Design and Performance of 20 Watts Portable Solar Generator

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Abstract. A new portable solar generator has been developed to generate electricity. It has the potential to replace petrol generator, widely used by peddlers at night markets *(pasar malam)*. Conventional generators are heavy, oily, have high maintenance and use fossil fuel to generate electricity. The solar generator can generate 20 Watts of electricity. This amount of power can supply up to 96 hours of electricity for the purpose of lighting and running small electrical appliances. The power output is (alternating current) AC current using 150 Watts inverter with 200 Watts surge, suitable for all commercial single phase electric appliances. Solar charge controller is used to maximize the charging rate and to protect the battery. The system has low maintenance whereby the batteries need to be changed every three to four years, depending on the usage. The main concepts of portable solar generator are to reduce installation cost and to introduce a compact design of an optimal energy sizing system. The materials used to develop the solar generator can be easily obtained from local markets, thus reducing the cost of developing the system and making it suitable for commercialization.

Keywords: photovoltaic, solar charge controller, inverter, battery

1. Introduction

Energy has become important in life nowadays. The fluctuation of energy price can affect daily human activities which contribute to political and economic stability [1]. This is due to the decline in energy sources from fossil fuel [2]. Fossil fuel pollutes the environment and increases global temperature [3][4]. Solar energy however is not popular in Malaysia. About 99 % of energy consumed in 2008 was produced from fossil fuel and hydro power [5]. The main problem with the solar system is that the price is still high in comparison to conventional energy source [6].

Generators are widely used if electricity from the grid is not available. Generators are used by hawkers such as at night markets (*pasar malam)* in Malaysia. Business at night markets in Malaysia usually starts at 5 pm until 10 pm in the evening. The main problem with generator is it needs petrol or

diesel to generate electricity. Furthermore, the generator requires maintenance and periodical servicing. Besides releasing gaseous pollutants, generators are also noisy, oily, heavy and consume space during its operation. In Malaysia, the demand for solar technology increasing due to the government support toward green technology. The cost of installing the grid connected photovoltaic system has increased to 29% in Malaysia [7], and for the stand alone system the cost is much higher due to extra wiring and energy storage. The objective of this research is to develop a portable solar generator using 20 Watts photovoltaic panel by combining two units of 10 Watts solar panel via a compact design. Solar generator is categorized as a stand alone system in which only the photovoltaic panel is used to provide energy to the battery.

2. Procedure

Selection of component is important in this research as it would determine the size of the system. The portable solar generator system is illustrated in Figure 1. The photovoltaic panel power is 20 Watts. Two sets of photovoltaic panels are used; each panel contributes 10 Watts power and they can be flipped or opened during charging. The photovoltaic power can be increased by using a photovoltaic extension port. It is designed in such a way to leave more space for storage and also to make it portable. Holders are placed on both sides of the system. The total weight of the system is 14.3 kg and the design is cubical with a dimension of the container are 26.0 cm (L) × 31.0 cm (W) × 22.0 cm (H), which is more compact, compared to a 650 Watts petrol generator which size approximately 36.6 cm (L) × 30.8 cm (W) × 37.6 cm (H). Photovoltaic panel is used to convert solar radiation into electric power. The type of solar panel used was polycrystalline due to its low cost and suitable for Malaysia climate. The battery used is lead acid 12 V (40 Ah) for 4 days 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 (5 A) to charge the battery and to protect the inverter.

