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Development of Hybrid Solar Photovoltaic and Wind Energy Powered UPS System for Small Loads Supply

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Abstract: One of humanity's greatest desires today is for reliable and sustainable electricity. Conventional, non-renewable energy resources (e.g., coal, nuclear) have been used to generate electricity for many years. However, with constant use, these resources were depleting. This prompted a shift in focus to renewable energy sources such as wind, solar, and tidal energy, among others. As a result, the goal of this project was to Develop a Hybrid Solar Photovoltaic and Wind Energy Powered UPS System for Small Loads Supply using renewable energy sources, namely wind and solar energy, to generate reliable and sustainable electricity. To accomplish this, a wind turbine was built to convert wind energy to electric energy, and a solar panel was built to convert solar energy to electric energy. A hybrid charge controller was also included to "multiplex" the inputs from the turbine and solar panel and provide an output voltage sufficient to charge the 12 V battery. The battery's DC output used to power household DC appliances. The results showed that the wind source is hard to get and only available in certain places in Sabah. In fact, it was lower than what the turbine needed to produce the 12 V DC output needed to power the system. On a brighter note, the results of the solar panel testing revealed that the solar panel was more than capable of producing at least 12 V for many hours, particularly during the day. The study concluded that, while the 12 V DC input required by the system to function would not be available at all times during the day, the use of a 12 V battery as an auxiliary power source extended the time the system was available. As a result, it is possible to conclude that the project's goal was met.

Keywords: Solar Photovoltaic, Wind Energy, UPS System

1. Introduction

A hybrid energy system is the element combination of two or more components of electricity [1][2]. In this study, solar power is combined with wind turbines to create a hybrid renewable energy system. Because the energy consumption of these renewable resources is primarily influenced by climatic

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factors such as temperature, solar radiation, wind speed, and so on, the output of the hybrid energy system is stabilized by incorporating an appropriate energy storage system. Most of the problems do not have electricity supply in rural areas because of far from the main electricity poles. To give electricity supply in rural areas cost a lot of money. Therefore, an easy solution and friendly use to supply a small house in rural areas need to be considered.

Thus, in this research, a system that integrated both the solar and mini wind plants in the Uninterruptable Power Supply (UPS) unit, which is more likely to be online UPS, will be implemented. This research aims to reduce the scarcity of electricity supply and help mitigate the problem in rural areas caused by natural causes such as power failure. An UPS device should have a clean output voltage with low Total Harmonic Distortion (THD), high performance, high reliability, and quick transient response for sudden load changes.

2. Materials and Methods

2.1 Method

Figure 1 shows the flow chart of the project.

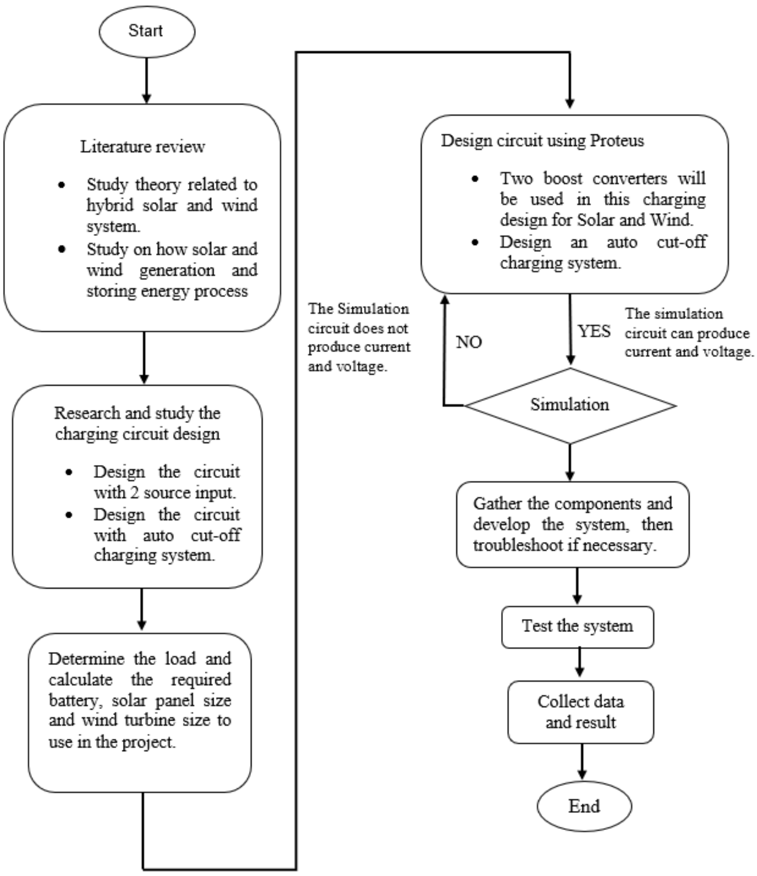

Figure 1: Flowchart of project

2.2 Block Diagram of the project

Figure 2 shows the block diagram of the project. Figure 3 shows the setup of the Hybrid system. This project is prototype hardware it consists of Wind turbine, Solar Panel, Charger controller, Battery and DC Load.

