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Mini Solar Power Supply for Night Market Hawker

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Abstract: A mini solar power supply is a power supply unit that can generate electricity and provide power within a specified time frame. Hawkers require electricity to operate their night markets, so a traditional generator is used to generate electricity. The traditional generator is large and cumbersome to transport. In addition, traditional generators required petrol to operate, which increases the cost of fuel for hawkers, and the disadvantage of using fuel is that it produces smoke, which contributes to air pollution. Hence, a mini solar power supply could be the answer for hawkers, as it does not require any fuel and lightweight. This project aims to replace the use of traditional generators to generate electricity for night market operations by night market hawkers. The main goals of this project are to develop a mini solar power supply using a solar photovoltaic panel to power USB ports, LED lamps, and other electrical appliances. A 12V battery was used to power the mini solar power supply, which was powered by a 50W solar panel controlled by a solar charger controller. In comparison to a traditional generator, solar energy was stored in a 12V rechargeable battery, and the mini solar power supply is lightweight. The developed system's results successfully demonstrated that the concept is viable and that it could be scaled up to a larger scale in the solar industry. The system has the potential to be useful in solar generator technology due to its energy autonomy and low cost.

Keywords: Mini Solar Power, Photovoltaic Panel, Solar Power Supply

1. Introduction

Renewable energy systems have captivated a great deal of interest over the last few years, as conventional energy sources are limited and there are several problems associated with their use, such as environmental pollution and high grid requirements [1]. Renewable energy is generated from naturally abundant sources such as sun, wind, biomass, etc. It is, therefore, regarded as an eco-friendly form of energy that has zero to minimal amounts of CO_2 emissions. Renewable and alternative energy

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has great potential to replace the dependency on fossil fuels, the progress of bringing it into the mainstream has been slow in most developing countries [2].

In recent years, solar energy is becoming more popular as the renewable energy source that could change the future. It is available in abundance and its usage does not harm the environment with greenhouse gas emissions [3]. As the world is more depending on technology, there is greater dependence on finding mobile power to sustain this technology. Malaysia is no exception, introduced several measures in its 8th Malaysia Plan during 2001 for rapid RE integration to its national grid [4]. According to the Malaysian Investment Development Authority (MIDA), thriving renewable energy technologies in Malaysia include solar energy, hydroelectric and biomass. However, compared to most renewable energy technologies, recent developments in solar photovoltaic (PV) systems have led to its phenomenal growth in Malaysia and across nations [5]. Malaysia experiences hot and humid weather with a generous amount of rainfall all year round due to its geographic location. It receives an abundant amount of solar radiation throughout the year, with most places having daily solar radiation mean of 4.7–6.5 kWh/m^2 [6]. Therefore, applications involving solar energy have also been gaining popularity in Malaysia due to favorable climate conditions of the country.

Hawkers need to use electricity for night market operation, therefore traditional generator used to generate electricity. Traditional generators require petrol to operate, this will cost hawker to buy fuel and the disadvantage of using fuel will cause smoke that led to air pollution. Hence, this device could be the solution for the hawkers since it does not cost any fuel and will not cause any air pollution. This project develops an alternative energy device which is Mini Solar Power Supply. The Mini Solar Power Supply is designed to optimize by capturing solar energy, storing it into a battery, and providing alternating current (AC) and most common direct current (DC) power for electrical appliances.

2. Materials and Methods

Developing of the mini solar power supply will be included the hardware and method used. The materials and methods used in this study are necessary to obtain the results and analysis of the system.

2.1 Materials

This project investigated the output from the forecast of the influence of sunlight energy accompanied by an automated system. Several factors need to be considered in order to obtain an optimal selection of solar cell panel, battery bank, and charge controller. Failure to do so will result in an undersized or oversized PV system, which will have a negative impact on the future use of solar cells in addition to being a financial waste. The main component of this project were 50 W solar panel, 12 V 12 Ah battery, 10 A solar charger controller and 200 W inverter.

2.2 Methods

Selection of component is important in this research as it would determine the size of the system. The mini solar power supply system is illustrated in Figure 1. The photovoltaic is designed in such a way to make it portable. The mini solar power supply is lightweight, and the design is compact which is more compact, compared to petrol generator. Photovoltaic panel is used to convert solar radiation into electric power. The type of solar panel used was monocrystalline due to the process to make it simpler and high efficiency [7]. The battery used is lead acid 12 V (12 Ah) for 2 hours autonomy. The maintenance cost of the solar generator is low, where only the battery needs to be changed once every three to four years. The solar charge controller used in the study is 12 V (10 A) to charge the battery and to protect the inverter.

