Socialization of Solar Energy Utilization in Ponpes Al Hidayah, Arjasa, Kangean Island, Sumenep

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Abstract. Electricity problem of most small islands in Indonesia has become a serious problem and need to be immediately resolved. In this present paper, Kangean Islands, Sumenep district of Madura, Indonesia, is one of the most suitable islands for an example. In this island, the existing electricity supply is mainly generated by diesel generators. Even though there are also electricity supplies from the government and private companies, it is very limited capacities just a few families. It is clear that the daily electricity requirements in the Kangean Islands are not adequately met. There is no self-supporting from the local residents to meet their daily energy needs. The community service activity helps to improve the understanding and the self-supporting of the Kangean Island community, especially for the young generation, in the field of electrical energy by utilizing renewable energy sources, especially solar cell system technology. Thus, it is expected that natural resources in Kangean Island can be utilized properly and able to increase the productivity. Finally, in this paper, the light intensity and surface temperature effects on the performance of a monocrystal solar cell are discussed.

1. Introduction

The problem of electricity availability on the islands of Kangean has become a protracted problem. Electricity limitations will certainly make the activities of the community to be limited [1]. Power supplies in the island are still generated by diesel generators, and some solar power plants are also still concentrated only for a few families. It is still very limited, so it can be said that it is not sufficient to meet the electricity daily needs for every family in the Kangean Islands. Solar power plants in the hamlet of Batu Putih and Pabitta is only limited to several families. Moreover, it is limited to 3 lamps for every family.

Geographical conditions in Indonesia consist of millions of islands, and the Kangean Island is a good example as a place for a renewable energy. It is known that Indonesia is very abundant for solar energy [2]. This energy can be utilized by converting the energy into electricity using solar cell panels [3]. Therefore, it should be utilized to overcome the lack of electricity in this kind of region [4]. The main purpose of this community service activity is to improve the understanding of the community in the field of electrical energy by utilizing renewable energy sources, especially solar cell science and technology. Finally, it may increase the productivity and independence of the community.

The ability of solar cell to produce electric energy is related to the photovoltaic effect and its ability to absorb electromagnetic waves. The properties of a solar cell for converting light energy into electric...
energy depend on environmental factors; those are weather condition [5], the intensity of light [6], panel orientation [7] and position of solar panel to the Sun [8,9], wind direction [10], and the temperature of the cell [11]. Photovoltaic parameters that determine the performance of a solar cell are open-circuit voltage, short circuit current, maximum output power, fill factor, and efficiency [12]. Generally the efficiency of the solar cells is used as parameters to compare the performance of a solar against other solar cells with similar treatment. In this paper, we also study the effect of sunlight intensity on the solar cell performance, in the case of maximum output power, fill factor, and its efficiency.

2. Methods of Activities
The socialization of implementing solar cell technology was held at one school in Kangean Island, namely Al-Hidayah Senior High School, Ponpes Al-Hidayah, Arjasa, Kangean Island, Sumenep District, Indonesia. The audience involved in this activity is especially for the young generation in Al-Hidayah ponpes, which are students of Upper Secondary School, where they are originally from the Kangean Island and the surrounding islands.

This socialization combined with training to the audience was conducted in the form of lectures, discussion, demonstration, and exercises to the young generations of Kangean Island to utilize solar cell panel as renewable energy. After a class lecture on the short-term theory of renewable energy (and photovoltaic effects), operation, and maintenance, the activity was continued by installing a solar power system as seen in Figure 1. Figure 2 shows the installation setup for the experimental purpose in order to analyze the efficiencies of Silicon monocrystalline solar cell panel with area of 0.27 m². The measurements were performed in the sunny and cloudy condition. From the experiment, the fill factor (FF) and the efficiency were obtained using Equation 1 and Equation 2. From these experimental results, it was considered as the achievement of socialization activities.

Figure 1. Installation setup for Solar Cell Panel.

Figure 2. Experimental Setup for Photovoltaic measurements.

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FF = \frac{I_m \times V_m}{I_{SC} \times V_{OC}}
\]

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\eta = \frac{FF \times I_{SC} \times V_{OC}}{P_{input}} = \frac{V_m \times I_m}{Intensity \times A}
\]
3. Results and Discussion

The main discussion of this socialization is the utilization of renewable energy, with a primary focus on the utilization of solar cell power plants and studies on its performance. It needs to be explained to the participants that the use of new and renewable energy sources needs to be developed. It is also explained how solar cell power systems are designed. A solar cell power system consists of a solar module, a regulator circuit, an electrical energy store (batteries), an inverter, an installation cable, and other mechanical equipment. The type of solar module used is monocrystal silicon. The main consideration for using this type of solar module is because it is the most efficient type of solar module available, with efficiency reaching 16-25% [13].

