Comparison Of the Results of Implementing a Hiking Bag with A Renewable Energy System Using Thin Film Solar Panels in Mountainous Areas

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Abstract — The use of small-scale solar energy is one of the strategic solutions for electricity needs in remote areas and outdoor activities. As the need for portable electrification increases, the development of solar backpack systems is becoming a practical and sustainable alternative. This research aims to design and test a portable backpack system based on a thin film solar panel with a capacity of 20 Wp, equipped with a 12V solar charge controller and a 7.2 Ah battery. The system is designed with two outputs, namely 12V DC and 5V USB, to support lightweight devices such as LED lights and smartphones. The test was carried out at two different locations, namely Mount Lorokan and Mount Penanggungan, with data taken which included latitude, longitude, solar elevation angle, PV voltage, PV current, and output power. The measurement results show that there is a variation in the performance of solar panels according to geographical conditions and solar elevation angles. On Mount Lorokan, the peak power reaches 8.55 W at an angle of 75°, while on Mount Penanggungan the maximum power is slightly higher, which is 8.6 W at an angle of 78°. Mount Lorokan excels at maximum power, Penanggungan shows more stable performance at low to medium angles. This research contributes to the development of a portable electrification system based on renewable energy that supports power continuity in locations without access to electricity.

Keywords—Hiking Bag , Solar Power Plant, Portable, Offgrid, Backpack.

I. INTRODUCTION

The use of solar energy on a small scale has become a strategic alternative to meet electricity needs in remote areas as well as in outdoor activities, such as climbing, expeditions, and other field activities. Along with the increasing demand for electrification systems, portable solar panel systems and portable power stations are being developed. Some studies suggest that microscale solar systems can be a reliable and sustainable solution for power supply for light loads such as in studies for 10 Ampere 12 volt loads.[1], [2] [3] [4] [5], [6], [7]

In previous research, portable power stations based on solar energy have been widely carried out in various contexts, ranging from outdoor needs to rural electrification solutions. The study designed portable solar stations for outdoor purposes such as camping and emergency conditions. The system uses folding solar panels, lithium-ion batteries, and small inverters, and is proven to be able to provide power for lightweight electronic devices such as LED lights and smartphones. In the next study, a feasibility study was conducted on the use of portable power stations in rural areas of Bangladesh that have not been reached by the electricity grid. The results of the study show that devices with a capacity of 200–500 Wh are quite effective in meeting the basic needs of the community, although they are not yet able to serve loads with large energy consumption. Further development was carried out by Kim who introduced the concept of a backpack-type solar power generator. The design of a backpack with a 60 W flexible solar panel is equipped with USB and DC outputs, making it practical for field workers and emergency situations.[8] [9] [10] [11] [12]

In this study, the author designed a backpack system with a 20 Wp thin film solar panel combined with a 12V solar charge controller and a 7.2 Ah battery. The output voltage generated is 12v and 5v (USB). The system testing will be carried out in two locations, namely on Mount Lorokan and Mount Penanggungan. Activities in the field with unstable energy consumption patterns. Therefore, this study aims to design and test a 20 Wp solar panel-based portable electrification system with variables in walking mode and standby mode in the lorokan mountain and the bearing mountain. The data taken is in the form of data obtained from the mountain in the form of Latitude, Longitude, Angle of Elevation, Sun, PV Voltage (V), PV Current (A) and Power (Watt). The test was carried out directly in two places and at the same time. The contribution of this research is as the development of renewable energy and portability and continuity of power when in areas where it is difficult to get access to electricity.[13] [14] [15]

II. MATERIALS AND METHODS

The design of the Solar Power Plant (PLTS) is carried out through several stages which include location surveys, equipment design, equipment trials, and research results. A direct survey is needed to find out the potential of solar energy as a source of electricity as well as the area of placement of solar panels. Research will be carried out in the development of this system. The explanation of each step can be explained as follows.

A. *Flowchart Experiment*

On the Figure 1 experiment process flow of a portable solar panel system integrated with a climbing bag. The process begins with the initial step of connecting the solar panels to the bag as the main energy source. After that, the system is activated by turning on key components such as the solar charge controller, battery, and load control. The next step is to verify that all the components are connected and working properly. If it is not connected, the system will return to the connection check process. After ensuring the system is working properly, the tests are carried out in the field, especially in mountainous areas. At this stage, location data such as latitude, the angle of elevation of the sun that affects the intensity of sunlight received by the solar panel is collected. The final step of this process is the collection of technical data in the form of voltage, current, and power generated by the solar panels, which will later be analyzed to evaluate the system's performance in real conditions. The process ends when all the data has been successfully collected. This flowchart systematically explains the important stages in the implementation of the testing of renewable energy systems based on portable solar panels.

