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Development of Hybrid Photovoltaic-Wind System for LED Street Lighting

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Abstract. This paper presents the development of hybrid Photovoltaic (PV)-Wind system connected to light emitting diode (LED) street lighting as the load. The aim of this research is to analyze the energy performance from the combination of PV system and wind system which is hybrid system to the LED lamp as the load. In this project, the PV panel and wind turbine used to generate the energy and the output of the energy control by two equipments which are solar charger controller and hybrid charger controller. The output of both PV and wind connected with the battery as storage energy for this system. In this research, the PV system produces the best energy compared to the wind system and it is reliable to charge the battery of the system and supply to the load.

Introduction

The increasing of technology development today causes high demand of energy. More of equipments today need to used energy especially electrical energy. Without electrical energy, economic activity will paralyzed because all works today needed electrical energy either in office, industrial, transportation place, bank, and all around the world. Because of the high demand in energy used, these can effect of decreasing the prime energy such as oil, coal, and natural gas. Besides, the uses of the prime energy such as oil, coal and natural gas as the demand to get energy also cause pollution to environment. It is about 40% of global energy will cause emissions of carbon dioxide and this become increasing up to 58% in 2030 [1,2].

Because of those problems, the alternative energy will be introduced to solve it. The concept of alternative energy that will use is relates to sustainability, renewability, and pollution reduction. The various form renewable energy will be introduced such as solar energy, wind energy, biomass energy, hydro energy, geothermal energy, wave and tidal energy. PV generation is one example provides a good solution for distributed energy generation especially in rural area [3]. Based on the increasing of renewable energy technology development today, it will becomes as alternative energy to replacement the fossil fuel energy in the future [1,2].

Hybrid PV-Wind

Hybrid system which is the system that control to combines the electrical energy from different sources such as combination of photovoltaic system and wind system to make the system become more efficient. Combining both PV and wind system can guarantee the high supply reliability, but in cloudy and no wind weather, it needs large storage capacity and it is very expensive [4,5].

Besides, without the hybrid system, it is difficult to manage the combination of energy that produces by PV and wind system. In that case, by using hybrid system, it can manage the energy of the both system based on the functional of hybrid controlled.

By using hybrid system, it will give a lot of advantages such as the possibility to combine two or more renewable energy sources, based on the natural local potential of the users. Besides, it also can

protect the environmental especially in term of carbon dioxide (CO_2) emissions reduction. Hybrid system also can give diversity and security of the supply system. It costs also predictable and will not influenced by fuel price fluctuation, although it has fluctuation in the battery prices and it were incorporated [6-8]. Hybrid system of PV and wind sysem had produce such a promising result that able to operate a load very well by using only the natural resources compared to the stand-alone resource [9].

System Description

This research focused on developing hybrid system and investigation of output energy that will produce from the prime energy which are PV and wind system to supply it to LED light as the load of the system. To control the energy of the system, the solar charger control and hybrid charger were used. Besides, the performance of the storage system will be investigated in terms of reliability. In this case, the battery of 24 Vdc will use as the storage device of the system. Fig. 1 show the hybrid PV-wind system that developed at Faculty of Electrical Engineering (FKE), Universiti Teknikal Malaysia Melaka.

Fig. 1. Hybrid PV-wind System installed at FKE

The PV-Wind hybrid system that were developed consists of six components which are wind turbine, solar panel, solar charger controller, and hybrid charger controller, LED street light and battery banks. Fig. 2 shows the wiring diagram of the hybrid system.