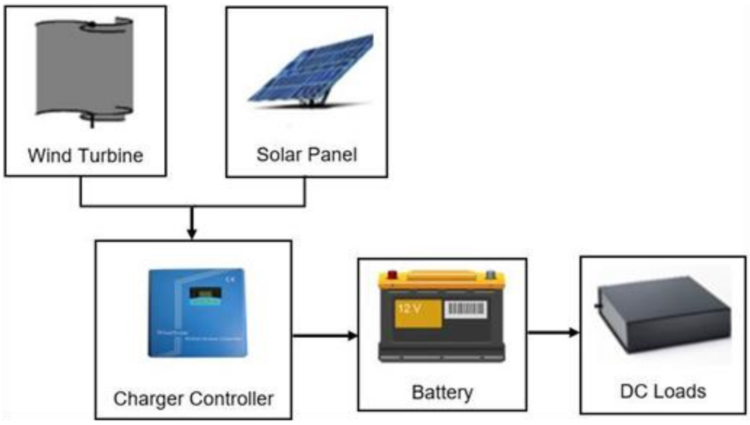

Figure 2: Block diagram of the project

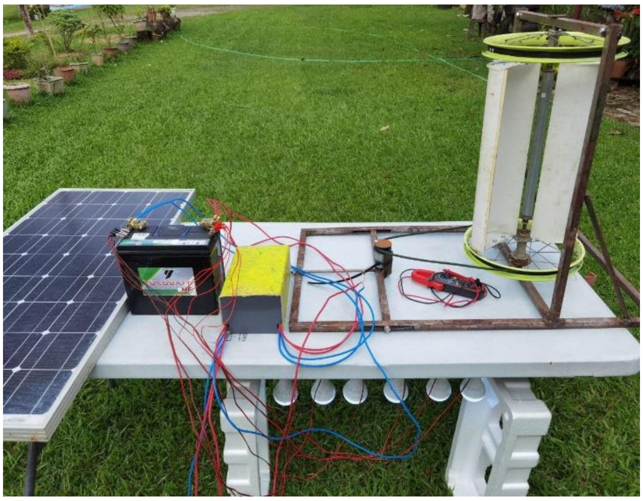

Figure 3: Setup of the Hybrid system

2.3 The analysis of load estimation

Table 1 tabulates the load estimation of project.

Table 1: Load estimation

No	Item	Quantity	Power consumes (W)	Total connected load (W)	Average use/day (h)	Max demand (W)
1	DC LED downlight	6	12	72	6	432
2	USB outlet (5v DC)	1	12	12	2	24
					Total demand	456

2.4 Type of Solar Panel

Figure 4 shows the solar panel of the project. Table 2 tabulates the specification of panel solar. In this project, it would be desirable to minimize the cost of the project as much as possible. This single point could have ruled out monocrystalline solar panels as an option. However, other considerations were made. For example, it is hoped that the entire project will be used for many years. As a result, a long-lasting solar panel was required, and no other type of solar panel lasts as long as monocrystalline solar panels. Furthermore, because solar panels are generally inefficient, it makes sense to choose panels with the highest efficiency possible. Again, among the various types of solar panels available, monocrystalline solar panels have the highest efficiency rates.

For this project, 100W monocrystalline solar panels are chosen. Based on the foregoing, it is clear that, despite its relatively high cost, using a monocrystalline solar panel for the project is quite logical.

Figure 4: Monocrystalline silicon solar panel

Table 2: Solar panel specification

Characteristic	Rating
Maximum power (Pm)	100 W
Maximum Voltage (Vmax)	18 V
Open Circuit Voltage (Voc)	21.60 V
Maximum Current (Imax)	5.56 A
Short Circuit Current (Isc)	6.11 A
Weight (kg)	5.6 kg
Dimension	1025 x 541 x 30 (mm)
Efficiency	75-85 %

2.5 Type of Wind Turbine

Figure 5 shows the structure of the wind turbine and Table 3 tabulates the specifications of the wind turbine.