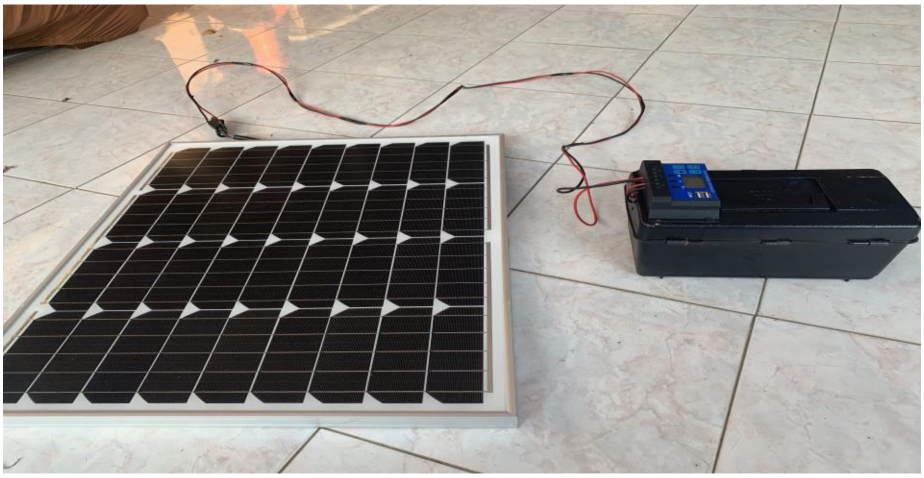


Figure 1: Mini solar power supply

2.3 Equations

A battery is required when using a solar panel because it stores energy during the day. The elements of the number's hours must be considered when choosing a battery to ensure that it can be used when there is no sunlight or at night. The battery time can be calculated by dividing the battery's stored energy by the load. It can calculate the battery charge time to charge by a solar panel after selecting the battery capacity and solar panel. The battery charge time can be calculated by dividing the battery capacity by the maximum current solar panel. The equation to calculate rating solar and battery selection as below [8][9]:

i. **Energy Consumption, Wh**

$$Wh = Watt\ of\ Load \times Hours \qquad \text{Eq.1}$$

ii. **Battery Capacity Needed for the System Ah**

$$Battery = \frac{Total\ energy\ consumption\ a\ day}{Battery\ loss \times Depth\ of\ discharge \times Nominal\ battery\ voltage} \qquad \text{Eq.2}$$

Battery loss= 0.85
Depth of discharge= 0.6
Battery voltage= 12 V

iii. **Energy Stored by The Battery, Wh**

$$Wh = Voltage\ of\ Battery\ (V) \times Capacity\ of\ Battery\ (Ah) \qquad \text{Eq.3}$$

iv. **Battery Time, h**

$$Battery\ time,\ h = \frac{energy\ store, Wh}{load, W} \qquad \text{Eq.4}$$

v. **Charging Current, A**

$$Charging\ current = proposed\ ampere\ hour\ rating\ battery \times \frac{10}{100} \qquad \text{Eq.5}$$

vi. **Battery Charging Time, h**

$$Charge,\ h = \frac{Proposed\ Ampere\ hour\ rating\ battery}{Charging\ Current} \qquad \text{Eq.6}$$

Charge controllers control the flow of energy from solar panels to batteries. A solar charge controller manages the power from the solar array that goes into the battery bank. It ensures that the deep cycle batteries are not overcharged during the day, and that power does not flow backwards to the solar panels overnight, draining the batteries. The equation to calculate solar regulator as below [10]:

i. Solar Charger Controller

$$SC\ Controller = (Number\ of\ Solar\ panel \times short\ circuit\ current) \times 1.3 \quad \text{Eq.7}$$

DC voltage is converted to AC voltage by inverters. They have a battery system that provides enough backup time to supply electricity. The inverter system then uses electronic circuitry to convert the battery voltage to AC voltage. During utility power, the inverter system has a charging system that charges the battery. During utility power, the inverter's battery is charged, and power is delivered to the loads at the same time. When the utility power goes out, the battery system starts supplying power to the loads via the inverter. For the inverter, the rating should be multiple by 125% for the excess power. The equation to calculate solar regulator as below [11]:

i. Inverter rating

$$Inverter\ rating = (load \times 125\%) \quad \text{Eq.8}$$

3. Results and Discussion

This section is organized based on the result and analysis from the conducted methodologies from subtopic 2.1 and 2.2, respectively.