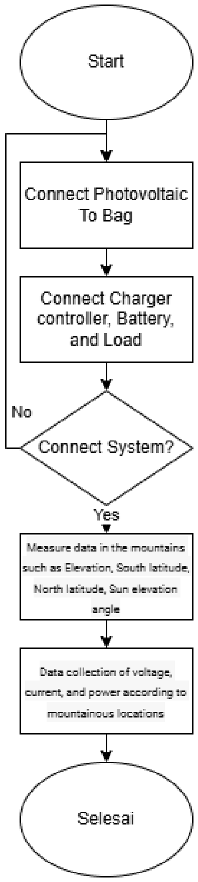

Figure 1. Flow Chart Experiment

B. *Tool Block Diagram*

Illustration on the design of the backpack which is based on a solar charging system. The backpack has a wide range of components that can be used to support self-charging using solar power. One of the main components is a solar panel located in the back bag and serves to convert daily energy into electrical energy. There are also several control features, such as solar charger control which functions to regulate and control the amount of energy transferred from the solar panel to the battery, and a DC meter that measures the amount of energy used.

In addition, the device has a battery indicator that allows users to activate or automate the battery's energy supply, as well as a USB port that allows users to connect electronic devices such as smartphones or tablets.

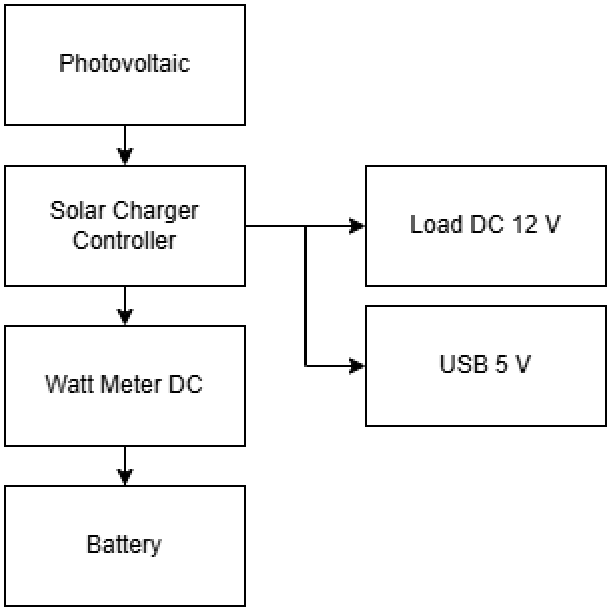

Figure 2. Block Diagram System

On Figure 2 Block Diagram System. The process begins with the initial step of connecting the solar panels to the bag as the main energy source. After that, the system is activated by turning on key components such as the solar charge controller, battery, and load control. The next step is to verify that all the components are connected and working properly. If it is not connected, the system will return to the connection check process. After ensuring the system is working properly, the tests are carried out in the field, especially in mountainous areas. At this stage, location data such as north latitude, south latitude, and solar elevation angle are collected which affect the intensity of sunlight received by solar panels. The final step of this process is the collection of technical data in the form of voltage, current, and power generated by the solar panels, which will later be analyzed to evaluate the system's performance in real conditions. The process ends when all the data has been successfully collected. This flowchart systematically explains the important stages in the implementation of the testing of renewable energy systems based on portable solar panels.

III. RESULTS AND DISCUSSION

In this study, a comparison was made of the performance of the Back Pack with portable PV which was tested in two different locations, namely Mount Lorokan and Mount Penanggungan. The comparison is focused on the relationship between the angle of solar elevation and PV output power to see the effect of geographical conditions on system performance. Based on the measurement data, the two locations show a similar pattern, namely the greater the angle of elevation of the sun, the PV output power tends to increase. However, there are differences in characteristics, where Mount Lorokan tends to produce higher peak power, while Mount Penanggungan shows more stable performance with a slightly superior average power. At the testing stage, an experiment was carried out with two people to test on two different mountains by taking Latitude and Longitude data using the solar location track with the Sun Locator at the location of the mountain. Sun elevation angle data is obtained by looking in the app with different time durations according to the direction traveled.

Figure 3. Backpack Testing

A. Backpack Testing in Mount Penanggungan

In testing Backpacks in a location it is very important to understand the characteristics of lighting and its potential utilization, especially in the field of solar energy. Mount Penanggunagan, located in East Java, is one of the points to be analyzed because of its position in the southern latitude and is on a tropical path with a fairly high intensity of solar radiation throughout the year. Analysis of the sun's position at a certain time can provide an overview of the angle of the rays, the length of the shadows formed, and the potential for energy reception by the solar panel system.

