Development of portable solar storage device

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Abstract. The demand for energy in Malaysia to use for all-purpose of small device charging has been developed. The purpose of this project is to develop portable solar storage (PSS) device with all the components of an off-grid solar station compact into a small portable handheld casing. The PSS is aimed for outdoor activity passionate such as hikers, campers and climbers that need a portable power charger that can charge their electronic gadgets while they carry on with their activities. The input current and voltage of the solar panel had been recorded over a span of two weeks. The generation of electricity is harvested from solar irradiation on 12 V and 18 V solar panel and stored upon 98 W energy storage beneath the solar panel. The power stored put on the test and capable to recharge up to 10,000 mAh capacity for one-time charging. As a comparison between 12V and 18 V solar panel, the result shows the average charging rate of the 12V and 18V solar panels could reach as high as 16.086 W/h and 13.35 W/h respectively which considered had reached 12.75% efficiency.

1. Introduction
As we all know, the demand for the usage of solar energy in Malaysia is not as high as the demand overseas even though some of us are aware of the advantages of solar energy. The sunlight is the main and biggest source of all source of energy [1]. Solar energy is free energy for the entire life. In order to consume and use it wisely, there are certain devices based on the solar panel have been invented for such purposes. The major benefit of Malaysia’s climate is the exposure to sunlight increases the ability of usage of the renewable resources of energy such as the Sun. Malaysia is known as a country which located near the equator alongside with Thailand, Indonesia and Singapore. Peninsular Malaysia with the coordinates of 4°0’N 102°30’E is in the humid province. The characteristics of Malaysia’s climates may include unvarying temperature, high humidity and abundant rainfall. The solar radiation received in January ranges from 6.5kWh/m² and decreases lower to 6.0kWh/m² in August [2]. The amount of exposure to sunlight in Malaysia qualifies the usage of solar panel as the source of electricity.

Humans depend on gadgets in daily lives same as how gadgets need batteries to stay alive and functioning well [3]. Even though we are off the grid, we have to admit we are living in a power-based world such cell phones, laptops and others devices especially for those who love to do outdoor activities [4]. According to Jake Walnut, 2017, while on outdoor adventures, the greatest way to stay plugged in is by portable power supply [5]. Portable power supply may include alternators and generators. Generators are originally used for backup power however, they are noisy, produce fumes and very unfriendly environmental [6]. The limitation of noise set by the national parks is to 60 decibels at fifty
feet [7]. In contrast, the usage of solar panels or solar power for campers is better since it is a silent power supply and most importantly environmental-friendly where there is no release of toxic fumes [6]. Moreover, the US Department of Energy’s National Renewable Energy Laboratories stated that the cost of utility-scale solar has fallen 30%. This falling cost is the reason why the utilization of solar increases by companies as the hardware can be bought at low prices [8]. Thus, we would like to develop a portable solar storage device which can be used as a power supply that depends on solar energy. This will prevent the pollutions made by the generators.

2. Methodology
The procedure to conduct this project is first, in the morning on the first day according to Figure 1.(a), a solar panel of 18V was connected to the solar charge controller (SCC). The initial voltage and resistance of the power supplied by the solar panel to the SCC were recorded by using a multimeter. Every hour starts from 7.00 am till 12.00 pm, the reading of the voltage and resistance were recorded until the PSS battery capacity is fully charged which have been displayed by the SCC. The power of energy captured by the solar was calculated with the formula of P=IV and I=V/R. The experiment conducted during the day will be continued at night after all the data required have been collected.

During the night, the experiment is set up where the SCC is being connected to the PSS battery and a load of 1400 mAh as shown in Figure 1.(b) The load is at 0% battery performance before being used in PSS for being able to compare its performance. The reading of voltage and resistance were recorded every hour from 7.00 pm till 12.00 am to calculate the power discharged to the load. The increments of the percentage of the load during charging also being recorded simultaneously with the reading of voltage and resistance.

The 18 V solar panel is used 3 times for loads of 1400 mAh, 4400 mAh and 10,000 mAh. The experiments were repeated for 3 days and 3 nights for the 18 V solar panel. All the procedures were repeated by charging the 18V solar panel to 12V solar panel. The 12V solar panel was also being used 3 times for load of 1400 mAh, 4400 mAh and 10,000 mAh. It was also repeated for 3 days and 3 nights for data collection.