3.1 Design of the project

In order to develop a hardware system, it is critical to sketch a prototype design. Sketching will aid in the discovery of the best concepts and solutions to design problems. Sketching also aids in the organization of the arrangement component. It will have a problem if there is no sketch, and the prototype concept will become disorganized. Sketching is an essential part of the design process when creating a prototype. Figure 2 shows the design of the real project.

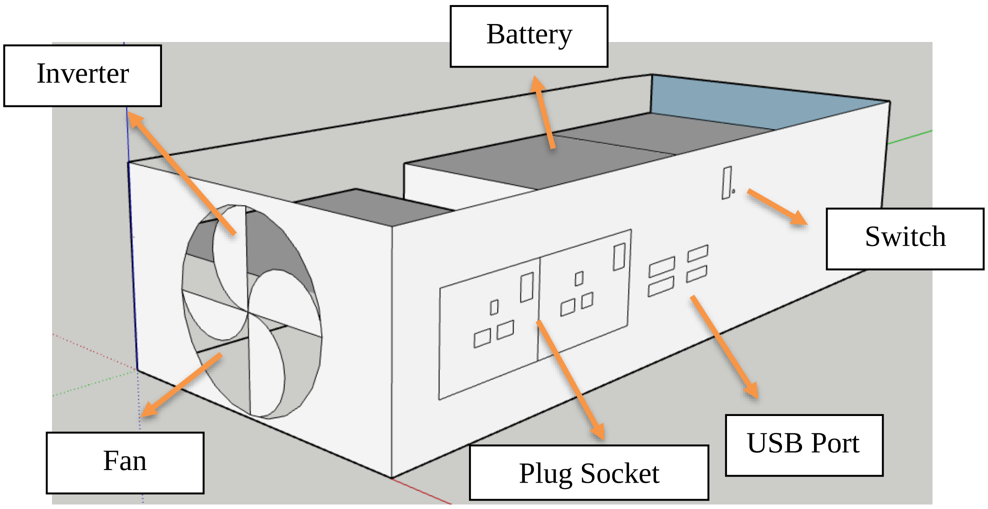


Figure 2: Overview of the design real project

3.2 Hardware prototype

The system prototype was successfully completed by following the design that had previously been completed using SketchUp. It is easier to develop the system when it is designed, and it is also easier to locate the items in the system when it is designed. The measurements taken when designing the system make it easier to cut and avoid mistakes during the process. The mini solar power supply is powered by a 12V battery with a solar panel to charge the battery as shown in Figure 1. It also was design to be lightweight and compact to carry by the night markets hawker. For the supply part, solar energy is used to charge the battery, and hawkers can carry the power supply to the night market as electrical sources. The functionality test of the developed prototype work has been carried out on real scenarios and the overall system works well.

3.3 Load consumption for prototype

The load calculation for the prototype of this project is shown in Table 1 below, and the component used is only for the prototype because the component's price is within budget.

Table 1: Assumption of load consumption by the night market hawker

Item	Estimated Power (W)	Quantity	Total load	Duration (hours)	Wh/day
LED DC 12V tube light	10	1	10	2	40
Stand fan	20	1	20	2	40
Small load (mobile charger and radio)	20	1	20	2	20

From the Table 1, the items are commonly used by the night market hawkers. The estimate total connected load is 50W, and the load used per day is 210Wh. By the estimating total load, components that will be used could be calculate. Table 2 shows that the PV sizing system of prototype and real project. Due to budget constrain, battery 12 V 12 Ah was chosen for the prototype.

Table 2: PV sizing system

Calculation	Prototype sizing system	Real project sizing system
Energy Consumption, Wh	100	5500
Battery, Ah	16.34	898.69
Energy Stored, Wh	144	12000
Battery time, h	2.88 = 3	10.91 = 11
Charging current, A	1.2	100
Charging time, h	6	10
Solar charger	3.98 A	42.24 A
Inverter rating	63 W	1375 W

3.4 Data of solar panel output

The test was used to evaluate the solar panel's output voltage and power output of solar panel to charging 12V batteries. SCC and optical multimeter were used to calculate the output voltage of the solar. The research took place on 2 June 2021 in Muar and solar panels generated data from 10:00 a.m. until 5.00 p.m. Table 3 subsequently shows the reading of voltage reading during the charging of the battery by the solar panel.