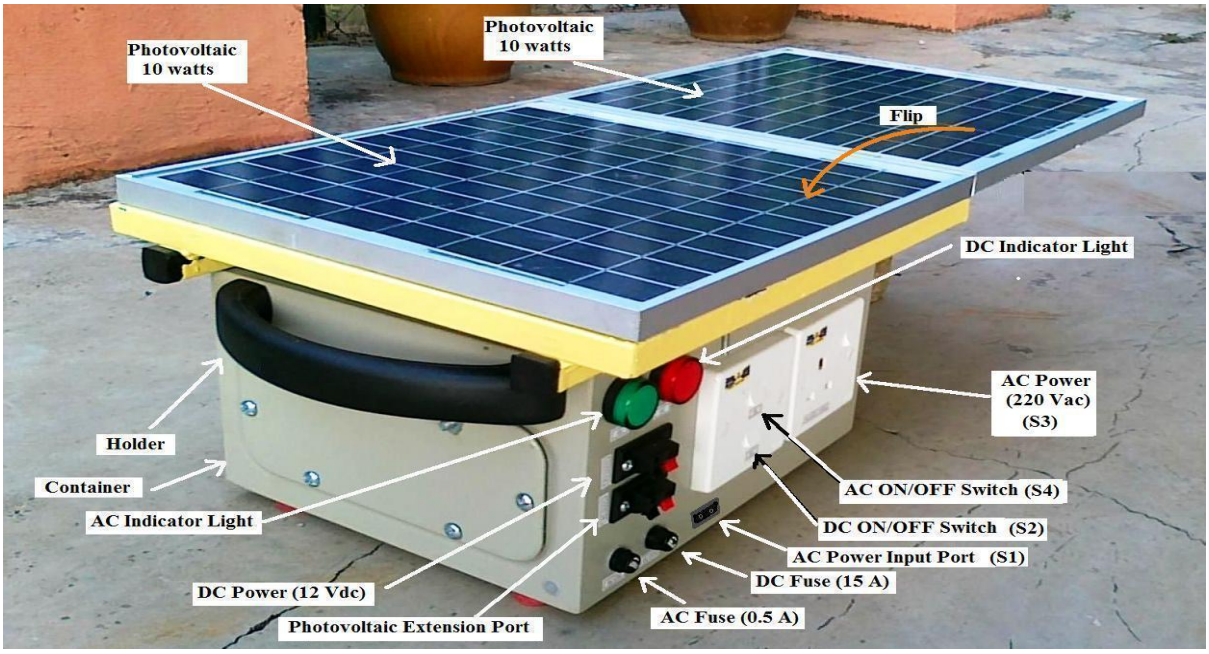

Figure 1. A 20 Watts portable solar generator

The schematic diagram of the system is shown in Figure 2. The power output of the system can be used to power the (direct current) DC and AC load simultaneously. The DC output is 12 Vdc and protected by a 15 A fuse. The AC output is a single phase 220 Vac modified sine wave using a 150 Watts peak powerinverter with a 200 Watts surge and is protected by a 0.5 A fuse. The main fuse current is 20A and is used to protect the battery and the inverter. If the solar radiation is too low because of bad weather, the system can be charged using electric power from grid by changing switch S1 at AC power input port. Switch S2 is used to switch the DC power and switch S3 is used to switch the AC power. The inverter needs to be disconnected using switch S4 from solar charge controller for the purpose of energy saving. In this research, the performances of the solar generator as well as the optimum operations were evaluated. The experiment was divided into two parts. The first experiment was conducted to obtain the maximum daily power output by the photovoltaic system while the second experiment was carried out to determine the system performance using variable loads. The load used was between 5 to 150 Watts. Temperature can affect the photovoltaic panel efficiency which can decrease the power gain [8]. The automatic fan was used to remove the heat generated by the photovoltaic system. The battery temperature was maintained at a temperaturebelow 35 °C during operation. Temperature higher than 35 ^{o}C could damage the battery or decrease the system's efficiency.