Since the wind speed in real life is usually low, it is important to construct a wind turbine that produces a booster circuit that can produce a decent amount of voltage. The type of wind turbine that can rotate without strong wind is the VAWT. Consequently, the wind turbine used for this project is a VAWT as it can receive wind energy in any direction.

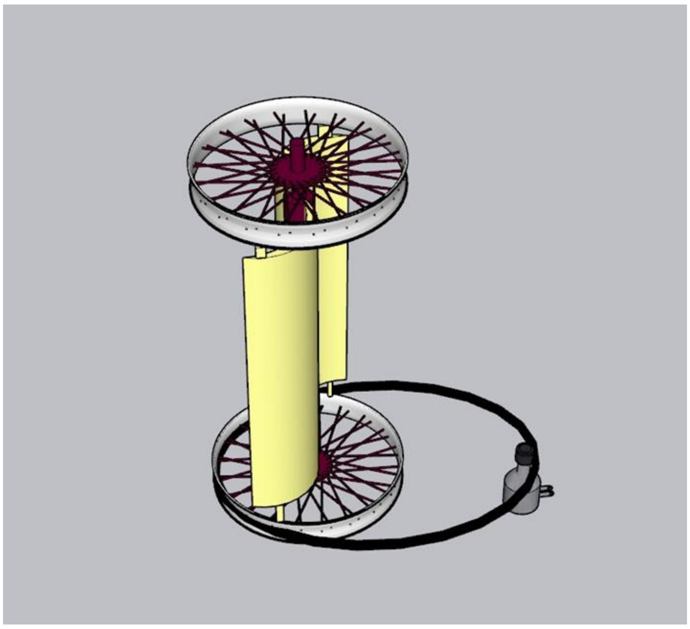

Figure 5: structure of wind turbine

Table 3: Wind turbine specification

MITSUMI RM1 4617 545 (Motor generator)	
Wattage	40W
Voltage	1.5V-24V

2.6 Charger controller

Figure 6 shows the charger controller circuit of the project.

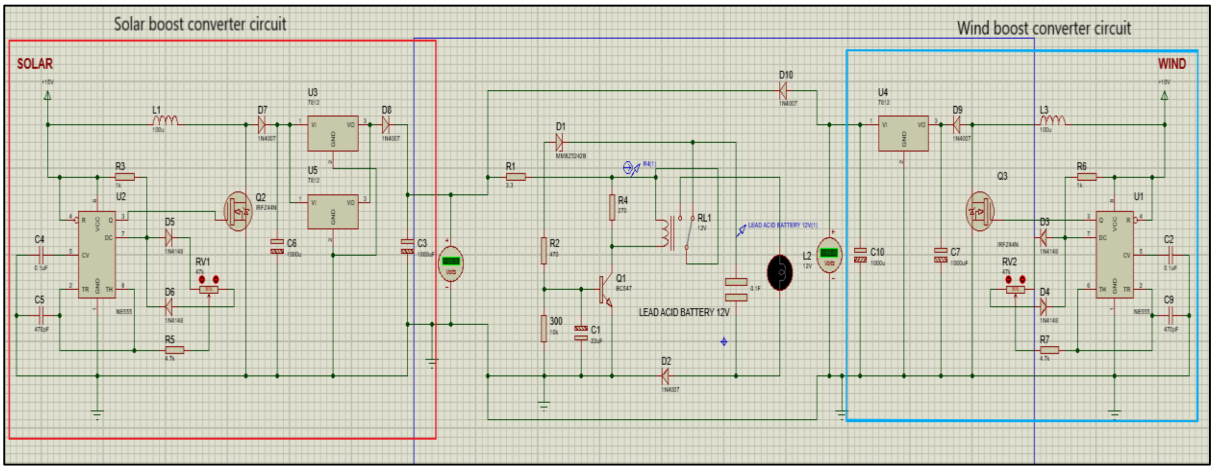

Figure 6: Charger controller circuit

As shown in Figure 6, it is expected that the constructed prototype can charge a 12V battery by using the circuit design from 2 sources which are solar panels and wind turbines. The produced charging circuit also has protection from overcharging.

3. Results and Discussion

3.1 Solar panel and Wind turbine charging test

Figure 7 shows the graphs of voltage battery charging. Table 4 tabulates the results of voltage and current battery from the hybrid system.