Table 3: Data of output solar panel

Time	Voltage(V)	Current(A)	Power(W)
10:00 a.m.	13.6	2.79	37.94
11:00 a.m.	14.9	2.8	41.72
12:00 p.m.	16.7	2.81	46.93
1:00 p.m.	16.5	2.81	46.37
2:00 p.m.	15.5	2.8	43.4
3:00 p.m.	14.8	2.8	41.44
4:00 p.m.	14.1	2.8	39.48
5:00 p.m.	13.2	2.79	36.83

Figure 3 shows the graph of output voltage against time. The reading value were taken every hour to obtain more accurate data. This testing was conducted at Muar, Johor. Based on the results, the minimum value of power output was 37.09W and the maximum reading of output power was at 12:00 p.m. ,46.93W. The solar panel could generate maximum output voltage at 16.7V and minimum 13.2V.

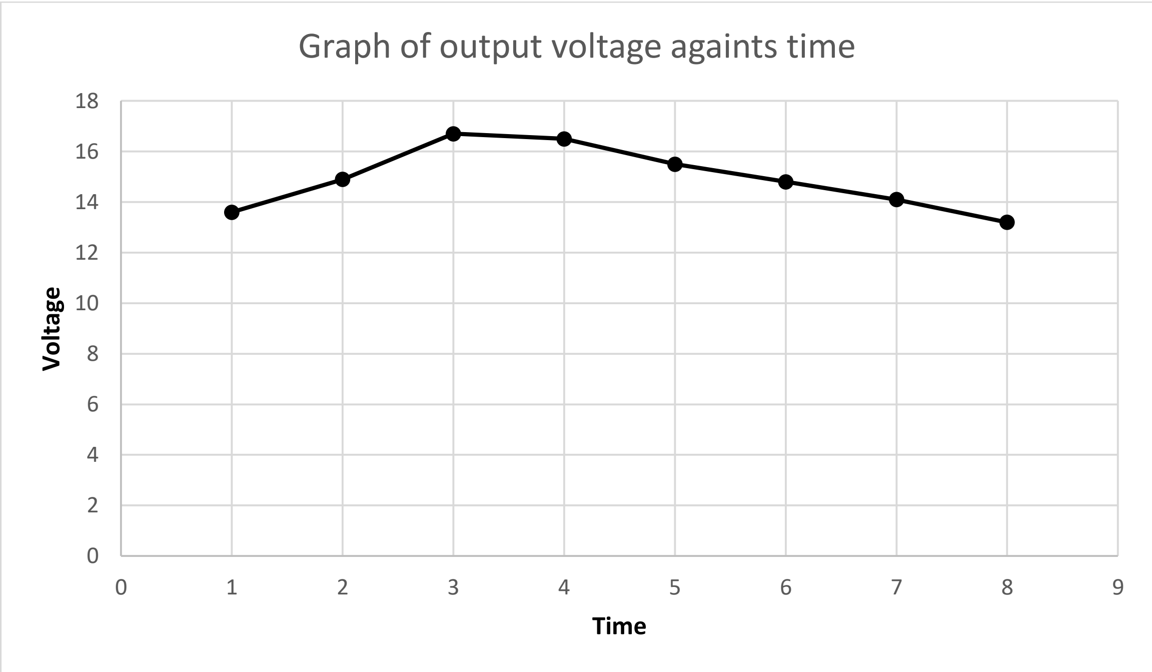


Figure 3: Graph of output voltage against time

Figure 4 shows that the minimum value of current output was 2.79 A and the maximum reading of current output was at 12:00 p.m., 2.81 A. The solar panel could generate maximum current output at 2.81 A and minimum 2.79 A

