Portable Green Energy Mobile Laptop Charging Station

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Abstract
Mobile phones and laptop computers require electrical power to recharge when the battery is down. As a result, it would be very useful if a portable charging station derived from renewable energy harvesting could be built, so that individuals could recharge their phones and laptops whenever needed. The objective of this project is to design and develop a green energy mobile and laptop charging station that uses wind and solar energy and evaluate the performance of the designed station under different working conditions. The efficiency of the power generated to charge the station is achieving 95.6% for solar charging, which is considered a high efficiency for a renewable energy charging station. Based on the analysis of the charging station results, it has been proven that it can provide sufficient power and is safe for use as a portable mobile laptop charging station.
Keywords: Energy conversion, Portable power supply, Universal mobile laptop charging

1. Introduction

Electricity is a vital part of modern life and for a country's economic growth and development. Over the next two decades, average power consumption is predicted to nearly double, with overall electricity demand expected to rise by 2.3 percent per year on average from 13,290 billion kWh in 2001 to 23,072 billion kWh in 2025 [1]. In Malaysia, home electric power consumption has grown substantially over the past years, resulting in high demand for energy to satisfy increasing social and economic activities.

Fossil fuels are the most famous resources used. However, these fuels are creating huge carbon emissions to the atmosphere which has negatively impacted the environment. As the demand for electric power rises, additional power generation is required to meet the demand. Due to the depletion of conventional resources, renewable energy resources are the most suitable resources for generating electric power with little environmental effect. Renewable or non-conventional energy are tidal energy, wind energy, hydropower, biomass, geothermal energy, and solar energy [2]. It also contributes to the achievement of Sustainable Development Goal 7 (SDG7), which calls for universal access to sustainable and renewable energy by 2030.

This project's goal is to create a portable dual-source charging station that can charge mobile phones and laptops using both solar and wind energy. A hybrid power system is a system that combines two or more renewable energy sources to provide continuous energy generation to fulfil load needs. Researchers have discovered that a combined solar and wind hybrid system is the most reliable and efficient, as well as being ecologically friendly and affordable in cost [3]. Several recent research [4], [5], [6] have combined two non-conventional sources to create a dual-mode portable mobile charger. Wind and solar hybrid systems for mobile chargers with minimal operating costs have been designed in this research. Additional components are necessary for laptop charging, which necessitates the use of an AC power source. When constructing a portable charging station for mobile and laptop devices, certain specifications and data are critical.

2. System overview

Major components of the system include power inverter, battery bank, system and battery controller, photovoltaic modules, wind turbines, and, in some cases, the prescribed electrical demands. Fig. 1 from MEDA [7] illustrates the system's basic working principle. The acquired energy from the wind turbine and PV array will be transformed into electrical DC power and stored in the battery bank. For the system under research, a monocrystalline solar panel and a vertical axis wind turbine are recommended. As compared to polycrystalline and thin-film solar panels, monocrystalline solar panels offer the highest efficiency of 15–20 percent [8]. According to the research [9], vertical axis wind turbines are more efficient to build and use in Malaysia's tropical and windy weather. A charge controller for wind and solar power is required to maintain your batteries properly supplied and avoid overcharging. For DC loads, the electric power stored in the battery bank may be utilized directly, however for AC loads, an inverter is required to connect to the battery bank. A power inverter is an electrical device that converts direct current (DC) from a battery bank to alternating current (AC). Finally, the system can be used to charge mobile phones and laptops.

2.1. *Fabricated prototype*

The prototype has been successfully built using polystyrene boxes, a plastic ammo box, and cardboard. The components of the prototype are labelled in Fig. 2 and listed in Table 1. Fig. 3 shows the complete fabrication of the prototype.

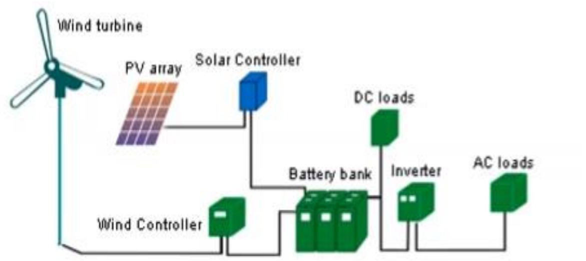

Fig. 1 A block diagram of Hybrid Solar-wind Energy system [7]