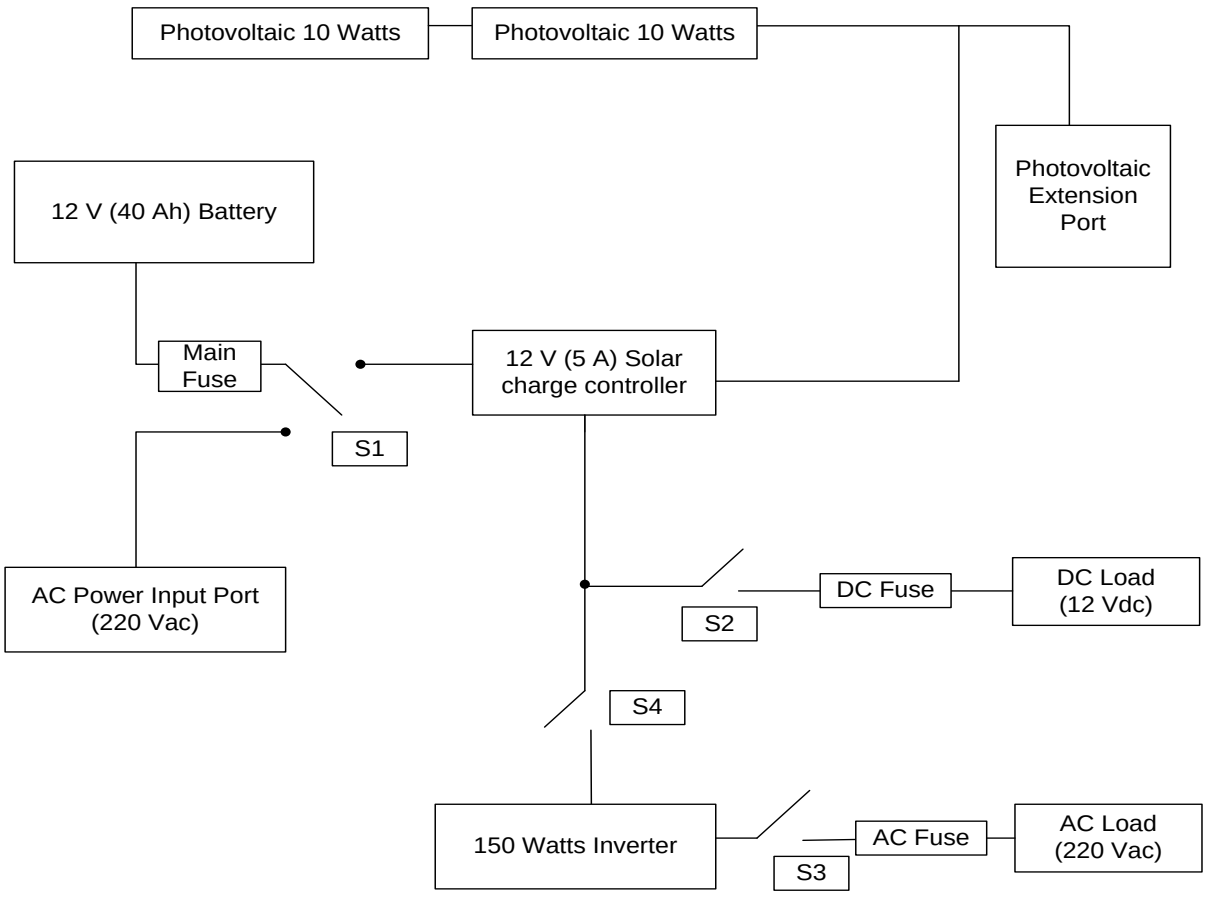

Figure 2. A 20 Watts portable solar generator schematic diagram

3. Analysis

Experimental results were obtained by using ADAM VIEW Programme. The maximum daily performance of the photovoltaic panel is shown in Figure 3. The maximum energy gain by 20 Watts photovoltaic panel was 153.1 Watts-hour. The maximum power of photovoltaic panel that could be added to the system is 60 Watts in total. This would contribute to the maximum daily energy gain of up to 459.3 Watts-hour. Since the daily average solar radiation in Malaysia is between 4 to 6 hours, the power gained by the system can be affected. Therefore, in order to get sufficient energy, the photovoltaic size should be increased. As the photovoltaic panels are almost flat, it issuggested that the collectors should be facing south in the northern hemisphere and facing north in the southern hemisphere [9]. This situation however will not affect the power gain in Malaysia because Malaysia is located near the equator. The total power gain throughout the year will not give any big difference [1].