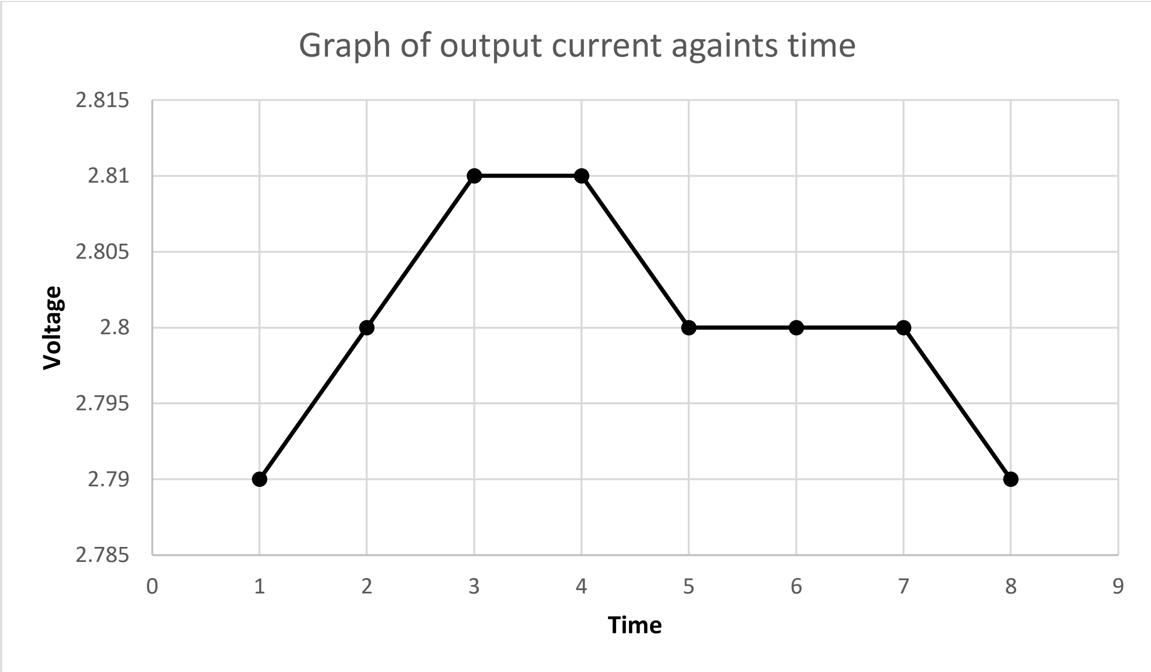


Figure 4: Graph of output current against time

Figure 5 shows the reading of output power generated by the solar panel with specification 18V/50W and the value was taken from 9 a.m. to 5 p.m. The output power generated increasing until it reaches at 12:00 p.m. because, at this hour, the sunlight produces the highest solar irradiance.