Fig. 2 Full components of prototype

Table 1 List of prototype components

No.	Component	Specifications
1	Power Inverter	200W
2	Dokio Solar charge controller	30A
3	PWM Solar Charge controller	10A
4	Battery Indicator Voltmeter	N/A
5	Dokio Solar Panel connector	N/A
6	SLA Battery	12V, 7.2Ah
7	Plastic Ammo Box	N/A
8	4-in-1 output panel	Voltmeter, switch, USB ports, 12V cigarette port

The portable charging station consists of a Dokio solar charge controller, a PWM solar charge controller, a battery indicator voltmeter, a 12V, 7.2Ah GP SLA Battery, a 200W power inverter, and a 4-in-1 output panel as shown in Fig. 4. All the components in the circuit are linked in parallel with the 12V 7.2AH SLA Battery,

Fig. 3 The completed prototype

Fig. 4 The charging mobile phone and laptop with using the charging station

ensuring that the station can function even if one of the components fails. A switch, voltmeter, USB ports, and a 12V cigarette port are all included in the 4-in-1 output panel. The charging station can be turned on and the mobile phones can start charging through the USB port, while a power inverter must be connected to the 12V cigarette port to convert power into AC power for laptop charging.

3. Result and Discussion

The system has been tested to evaluate the performance of the designed station. The equipment used in the experiments was an 80 W Mono-solar panel, a 100 W wind turbine, and a 1000 W halogen lamp to generate electrical power. Several experiments have been conducted and the data were recorded and analyzed to evaluate the performance of the designed station under different working conditions. A multi-meter has been used to measure the current and voltage output from the solar panel and wind turbine, and then the energy output over the state of the battery of the experiments have been measured by the charge controller. The experiments have

Table 2. Data collected for four different experiments conducted

Experiment	Trial	Average Voltage Generated (V)	Average Current Generated (A)	Charging Duration (Hour: minute)	Solar Irradiances (W/m^2)	Light Intensity (W/m^2)	Speed of Wind (m/s)
1	1	12.75	0.935	2:42	734.95	-	-
	2	12.67	0.873	3:01	679.46	-	-
	3	13.50	1.450	1:08	839.69	-	-
	4	13.24	1.140	1:36	837.85	-	-
	5	12.85	0.982	2:14	760.80	-	-
	6	12.72	0.955	2:38	745.23	-	-
2	1	12.41	0.340	18:18 (Not completed)	-	238.17	-
	2	12.62	0.450	24:25	-	451.99	-
	3	12.65	0.480	19:09	-	493.19	-
3	1	11.30	0.250	23:00 (Not completed)	-	-	3.0
	2	11.32	0.275	23:12 (Not completed)	-	-	3.3
	3	11.38	0.300	22:30 (Not Completed)	-	-	3.6
4	1	12.64	0.750	14:51	-	474.61	3.6

been conducted to fully charge the 12V 7.2Ah Sealed, Lead Acid Rechargeable Battery for each trial of experiments.

Experiments 1 and 2 are solar power charging for the designed station, with experiment 1 using sunlight to generate electrical power outdoor under the sun, whether experiment 2 is by utilizing a halogen lamp as the source of light to simulate the solar energy. The wind power charging for the station is evaluated with a power fan in experiment 3 to simulate the wind energy because of the low wind speed available outdoors. Experiment 4 is a hybrid solar and wind power charging system for the station, with a halogen lamp and a power fan used indoors to get more consistent and precise results. Table 2 shows the data collected for the four different experiments conducted.

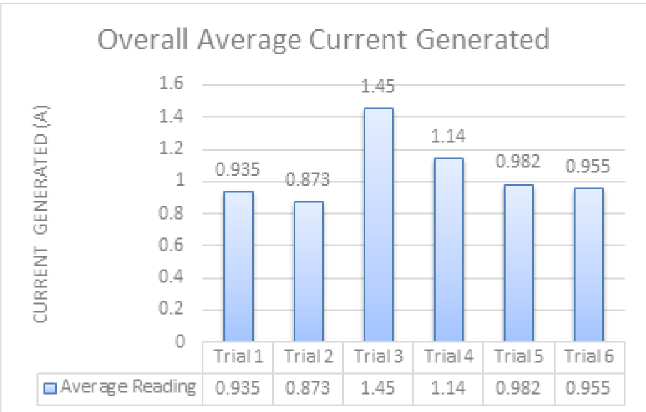

Fig. 5 Overall average current generated and solar irradiance for experiment 1

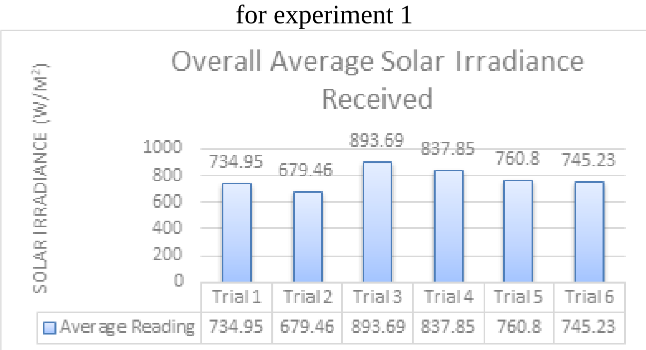

Fig. 6 Overall average solar irradiance received for experiment 1.

