following:

$$\eta = \frac{V \times I \times FF}{G \times A} \times 100\% \quad (1)$$

Where V is the potential electricity that PV generated in Volt (V), I is the current that PV generated in Ampere (A), FF is Fill Factor, G is solar radiation in Watt per square meters (W/m^2) and A is surface area of the PV in square meters (m^2).

Fill Factor is an equation relating to open-circuit potential of PV during measurement, Fill Factor formula can be obtained in the following:

$$FF = \frac{V_{oc} - \ln(V_{oc} + 0.72)}{(V_{oc} + 1)} \quad (2)$$

In the above equation, V_{oc} is open circuit potential electricity conducted in PV in volt (V) and FF is Fill Factor.

The second set-up is mainly to measure the charging rate of each PV produced to battery, multimeter is no longer necessary because solar charge controller indicates the level charging of the battery. This indicator has a maximum level charge of 13.7 V meanwhile the legible minimum scale is 10.2 V. This interpretation generates formula of charging rate as follows.

$$\text{Charging rate} = \frac{V_{final} - V_{start}}{V_{max} - V_{min}} \times 100\% \quad (3)$$

3. Results and Discussions

The experiments have been carried out during May 2018. Figure 3 and Figure 4 indicate the diagram of PV efficiency and charging rate of the battery. Figure 3 experiment summarizes the efficiency of PV lasted for 10 days with 30 minutes interval measurement. On the other hand, the measurement data of charging rate was actually lasted for 2 days. The data displayed on Figure 4 is at the second day of experiment due to lack of solar radiation from first day experiment. The classification of each effects are displayed in the followings.



Figure 3. PV Efficiency

3.1. Efficiency of the Photovoltaic

Figure 3 shows the results of measurement which lasted for 10 days. The lowest amount efficiency of 0° Photovoltaic is 12.03% meanwhile the highest rate calculated is 14.34 %, and resulting average amount 13.21% . On the other side, the lowest amount efficiency of 5° Photovoltaic is 13.07% and the highest rate calculated is 15.13 % and resulting average amount 14.1 %.

3.2. Charging rate

Figure 4 shows the level charge of the battery lasted from 10 AM until 4 PM. The horizontal axis shows the time and vertical axis shows the voltage. The initiate charge level for 0° was 12.12 V and final charge was 12.73 which generated increasement of 0.61 V level charge and 17.42 % increasement in percentage. On the other hand, the charge level for 5° was 12.24 V and listed final charge was 13 V which resulting increasement of 0.76 V level charge and 21.71 % as percentage.

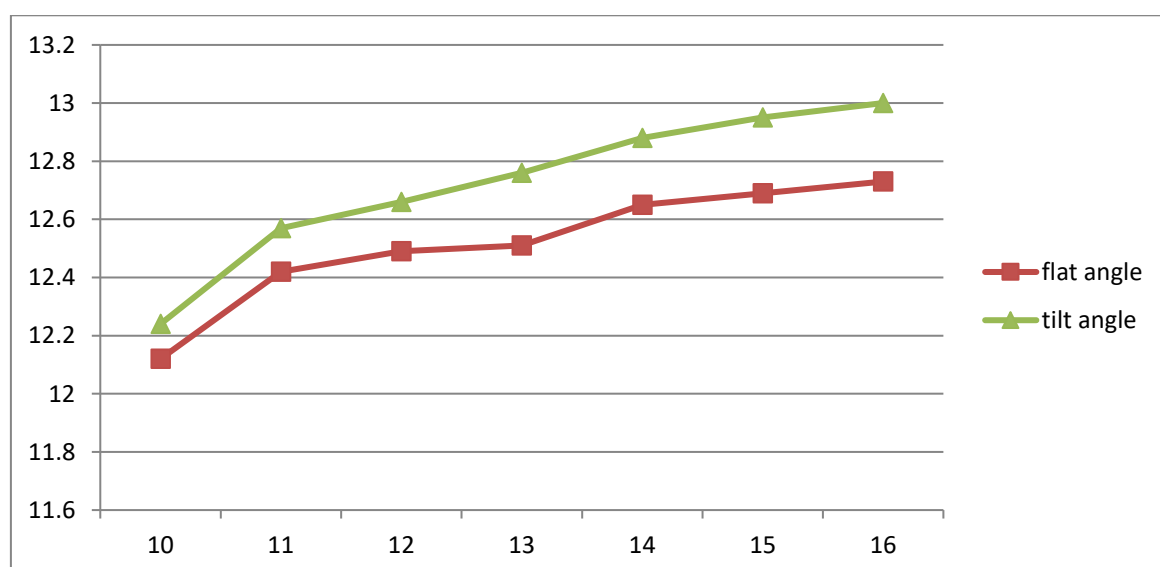


Figure 4. Charging rate of the battery

4. Conclusions

The experimental results reveal that the average efficiency of 0° and 5° Photovoltaic are 13,21 % and 14,1 %. There are some conditions which the rate efficiency of 0° is higher than 5° Photovoltaic based result and discussion chart diagram in consequence of unfavorable weather resulting the electron of photons spread unevenly into photovoltaic surface and most of the electron collected by 0° surface, meanwhile the charging rate battery on 0° and 5° photovoltaic lasted for 6 hours generate 17,42 % and 21,71 %.

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