![Figure 1](image1.png)

**Figure 1.** (a) The PSS under the sunlight and (b) the PSS connected to a load.
3. Result and Discussion

The data collected on the charging and discharge of voltage on the Portable Solar Storage (PSS) has been done at Student's Residential College, University Tun Hussein Onn, Pagoh, Johor over the span of two weeks from 10th until 27th October 2018. The data was collected on the average from the 7 am until 3 pm depending on the weather and the time it takes for the power storage to reach maximum capacity. Two different voltages of solar panels used which were 12 V and 18 V where the data collection starts with the later. Furthermore, the desired altitude and latitude of Malaysia which is 19 m and 101.5°E respectively and the irradiation in the month of October according to the Meteorology Data (refer appendices) is 135.5 kWh/m² which makes it possible to harvest energy during the 6 hours span of the day. Also, contribute to the energy harvesting is the Ambient Temperature of the month of October which is 27.48°C. Both solar panels were setup up at a 20° angle for the best tilt.

![Figure 2. Charging power (W) against the time of different panels.](image)

On average of both days, the 18 V solar panel managed to produce a power of 25.0 W at 7.00 am where the sun was about to radiate. Next, for the 12 V solar panel, it took 5 hours to completely charge the battery storage. It took a higher amount of power to charge the battery storage compared to using 18 V solar panel due to the small area of the 12 V solar panel. The charging rate of the 18 V solar panel is 13.35 W/h (177 Wh/m²) whereas for the 12 V solar panel is 16.086 W/h. (765 Wh/m²). This result showing 12 V panel provides great energy harvesting as compared with 18 V one.
The data of PSS was collected at night starting from 7.00 pm with a 1400 mAh load capacity of a phone at 0% power percentage. Different from the 1400 mAh, the 4400 mAh and 10,000 mAh load capacity took 4 hours to charge until it reaches full capacity. The 4400 mAh load has a constant increase in percentage which is between the ranges of 17% to 26% until it reaches full percentage by 11.00 pm. The 10,000 mAh is able to charge at a constant pace as the 4400 mAh where by 9.00 pm it reaches 57% and 2 hours later it reaches 100%. The fast pace of charging was due to the power supplied by the solar panel when charging the PSS. The device had been charged earlier in the morning until afternoon by the 12V solar panel. After two attempts, the percentage of load for the 4400 mAh and 10,000 mAh load could not be completed due to low voltage released by the solar charge controller. This shows that the PSS is not suitable in being charged by a 12V solar panel and the SCC cannot retrieve as the same amount of power as when the device is charged with the 18 V solar panel.
capacity. It took 11.27 W to charge the load capacity of 1400 mAh meaning that the PSS has the ability to charge 1400 mAh load capacity twice in a day although not fully charged when the second time the load is charged when using 18 V solar panel. While discharging from the load of 1400 mAh, it needed 72.7 W to fully charge due to less power given by the 12 V solar panel means there were restrictions when doing that experiment. Attempts on discharging the 4400 mAh and 10,000 mAh load cannot be completed due to some technical errors in the solar charge controller.

4. Conclusions
Peninsular Malaysia which is situated near the equator has a great advantage of retrieving a 6 hours' sunlight in a day. This benefits the Portable Solar Storage (PSS) device in being able to generate energy and to supply power to the load. The PSS has an average charging rate of 16.086 W/h and 13.35 W/h of power rate generated by the 12 V and 18 V solar panels respectively. The power is enough to supply power to the 1400 mAh, 4400 mAh and 10,000 mAh load capacity.

Load with capacity 1400 mAh load such as a Nokia phone that can only be used for calling and messaging needed less power during charging to full load capacity. Compared to the 4400mAh load capacity such as the Smartphone and iPhone that uses many features such as WhatsApp and Instagram consume higher power during charging to full load capacity. For 10,000 mAh the power bank uses high power to reach full load capacity but took almost the same time to charge the same as the 4400 mAh. In this study, we had shown that the capability of the solar panel to harvest solar energy with efficiency of 12.75%.

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