The result for Hybrid Solar Photovoltaic and Wind Energy charging the battery for 6 hours. Both Solar Panel and Wind Turbine were connected to the Charger Controller and then go to the battery which is shown in Figure 7. The battery was managed to fully charge at 13.2 V for 6 hours.

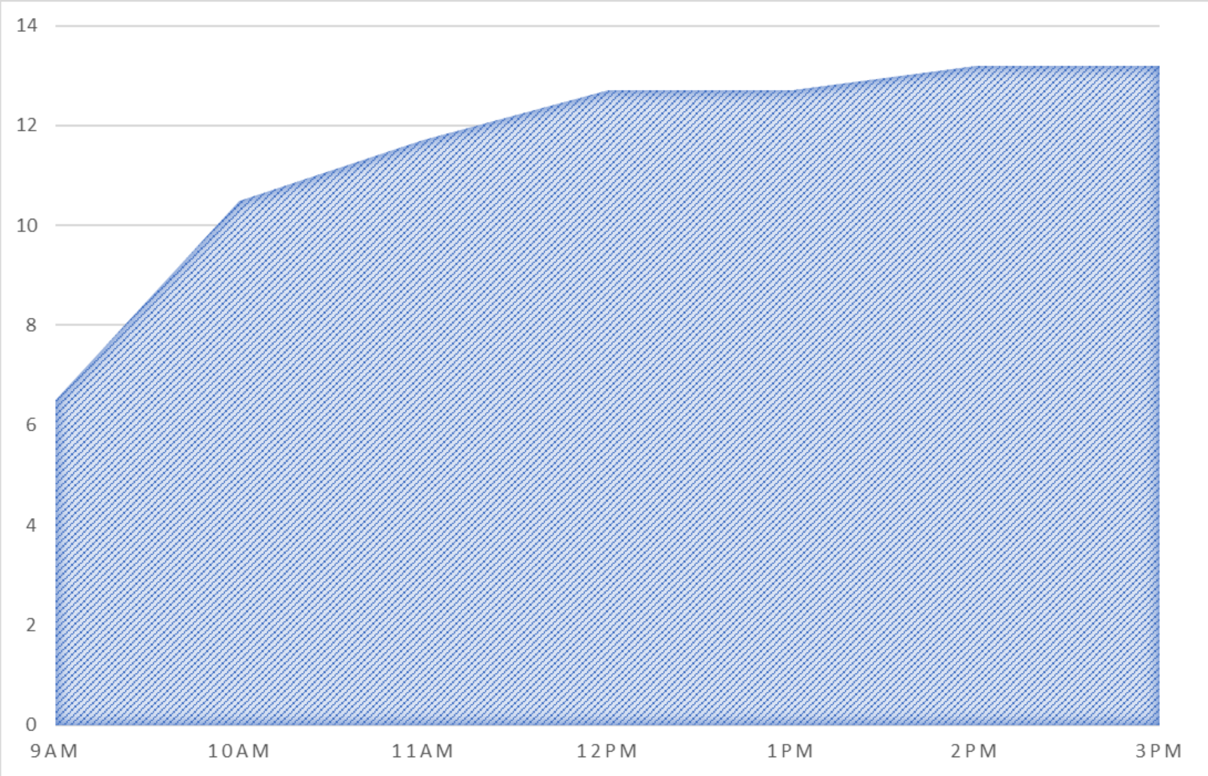

Figure 7: Graph of battery voltage vs time of charging

Table 4: Results of battery voltage and current from the hybrid system

Time	Voltage (V)	Current (A)
09:00 am	6.5	2.78
10:00 am	10.5	3.38
11:00 am	11.7	4.78
12:00 pm	12.7	5.1
1:00 pm	12.7	2.8
2:00 pm	13.2	2.5
3:00 pm	13.2	2.2

3.2 Hybrid Solar PV and Wind Energy Powered UPS System for Small Loads Supply

Figure 8 shows the graph of battery voltage to connect the load. Table 5 tabulates the results of battery voltage and current when the load is connected.

The results of the UPS system testing for Hybrid Photovoltaic and Wind Energy. The outcome was tested from 9 p.m. to 5 a.m. using six 12V DC LED downlights rated at 12 watts each. The total load current was approximately 3.09 Amp per hour, and the system was able to supply the small DC load for approximately 8 hours without charging. The DC Led downlight was becoming dimmer after 8 hours of supplying the loads due to insufficient power. As a result, this system can provide 8 hours of continuous loads.