The important thing to be noted in the installation is that it should be located in an open area that is not blocked by trees or tall buildings. The battery should be placed in a humid place and out of reach of children. While the other solar panel accessories located outside the room and it should be resistant to sunlight. The regulator's position should be easily accessible for easy checking and maintenance. The next session is observing and performing experiments on the phenomenon of photovoltaic effects.

Figure 3(a) and 3(b) show I-V characteristics of the solar cell during sunny and cloudy condition, respectively. In the measurements, the values of Voc (voltage in the circuit without resistance) and Isc (electric current in the circuit without resistance) were 21.56 V and 2.68 A, respectively. The I-V measurements were conducted with the variation of resistance in the range of 1 to 1 kΩ. In the case of minimum resistance, the electric current will have maximum value, whereas the voltage will have low value.

It can be seen from Figure 3 that the maximum values of both electric current and voltage can be obtained. They are important to calculate the value of Fill Factor (FF). The FF value corresponds to how much intensity of the sunlight can be absorbed by the solar cell. In the case of sunny condition, the FF value is 0.62 or 62%, meaning that the ability of the solar cell to absorb sunlight during the measurement is about 62% with the intensity average of about 1.44 W/m². In fact, the FF value is proportional to the area of the solar cell. The wider area, the higher FF value would be obtained. In Figure 3(a), it can be obtained that the maximum values of electrical current, voltage, and output power are 2.24 A, 16.08 V, and 36.07 W, respectively. By calculation using Equation 2, the efficiency of the solar cell panel in sunny condition is approximately 13.5%.

It can be seen from Figure 3(b), the values of the maximum output of electrical current, voltage, and power are 0.67 A, 16.94 V, and 11.42 W. The calculation results of FF value and its efficiency are 65% and 18.9%, respectively. The increase of FF value may result in the increase of efficiency of the solar cell. From both Figure 3(a) and 3(b), it can be analyzed that the weather (sunny or cloudy) may cause the change of both solar cell efficiency and light absorption characteristics. The light illumination of solar cell in the sunny condition provides higher electrical current with almost the same voltage compared with in the cloudy condition.

In order to study more detail on the relationship between the light intensity and the solar cell performance, for instance output power and efficiency, we have performed the intensity measurements collected in both sunny and cloudy condition. Figure 4(a) and 4(b) show the sunlight intensity dependence on the maximum output power of the solar cell in sunny and cloudy condition, respectively. Both Figures show a nonlinear behaviour because of the effect of surrounding temperature on the surface of the panel. As the temperature close to room temperature, the solar cell produces decreasing output voltage and increasing electrical current. Otherwise, as the temperature on the solar cell surface is high enough, the output voltage decreases, however, the electrical current is relatively constant. Hence, it produces a lower output power.
In a short summary, the output power of solar cell may change significantly due to the change of temperature on the surface of the panel. In Figure 4(b), it can be seen that the output power increases as the sunlight intensity increases. This can be understood that the surface temperature remains constant at around room temperature, while the output voltage decreases and the electrical current increases with increasing the intensity.

Figure 3. I-V characteristics of the solar cell panel in (a) sunny and (b) cloudy condition.

Figure 4. Sunlight intensity dependence of maximum output power of the solar panel in (a) sunny and (b) cloudy condition.
The sunlight intensity dependence on efficiencies of the solar cell in sunny and cloudy condition are illustrated in Figure 5(a) and 5(b), respectively. It can be seen from both Figures that it has irregular pattern meaning that there is a contribution from the surface temperature of the solar cell panel affecting the output power and hence change its efficiency significantly. For example, in Figure 5(a), the solar cell has efficiency of about 9.9% at the sunlight intensity of 893.7 W/m², even in this case, the intensity is higher than before. This is because the measurement at a relatively high temperature results in the decrease of output voltage and relatively constant electric current, and hence, the efficiency decreases. In the cloudy condition, as seen in Figure 5(b), the surface temperature is relatively constant. Then, this results in the decrease of output voltage and the increase of electric current with increasing sunlight intensity. At a high intensity and low output power, the efficiency of the solar cell becomes low. Otherwise, the efficiency becomes high when the intensity decreases and the output power is high. Therefore, it can be summarized that the change in sunlight intensity and also the temperature on the surface influence the efficiency of the solar cell.

![Figure 5](image)

**Figure 5.** Sunlight intensity dependence of efficiency of the solar panel in (a) sunny and (b) cloudy condition.
4. Conclusions

From the activities of the community service that has been done in Kangean Island, Indonesia, it can be concluded two important points. First, the activity has been successfully implemented. The participants have the ability to understand about the utilization of renewable energy, especially the utilization of solar energy using solar cells. Second, from the experiment using installed solar cell, it can be summarized that the maximum values of the output power and efficiency of the solar cell are strongly influenced by the surrounding weather and the surface temperature of the panel. For the Silicon monocystal solar cells, the minimum efficiency during cloudy weather is 10.5%, while the maximum efficiency during sunny weather is 20.5%.

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