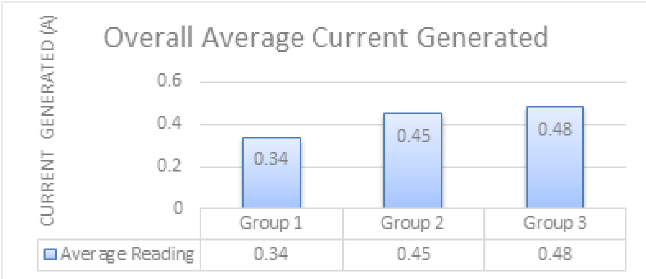

Fig. 7 Overall average current generated for experiment 2.

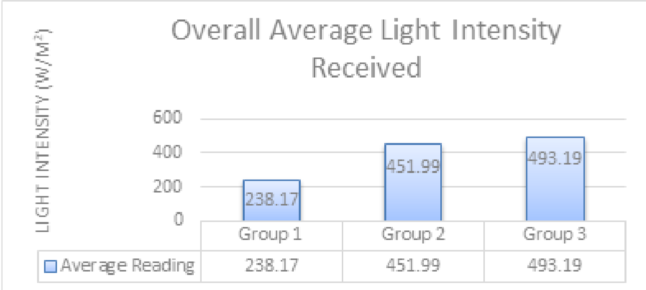

Fig. 8 Overall average light intensity received for experiment 2.

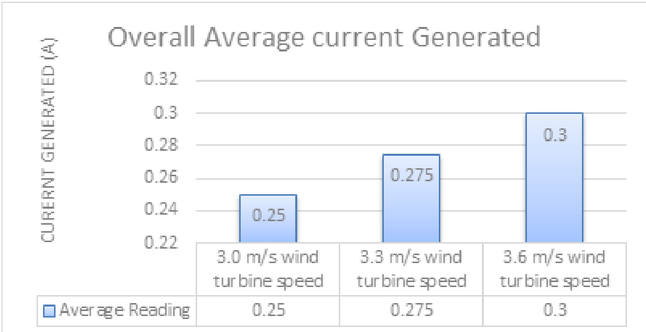

Fig. 9 Overall average current generated with three different speeds for experiment 3.

The average overall electrical current generated and overall average solar irradiances received for experiment 1 are plotted and illustrated in Fig. 5 and Fig. 6 based on the data obtained. In Fig. 7 and Fig. 8, the overall average current generated and overall average light intensity received for experiment 2 are plotted and shown. Fig. 9 illustrates the relationship between current generated and wind speed.

According to Fig. 5 and Fig. 6, it is shown that the higher the solar irradiances come the higher the current generation output result. The results reveal that even the lowest solar irradiation of 679.46 W/m2 can generate an average of 12.67 volt and 0.873 amperes.

Fig. 7 and Fig. 8 are showing that as the light intensity increase, the current generated and output power increase.

As the solar panel receives more light intensity from the halogen lamp, the current generated is increasing as well as the power output. Although the light source to the solar panel is stable, the current and power generation is respectively low which is not utilizing the sunlight that contains higher solar irradiances. As a result, it also corresponds to the research done by [10], whereby the current rises steadily with an increase in solar irradiances or light intensity.

Fig. 9 shows that when the wind speed increase, the current generated will also increase. However, it can still be observed that the current is increasing with the speed of wind increase which gets a maximum of 0.3A with a 3.6 m/s wind speed. As a result, it can be concluded that the greater the wind speed, the greater the magnitude of the current.

From Table 2, it is shown that an average of 0.75A is generated with an average light intensity of 474.61 W/m^2 and a constant speed wind of 3.6m/s. The results have been taken when both solar and wind harvesting systems are working together to charge the station. The duration to fully charge the station is around 14.85 hours which is faster than experiments 2 and 3.

