International Journal of Scientific Engineering and Science
Volume 2, Issue 7, pp. 41-44, 2018. ISSN (Online): 2456-7361

Solar Cell Capacity Improvement Using Fresnel Lens Concentrator with Solar Tracker Control

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Abstract— *The current solar panel efficiency level reaches only about 5-16% of the total solar energy that can be converted to electrical energy. Even to get a high level of efficiency requires high quality solar panels and expensive investment costs. So to increase the efficiency required tools to increase the intensity of sunlight by combining solar panels with Fresnel lens and use solar tracker control. Solar tracker working system is to find the direction of the coming sun that uses two sensors that provide information on the intensity of light received by each sensor. The characteristic of the Fresnel lens is similar to that of a convex lens that collects light and passes it into a single focal length. Based on experimental results with a 20 ° deviation angle facing north using Fresnel lens optimization has increased power in sollar panel by 119.2%. From the results of the overall test, the highest power was obtained at sollar panel output using Fresnel lens optimization of 29.7 watts. While the experimental results using diesel tracker, the average voltage percentage is 6.1% larger on the first day, the average percentage of average voltage is 3.8% on the second day, and on the third day the average voltage is 6.1 %.*

Keywords— *Solar panel, Fresnel lens, concentrator.*

I. INTRODUCTION

Energy issues remain an interesting research topic throughout the human civilization. The search for alternative energy sources as a substitute for fossil fuels is still busy talking about. There are several natural energy sources available as clean, non-polluting, secure and unlimited alternative energy such as solar energy [1]. In bright weather conditions, the Earth's surface receives about 1000 watts of sun energy per square meter. Less than 30% of the energy is reflected back into space, 47% is converted to heat, 23% is used for all work circulation located above the earth's surface, a fraction of 0.25% is accommodated by wind, waves and currents and there is still a very small 0.025% is stored through the process of photosynthesis in plants that is eventually used in the process of forming coal and petroleum (fossil fuels, photosynthesis that takes millions of years) [2].

The current solar panel efficiency level reaches only about 5-16% of the total solar energy that can be converted to electrical energy. Even to get a high level of efficiency (about 16%) required high quality solar panels and expensive investment costs. This makes people increasingly reluctant to apply solar panel technology as one of renewable alternative energy sources to meet their daily electrical energy needs. For that researchers designed solar panel system by combining Fresnel lens. Fresnel lens can increase and optimize the intensity of sunlight absorbed by solar cells so that its efficiency becomes increased [3].

In the research of Design of Solar Tracker Based Atmega 8535 Microcontroller With LDR Sensor (Light Dependent Resistor) And LCD Viewer (Liquid Crystal Display), solar tracker design used four LDR sensors to sensing the direction of solar motion. Solar tracker was used to drive solar cells to follow the direction of solar motion. The electronic circuit consisted of a series of power supplies, Atmega8535 microcontroller circuit, LCD, stepper motor driver circuit, and LDR sensor circuit. The mechanical design used two rotary axes with a unipolar type stepper motor as a drive for solar cells to follow the solar daily pseudo motion (in the east-west direction) and the annual solar pseudo motion (in the north-south direction). The solar cell used was Amorphous 10 V / 30 mA. The measurement results showed that the increase of solar cell voltage reached 11.53% compared to those that did not use diesel tracker while the maximum voltage rised 1.18 V compared to the static [4].

II. METHOD

Based on the specifications of the above solar panel devices then the next step will be to know the value of power (watts) that can be generated by each solar panel module. Calculation of solar panel capacity required can be calculated by Equation (1) as follows

$$\text{P solar module} = \frac{\text{EB}}{\text{Solar Insolation}} \text{x1,1} \tag{1}$$

P solar module was the capacity of the solar panel, EB was the total power of the load and the Sun Insolation was the lowest solar radiation value. Based on the calculation of solar panel capacity required of 28.3 Wp, but the capacity of solar panels with nominal was not available therefore transferred by using solar panels with a capacity of 50 watts. The angle of the solar panel to obtain maximum illumination could refer to units and formulas [5].

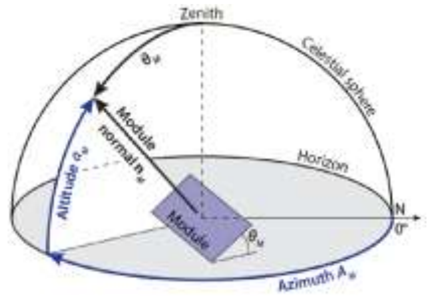

Fig. 1. Angular illustrations are used to illustrate the orientation of Photovoltaic modules (PV) mounted on a horizontal plane.

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The tilt angle for the installation of the Photovoltaics module is relative since the declinance angle will change from month to month (Figure 1). Determination of the angle by declination shall take into consideration the state or location where the photovoltaic module will be installed. Therefore, from the consideration of some of these factors the slope angle for the Photovoltaic module was set at a slope of 20 degrees (altitude) and 260 degrees (azimuth) [6]. In this study, Fresnel lens (Figure 2) type was used. Consideration of choosing Fresnel lens due to the affordable price with the character of thin, light and not broken because of previous used as a medical device, has a diameter of 9 cm with a focal length of 15 cm.