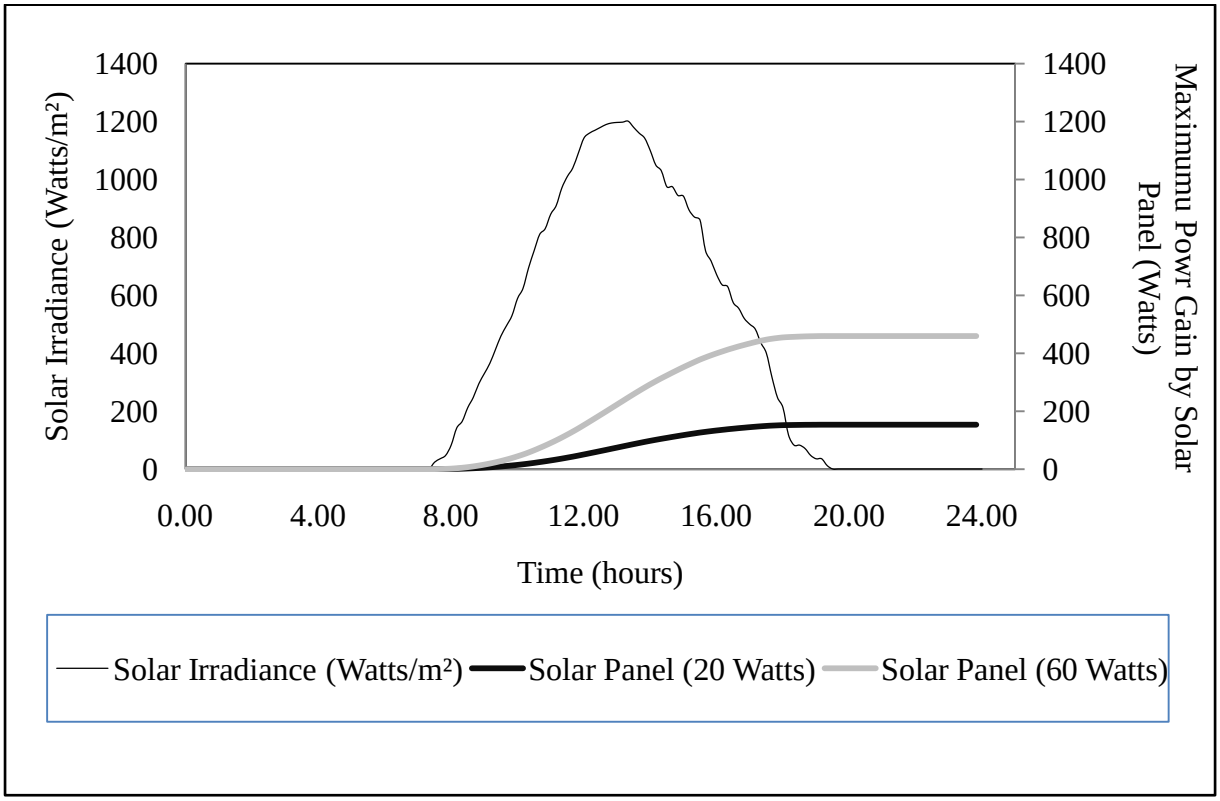

Figure 3. Maximum power gain by photovoltaic at maximum daily solar irradiance

Figure 4 shows lower load would increase the duration of the solar generator operation time. This can be explained by the gradient of the graph which increases by increasing the load. For 5 Watts load, the solar generator can be operated up to 96 hours, but reduces to 2 hours for load of 150 Watts. The energy generated by the battery cannot be completely discharged. It can reduce the battery life, and normally the battery should remain for at least 30 % of energy. The battery can be protected by using an inverter because the threshold voltage is set at 10.5 V, which will stop operating if the voltage of the battery drops lower than the set value. For DC power, the battery is protected by the solar charge controller which will stop operating if the voltage drops to 8 V. The solar generator is suitable for lighting at night market using a 40 Watts energy which can last for 3 to 4 hours.