The duration to fully charge the battery is also dependent on the renewable power supply. The higher the power supply to charge the station, the shorter the duration of the battery to be fully charged. The fastest battery of 7.2 Ah capacity could be fully charged in around 68 minutes with a charging current of 1.45 A. To protect the battery, the battery is recharging at 12 V which is around 50 % to avoid irreversible damage occurring. The fully charged battery can fully charge an iPhone 11 with a battery capacity of 11.9 Wh for 5.5 cycles and an Asus gaming laptop with a battery capacity of 48 Wh for 1.8 cycles.

3.1. *Result comparison*

The average experimental results from experiment 1 through experiment 4 are plotted and illustrated in Figure 10. The average result is calculated by averaging the measurements based on the state of charge of the battery, which acts as a comparison point. This is because the charge controller will supply power following the battery's status, which means that the power delivered will gradually grow following the status of the battery to prevent the battery from being damaged.

According to Fig. 10, experiment 1 is the most efficient

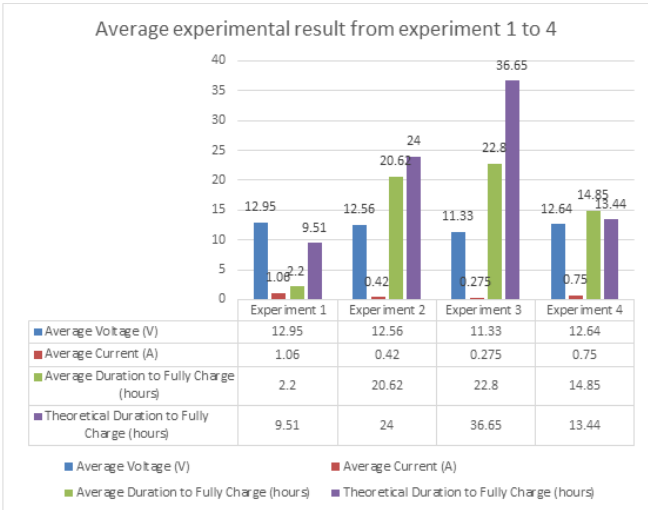

Fig. 10 Average experimental result from experiment 1 to experiment 4.

way, taking just 2.2 hours to fully charge the station with an average voltage of 12.95V and a current of 1.06A. It took around 7.31 hours less time than the expected result based on calculation. Even though the readings fluctuated during the experiment, it was still the most efficient method for solar charging when compared to experiment 2 which utilized a halogen lamp as the light source.

From Fig. 10, experiment 2 took an average of 20.62 hours to completely charge the station battery, which is around 18.4 hours longer than experiment 1. With an average of 12.56 V and 0.42A, the power generated was likewise significantly lower than experiment 1. It took around 3.38 hours less time than the expected result based on calculation. As a result, the most effective approach for successfully charging the station batteries for the solar harvesting system is charging with a solar panel directly under the sun, which will maximize the power generated among other methods.

Due to the low wind speed available in Malaysia, experiment 3 aims to see how much power can be generated at various wind speeds. It only can generate an average of 11.33V and 0.275A, which only charged station batteries to 60% in an average of 22.8 hours. This is because the charge controller utilized for the wind harvesting system is a solar charge controller, resulting in the charge controller power output being unstable and low. Furthermore, the solar charge controller is only designed for solar power systems with electrical characteristics that differ from those of wind power, resulting in low power received to charge the station. As a result, by adopting an appropriate wind charge controller, the wind power charging system may be more effective.

Experiment 4 feeds the station using both solar and wind harvesting technologies. It aims to see if operating the combined harvesting system at the same time as charging the station is more efficient than working independently. According to Figure. 10, the result showed an average of 12.64V and 0.75A, and it took an average of 14.8 hours to fully charge the station. However, the required duration to completely charge took 1.41 hours longer than the theoretical calculation. This outcome might be impacted by the fact that an inappropriate charge controller is used for a combined solar and wind harvesting system that prolongs the duration to be fully charged. As a result, it can be proven that the combined solar and wind harvesting system has a better performance than a system that only harvested wind or solar.

4. Conclusion

In summary, the design of a mobile dual source charging station, by using wind energy and solar energy, has been fabricated with several materials such as polystyrene boxes, cardboard, and plastic ammo toolbox. The performance of the designed station under different working conditions was investigated and evaluated using handphone and laptop as load. Based on the comparison, the designed station has the best performance when both solar and wind harvesting systems are working at the same time. Therefore, this study is promising to develop a clean energy portable charging station that is environmentally friendly and able to act as a charging station when there is no power supply available.

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