Fig. 2. Fresnel lens.

Fresnel lens arranged lengthwise as much as 6 pieces of lens with a distance of each lens 1 cm so that the total number of lenses used 24 pieces. The arrangement of the lens was glued to the acrylic mica with a length of 71 cm and 49.5 cm wide with 3 mm acrylic thickness. The design of lens arrangement looks like in figure 3.

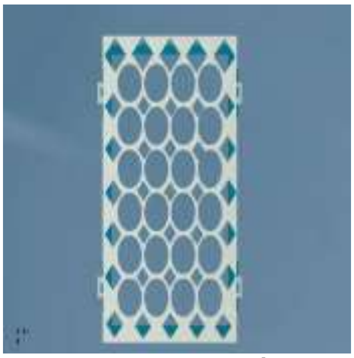
Fig. 3. Lens arrangement design.

The height of the lens greatly affects the light generated by the lens itself because the Fresnel lens is collecting light and forward it to 1 point of fire (focal length).

This experiment used solar panel 50 WP diameter (D) 1 lens 9 cm, solar cell diameter to 9 cm lens to get uniform concentration on the surface of solar panel to lens and focus 15 cm lens. By using the special light properties of the lens ie the rays coming through the optical center of the lens (O) were forwarded, not refracted, so that Equation (2) was obtained by taking the crossing angle tangent so that:

$$\frac{r}{f} = \frac{r'}{f - x} \qquad (2)$$

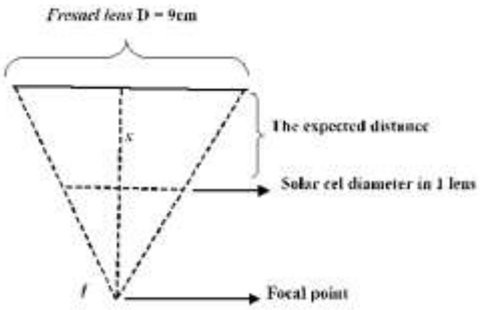

Fig. 4. The lens distance scheme to the solar panel.

Where *r* and *r '* represented the radius of the lens, f was the lens focus and x was the distance of the lens to the focal point. With that distance expected the surface of the solar panel-lens would get optimal solar radiation. After doing data processing, then next was to determine Quantitative Significance of power improvement after using Fresnel lens by using Equation (3)

$$\frac{\text{p average using Fresnel lens}}{\text{p average without Fresnel lens}} \text{x100\%} \qquad (3)$$

Data collection was done with several parameters: temperature (°C), wind speed (mph), air humidity (Rh%), intensity of sun (lux), In the process would see the result of voltage (volt) and electric current (amper) generated by solar panels and their effects on other parameters while the magnitude of power (watt) power could be calculated by Equation (4)

$$P = V \times I \qquad (4)$$

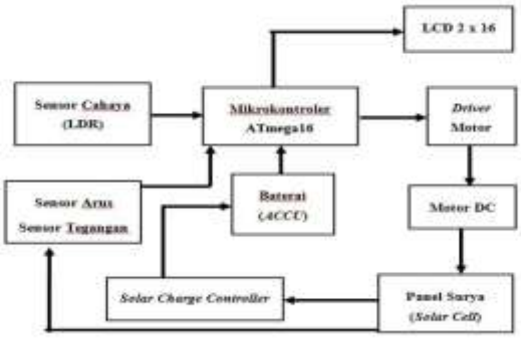

Fig. 5. Block diagram solar system tracker.

The design of solar tracker covered all things related to electronic circuits and other components. This tool consisted of a power supply used to energize all components on a solar tracker. LDR in this study was used to detect the position of the sun, current sensors and voltage sensors were used to measure the current and voltage generated from solar panels. Microcontoler served as a data processing center of the system (especially from the sensor) in the form of analog data into digital data. The diagram block system solar tracker can be seen at figure 5. The microcontroller was used AVR Atmega16. LCD is the measurement viewer, solar panels is a catcher of the sun, solar charger controller is a controller of the panel solar, motor drivers and dc motors are the mechanical drivers of solar panels, and battery accu to collect the electrical charge generated by the solar panel and distributed it to the whole system. The installation of solar tracker can be seen in figure 6.

Fig. 6. Solar tracker installation.

III. Results and Discussion

Here is the result of comparison of voltage, current, and solar cell power with Fresnel lens and without Fresnel lens in graph can be seen at figure 7, 8, and 9.

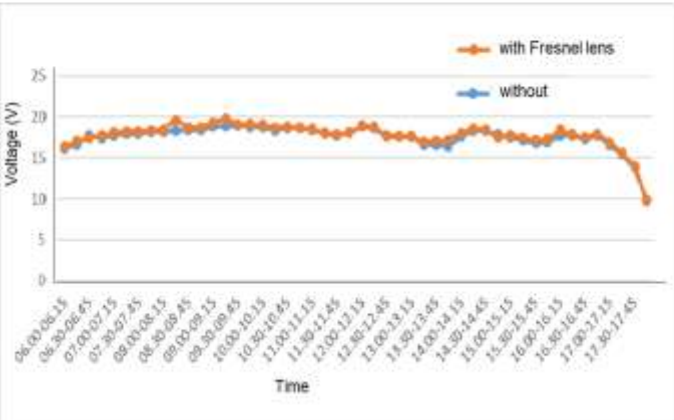

Fig. 7. Comparison of solar panel voltage output using Fresnel lens and without using Fresnel lens.