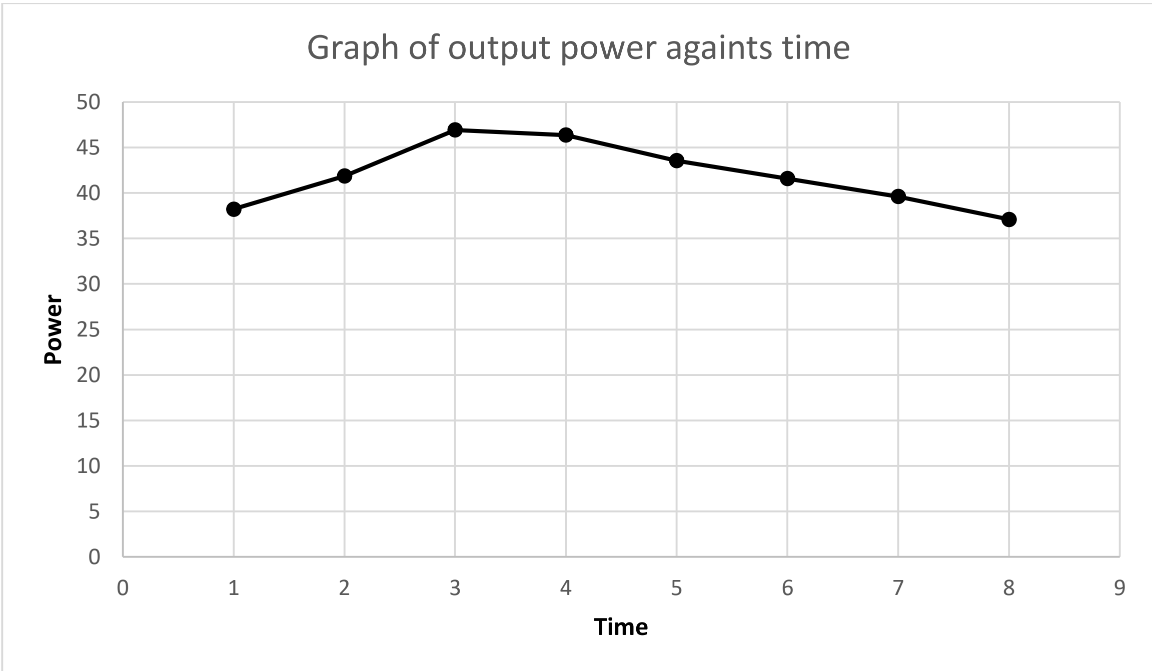


Figure 5: Graph of output power against time

This was an incremental change due to the solar panel starting to receive maximum sunlight at 12 pm. This is because the sun should be at the highest point in the sky at 12 pm [11]. And the entire area of the solar panel will receive solar illumination. However, the output power started decreasing by the evening. This monitoring test was performed in this research. This indicates that the reading sample has properties that are closely related to the amount of sunlight. Table 4 subsequently shows the reading of voltage reading during the charging of the battery by the solar panel

Table 4: Data of output prototype

Time	Voltage(V)	Current(A)	Power(W)
7:00 p.m.	12.6	9.8	123.5
7:30 p.m.	11.4	9.6	109.4
8:00 p.m.	10.5	9.2	96.6
8:30 p.m.	9.6	8.8	84.4
9:00 p.m.	8.7	8.4	73.1
9:30 p.m.	7.6	7.9	60.0
10:00 p.m.	4.5	6.5	29.3
10:30 p.m.	0	0	0

The reading value were taken every 30 minutes to obtain more accurate data. This testing was conducted at night to test the mini solar power supply could be used at night for night market operation. Based on the results shown in Figure 6, the voltage start decreasing when the load was connected to the power supply and stop supply voltage at 10.30 pm. The mini solar power supply maximum output current was 9.8 A and slowly decreasing with time as it run out of battery.

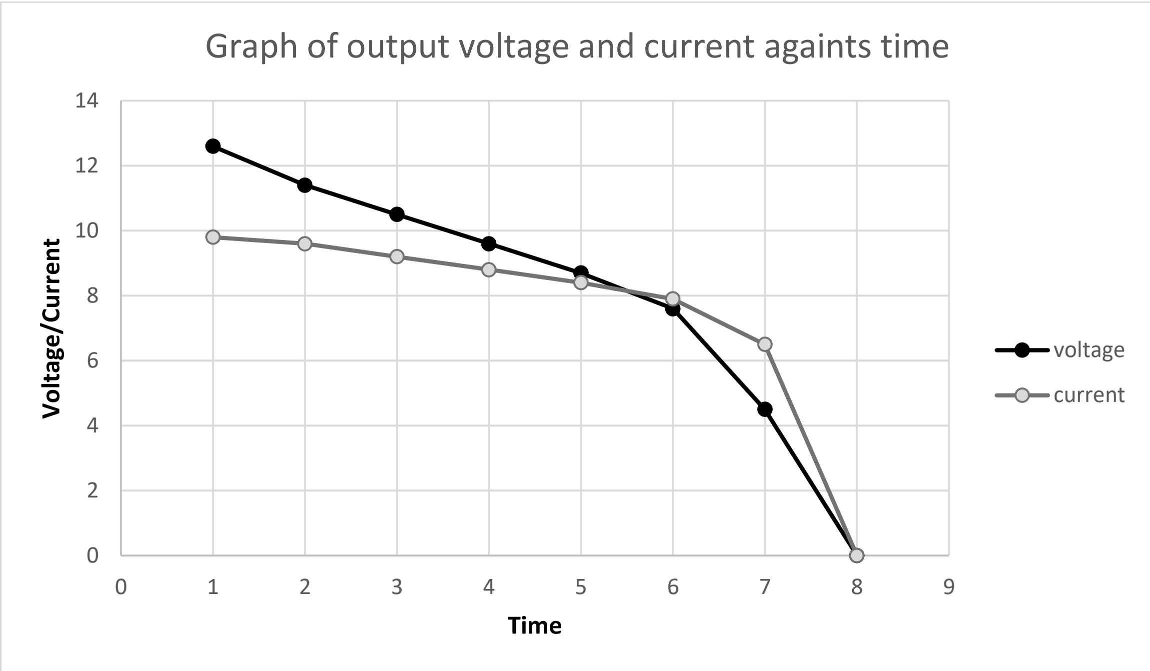


Figure 6: Graph of output voltage and current against time

Figure 7 shows that the output power generated by the mini solar power supply could supply to the load for around 2 hours and slowly decrease until it reaches the limit time to supply power. From all the data gathered, mini solar power supply objective has been achieved which could supply power for 2 to 3 hours standby for the night market operation.