Figure 4. Sun Position Mount Penanggungan

Figure 4 above shows the use of the Sun Locator application of the position of the sun on Mount Penanggungan at 11:44 with latitude coordinates -7.6132 and longitude 112.6206. The data shows that the sun has an azimuth of 351° which means that its position is almost parallel to the geographical north, and the elevation reaches 70.8° which indicates that the angle of the sun's altitude is quite high towards noon. This condition results in a shadow ratio of 1:0.35, indicating that the object's shadow becomes very short because the sun is close to the zenith point. Critically, such a high elevation angle is advantageous for solar panel systems because the maximum intensity of solar radiation can be absorbed, resulting in a more optimal potential for electrical energy conversion. However, the azimuth that is almost exactly north also needs to be considered in the orientation of the panel to ensure that the angle of capture of the rays corresponds to the direction of the sun's movement throughout the day. Then tabulated in Table 1

TABLE 1 BACKPAK TESTING ON MOUNT PENANGGUNGAN

No	LL	T	You EV	V PV (V)	IPV (A)	Power (W)
1	7,6132° LS 112,606° BT	11:41	62°	13.85	0.54	7.48
2		11:44	75°	14.25	0.60	8.55
3		11:40	58°	13.55	0.51	6.91
4		11:39	49°	12.90	0.46	5.93
5		11:43	70°	13.95	0.56	7.81
6		11:42	64°	13.60	0.52	7.07
7		11:41	56°	13.20	0.49	6.47
8		11:39	48°	12.80	0.45	5.76

In table 1 above LL is lattitude and longtittude, Deg is the elevation angle, V is the voltage, I is the current and T is the time shown by the sun Ouput solar panels at the location with coordinates 7.6132° South Lattidude and 112.606° E, which represents the relationship between the angle of elevation of the sun and the electrical performance in the form of voltage, current, and power. It can be seen that the maximum power is reached at an elevation angle of 75° with a value of 8.55 W, while the minimum power occurs at an elevation angle of 48° with only 5.76 W. This is consistent with the theory of solar radiation, where the higher the elevation angle, the greater the intensity of illumination received by the photovoltaic module as the sunlight comes more perpendicular to the surface of the panel. The difference in power values is not only influenced by the elevation angle, but also by other factors such as atmospheric conditions, solar cell temperature, and the possibility of reflection or absorption of light around Mount Lorokan.

B. Backpack Testing in Mount Lorokan

In the second test, the Backpack was carried out at the location of Mount Lorokan located in Mojokerto, East Java, located in the southern latitude and on a tropical path with a fairly high intensity of solar radiation throughout the year. This test was carried out to determine the performance of the backpack tested on Mount Lorokan. In the test using the Sun Locator application as shown in figure 5

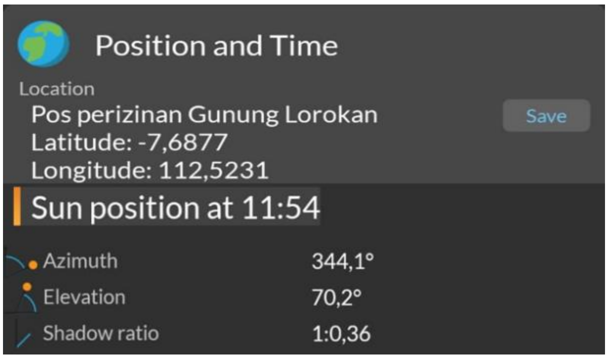

Figure 5. Sun Position Gunung Lorokan

Figure 5 shows the position of the sun at the Mount Lorokan Licensing Post at 11:54 with latitude coordinates -7.6877 and longitude 112.5231. At that time, the sun had an azimuth of 344.1°, which meant that it was slightly tilted to the northwest from the geographical north, as well as an elevation angle of 70.2°, indicating that the sun was quite high in the sky by noon. This condition results in a shadow ratio of 1:0.36, which indicates that the shadow of the object is very short due to the angle of light coming almost perpendicularly. Critically, a high elevation angle like this is an ideal condition for solar panels because the intensity of solar radiation is maximized, so the energy conversion efficiency is increased. However, the azimuth factor shifting from north needs to be considered in determining the orientation of the panel, as an improperly straight direction of light can lead to a slight decrease in energy absorption. Then for the tabulation of Sun Locator data, you can see Table 2