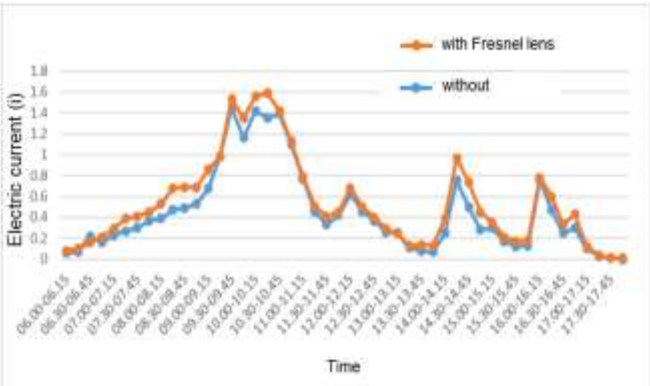

Fig. 8. Comparison of solar panel current output using Fresnel lens and without using Fresnel lens.

The power generated by the solar panel can be calculated by equation 4, so that it is obtained.

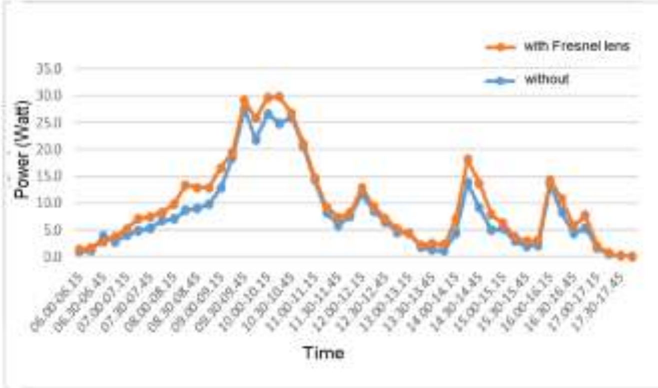

Fig. 9. Comparison of solar panel power output by using Fresnel lens and without using Fresnel lens.

The power graph analysis can be seen in figure 10. The figure explains output of solar panel without using Fresnel lens, the highest power of 26.7 watts, the lowest power of 0.0 watt, and the average power of 8.3 watts. It is shown that the output solar panel using Fresnel lens, for the highest power of 29.7 watts, the lowest power of 0.1 watts, and average power of 9.9 watts. So that the quantitative significance of power increase after using Fresnel lens can be calculated by equation (3), then by using Fresnel lens optimization has increased power in solar panel equal to 119.2%. The average value of solar panel output for three days based on solar panel voltage output using tracker and without tracker can be seen on the graph below. Figure 8 is the average voltage value of the solar panel output using a solar tracker and without a tracker.

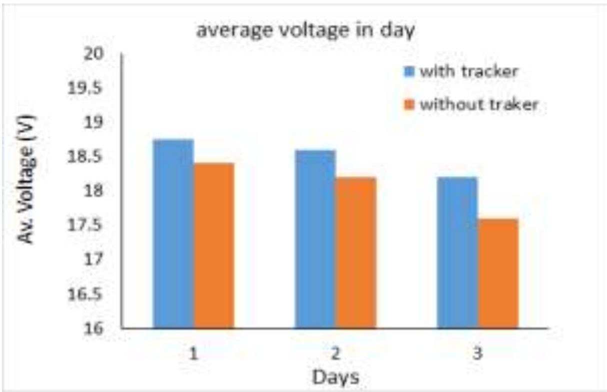

Fig. 10. Graph of the average voltage value of solar panel output using tracker and without tracker.

The experimental results using diesel tracker, the average voltage percentage is 6.1% higher on the first day, the average percentage of average voltage is 3.8% on the second day, and on the third day, the average voltage is 6.1%. While the results of the experiment using diesel tracker, the average voltage percentage is greater than 6.1% on the first day, the average voltage percentage is 3.8% higher on the second day, and on the third day, the average voltage is 6.1%.

IV. Conclusion

The efficiency of solar panels can be enhanced by adding a Fresnel lens with a 20° angle facing north. After using Fresnel

Volume 2, Issue 7, pp. 41-44, 2018. ISSN (Online): 2456-7361

lens, obtained quantitative significance of power increase at solar panel equal to 119.2%. From the overall test result, the highest power was obtained at solar panel output using Fresnel lens optimization of 29.7 watts. The percentage of experimental voltage difference using diesel tracker and without diesel tracker, using average solar tracker 6.1% larger on the first day, 3.8% on the second day, and on the third day 6.1%.

ACKNOWLEDGMENT

This work was supported by the Lembaga Penelitian dan Pengabdian Kepada Masyarakat, Institut Sains & Teknologi AKPRIND Yogyakarta.

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