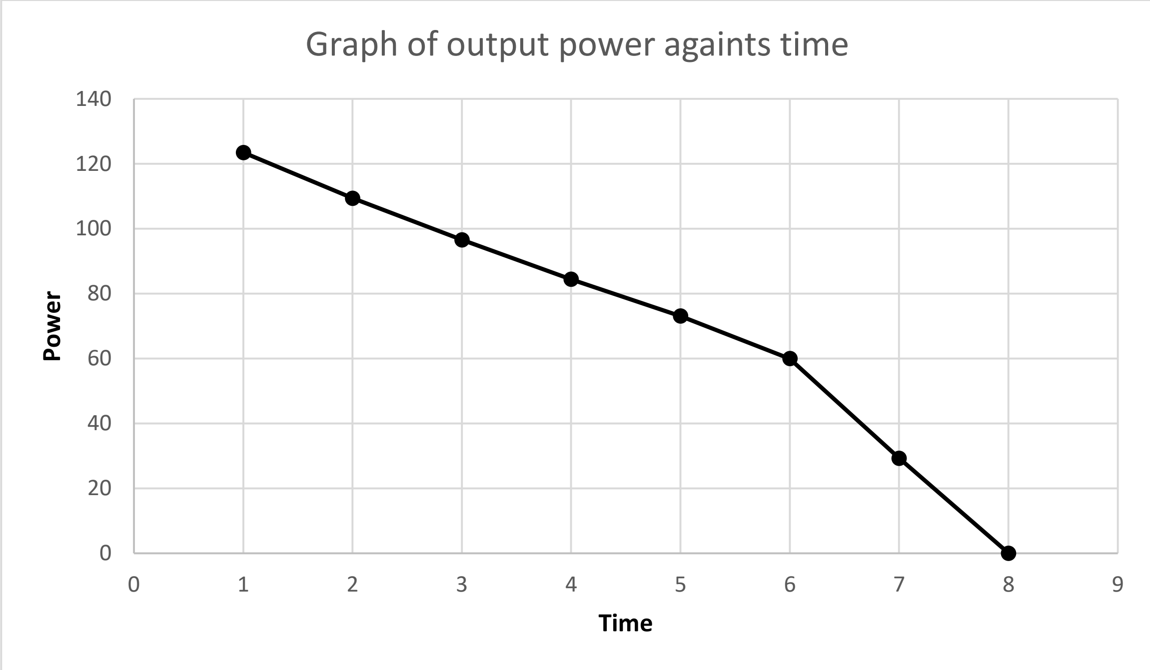
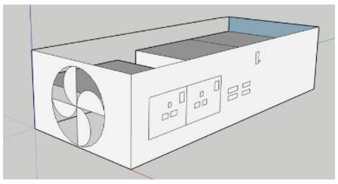


Figure 7: Graph of output power against time

From Table 5, the cost for the real project is cheaper compared to traditional generator and both generators can generate 5500 Watt. Traditional generator required maintenance regularly which mini solar power supply does not require maintenance. Hence, mini solar power supply has lower cost compared to traditional generator.

Table 5: Comparison between real project and traditional generator

Real Project	Diesel Generator
 • Costing for the project, RM 3,060 • No fuel consumption • Only need to change battery every 3 to 4 years.	 • Market price between RM 3,500 to RM 4,000 • Diesel consumption per day, RM 30 • Require maintenance regularly

4. Conclusion

In conclusion, the analysis about mini solar power supply for night market hawker have been analyzed and investigated. The procedures to design mini solar power supply has been clearly explained. This project consists of solar energy study and the output power of solar panel. The performances of the mini solar power supply, such as output power and output voltage have been investigated. Solar power supplies enough energy to drive the system and the battery to ensure the system can be operated for night markets hawker operate their business. The results revealed that Mini Solar Power Supply were focused on to supporting night markets hawker and users to reducing their workload, help to reduce the time limit, minimize energy usage, and decrease expenditure. Finally, the proposed Mini Solar Power Supply is suitable for various application with various performance.

Acknowledgement

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