TABLE 2 BACKPAK TESTING IN MOUNT PENANGGUNGAN

No	LL	T	You EV	V PV (V)	IPV (A)	Power (W)
1	7,6877° LS 112,5231° BT	11:54	65°	13.95	0.55	7.67
2		11:56	78°	14.10	0.61	8.60
3		11:53	60°	13.65	0.52	7.10
4		11:51	50°	13.10	0.48	6.29
5		11:55	72°	13.90	0.57	7.92
6		11:54	65°	13.70	0.53	7.26
7		11:52	58°	13.30	0.50	6.65

In Table 2 above LL is lattitude and longtittude, Deg is the elevation angle, V is the voltage, I is the current and T is the time shown The table illustrates the results of the solar panel output measurement at the location of Mount Lorokan with variations in the angle of solar elevation. The results show that the highest power of 8.60 W is achieved at an elevation angle of 78°, which is in line with the theory that the more perpendicular sunlight hits the panels, the greater the intensity of radiation absorbed and converted into electricity. In contrast, the lowest power is only 6,29 W at an elevation angle of 50°, when the sun's position is lower so that the rays come more at an angle and the energy received by the panel is reduced. The voltage ranges from 13.10 – 14.10 V, while the current is in the range of 0.48 – 0.61 A, which indicates the stability of the PV system even though the power fluctuates according to the elevation angle. Critically, these results confirm the importance of optimal orientation of solar panels to local elevation angles, as small differences in solar angles can significantly affect power output. In addition, the data also indicate that although voltage is relatively stable, current variations contribute greatly to power changes, so light intensity and atmospheric conditions play an important role in the performance of photovoltaic systems.

C. *Comparison of Back pack Testing in Gunung Lorokan VS Mount Penanggungan*

A comparison of the performance of the Backpack with thinfilm solar panels in two different locations can provide an overview of the influence of geographical position on the potential energy produced. The main factor that affects the output power of solar panels is the angle of elevation of the sun, because the higher the position of the sun, the greater the intensity of radiation the surface of the panel receives. In this context, Mount Lorokan and Mount Penanggungan were chosen as observation points to see how variations in elevation angles affect the output power of solar panels.

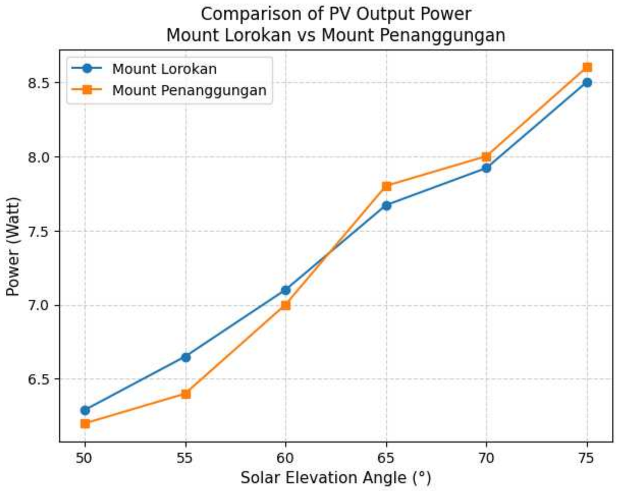

Figure 6. Comparison of Power G. Lorokan VS G. Coverage of the Angle of Elevation of the Sun

In figure 6 the graph shows the comparison of solar panel (PV) output power in two different locations, namely Mount Lorokan and Mount Penanggungan, based on variations in the angle of elevation of the sun. From the curve, it can be seen that both locations have a pattern of increasing power as the elevation angle increases, with Mount Lorokan reaching a peak power of 8.55 W at an angle of 75°, while Mount Penanggungan is slightly higher at 8.6 W at an angle of 78°. On Mount Lorokan superior at maximum power, Penanggungan shows more consistent performance at low to medium angles, thus providing a slightly higher average power.

CONCLUSION

Based on the results of tests on Mount Lorokan and Mount Penanggungan, it can be concluded that the angle of elevation of the sun plays a significant role in the performance of the solar panel on the Backpack, where the higher the position of the sun, the more optimal the output power. At Mount Penanggungan, the maximum power is recorded at 8.55 W at an elevation angle of 75° (voltage of 14.25 V and current of 0.60 A), while the minimum power occurs at an elevation angle of 48° with 5.76 W (12.80 V; 0.45 A). Meanwhile, on Mount Lorokan, the highest power reaches 8.60 W at an elevation angle of 78° (14.10 V; 0.61 A), and the lowest is 6.29 W at an elevation angle of 50° (13.10 V; 0.48 A). Overall, Mount Penanggungan showed more consistent performance at low to medium angles, resulting in a more stable average power, while Mount Lorokan excelled in peak power achievement.

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