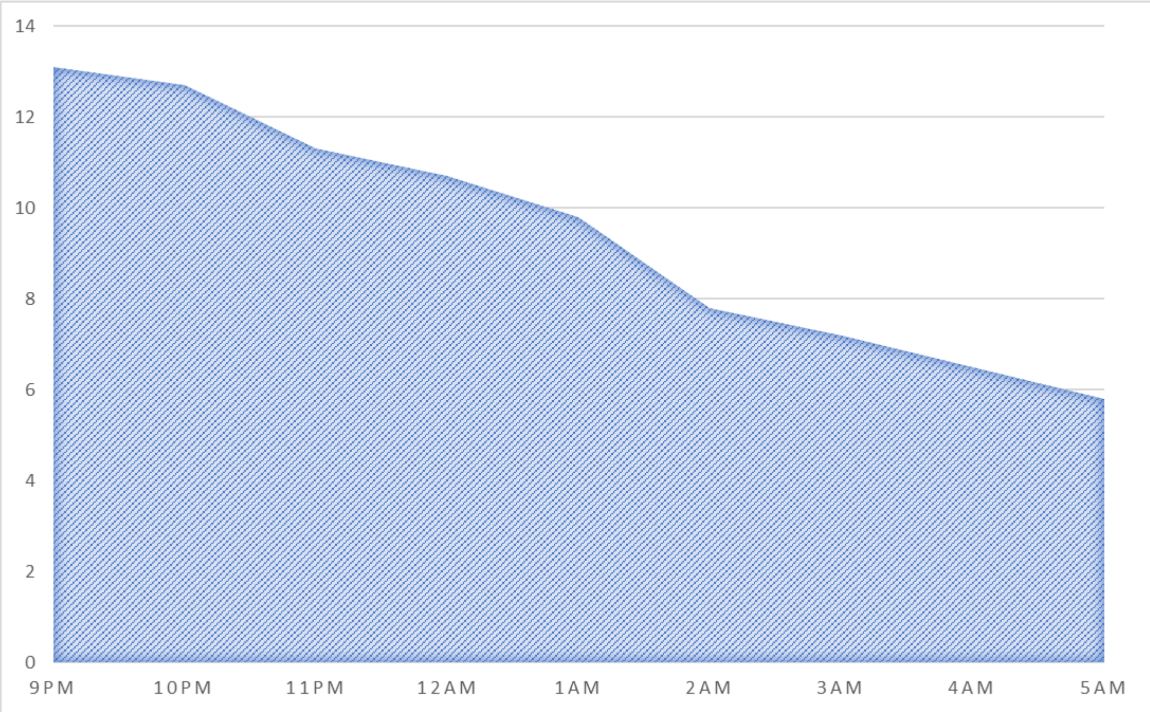

Figure 8: Graph of battery voltage vs time when the load is connected

Table 5: Results of Battery voltage and load current

Time	Battery Voltage (V)	Load Current (A)
9:00 pm	13.1	3.09
10:00 pm	12.7	3.09
11:00 pm	11.3	3.09
12:00 am	10.7	3.09
01:00 am	9.8	3.09
02:00 am	7.8	3.09
03:00 am	7.2	3.09
04:00 am	6.5	3.09
05:00 am	5.8	3.09

4. Conclusion

This project's goal was to create a Hybrid Solar Photovoltaic and Wind Energy Powered UPS System for Small Loads Supply. The main goal of combining the two systems was to try to achieve constant electric power production in order to supply a small load DC application for a rural house. The results of the solar panel tests revealed that it produced the required voltage and power output to supply the application. This implies that the hybrid system was suitable for use in the morning and afternoon because solar radiation produces a lot of energy to accommodate the loads. However, in the evening, the solar radiation dropped to such low levels that the solar panel was unable to generate the 12 V needed to power the system. During this time, the battery served as an auxiliary power source, ensuring that the system remained operational for an extended period of time during the evening. The results of the wind turbine tests revealed that the wind turbine cannot power up the 12V system due to the low voltage produced. Despite the fact that the system is a hybrid of solar and wind energy, using both sources can provide enough power to power the small load DC application. Furthermore, because the hybrid system will be used to power a small load DC application, it is reasonable to expect that the planned system will serve its intended purpose in the morning and can also can be used for 8 hours in the evening without the Solar or Wind Turbines supply. In summary, it can be concluded that the objectives established at the beginning of the project were met. As a result, the project was a success.

Acknowledgement

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