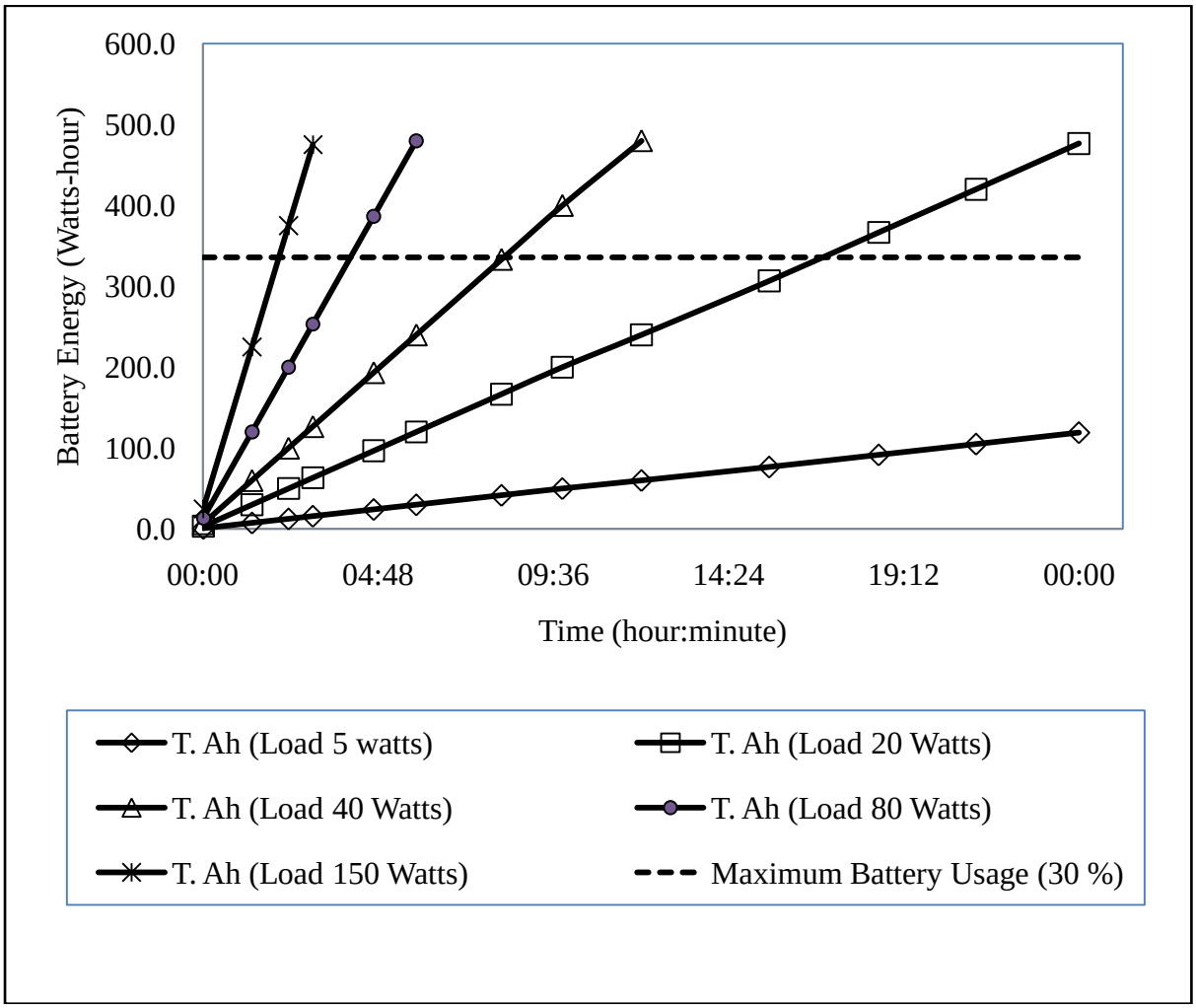

Figure 4: Load and time of operation of the portable solar generator

The main concept of solar generator is to reduce the installation cost. The installation can be done at a factory and the materials used to develop the system can be obtained from local market, thus reduces the cost of developing the system. This would make the solar generator very marketable. Besides night market, the product can be used at home or for outdoor activities such as camping or picnic. It also can be used by army, fire engine, police car and ambulance as backup power supply. However, the solar generator cannot compete with petrol generator in terms of energy output based on size. For instance, petrol generator can produce a maximum power of 650 Watts, which is the power commonly used for lighting and running fans at night market. The major drawback of petrol generators is the need for fuel for operation. A petrol generator consumes an average of 4.2 liter fuel for 8 hours operation. At night market, petrol generators are run for at least 3 hours and the cost of the petrol is RM 3/day or about RM 1100/year. As a comparison, the battery of portable solar generator costs around RM 340 and can be used up to four years. The payback value for portable solar generator is less than a year compared to petrol generator; therefore portable solar generator is more economical. Furthermore a portable solar generator can permanently store its energy without the need to warm up.

Solar generator is categorized as stand alone system and is more realistic compared to grid connected photovoltaic system in generating power from the sun and converting it into electricity. The energy comes from the photovoltaic system and stored into the battery, thus creates a greater awareness concept especially on the energy usage. Grid connected photovoltaic system however presents a concept of selling and buying energy, and at the same time being used to support the grid system especially during peak hours. This kind of practice does little to energy saving concept. Furthermore, the power generated by the grid system is always higher than the demand [10].

4. Conclusion

The portable solar generator has the potential to replace petrol generator in future especially for lighting and running small electrical appliances. The maintenance cost is low with only the battery needs to be changed once every three to four years. It is small, lighter and portable making it easy to store and suitable for use at home or night market and as backup energy supply.

5. Acknowledgment

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