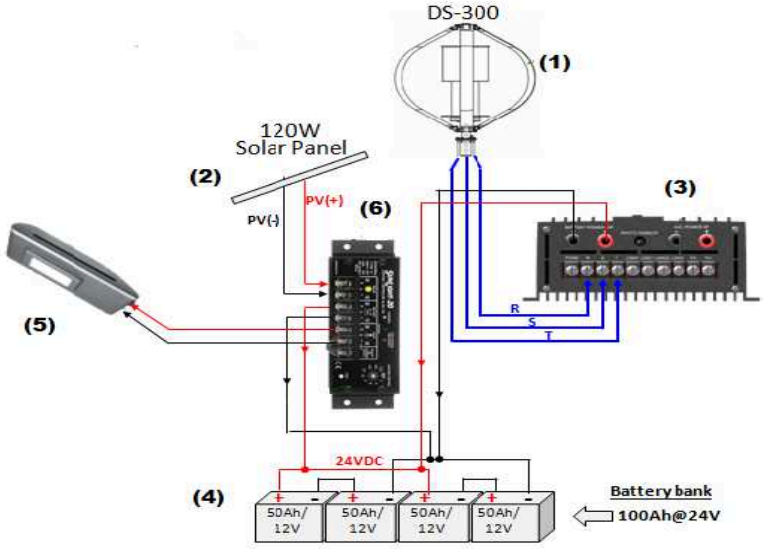

Fig. 2. Schematic diagram of PV-wind stand alone system

Table 1 shows the equipment used and describes the main components specifications for this hybrid system. As can be seen there are two controller which are hybrid charger controller and solar charger controller that were used to control the energy flow of the system. The type of wind turbine used is vertical axis wind turbine.

Table 1. Main component in hybrid system and their specification

No.	Equipment	Specification
(1)	Wind Turbine (Model DS300)	Rotor
		· Blade diameter – 1.06m
		· Number of blade – 3
		· Rated wind speed – 15ms^{-1}
		· Rated speed – 835rpm
		Generator
		· Type – 3 phases AC
		· Rated power – 300W
(2)	Solar Panel	· Rated power – 120W
(3)	Hi-VAWT Hybrid Charger (Model WS320)	Wind channel
		· Voltage – 0 to 50VAC
		· Current – 0 to 17A
		· Withdrawing power algorithm – MPPT
		· Cut-out rotor speed – 750rpm
		PV channel
		· Voltage – 0 to 50VDC
		· Current – 0 to 10A
		· Cut-in voltage - >V battery
		LED indicator
		· Battery – battery capacity status
		· Wind – wind power input status
		· PV – PV power input status
		· Load 1 – Load 1 discharge power status
(4)	Battery	· 12V (each)
		· 50Ah
		· Deep cycle lead-acid battery
(5)	LED Street Light	Lighting control options
		· OFF
		· 2 hours ON, 4 hours ON, 6 hours ON, 8 hours ON, 10 hours ON (was set)
		· Dusk to dawn
(6)	Solar Charger Controller	· Rated solar input – 10/20A
		· Rated load – 10/20A
		· Load disconnect – 11.7V

Results

Data were recorded by using 'Fluke Power Quality Analyzer'. The parameters that are being recorded were voltage, current, power, power factor and also the waveform. The hybrid system is placed right behind Electrical Machine Laboratory at FKE. The data has been recorded on 3rd and 4th April 2013. Fig. 3 shows the graph Voltage versus time for hybrid PV-wind system on 3rd and 4th April 2013. The graph in Fig. 3 shows the value of the voltage for four main systems in the Hybrid PV-wind which are PV, wind, load and battery systems. Based on Fig. 3, the value of voltage of the battery is almost constant for which the value is around 25 V to 23.4 V. Solar system exhibits horizontal line in the graph indicates the value is around the same along the day and will fall when the sunset at 1900. This happened because of the factor of sun radiation. The PV panel will depends on the radiation of the sun to generate the energy from the panel. The wind system will produced the higher values of voltages in the daylight which average around 1 V to 8 V but lowest at night. In this case the wind speed in Melaka is higher in the day light but lowest at night. For the load system, the voltage will produce when the light is operated. Based from the graphs shows the time for the load operates at time 1900. Normally the light will operate until time reach 0500 as the time setting in the solar lighting controller. In certain case the controller will shut down the entire load when the voltage of the battery falls down at 23.4 V. The battery need to be recharge to obtain its nominal value. If the load is shutdown, it will not operate again until the sunset for other day although the battery is recharge higher than the shutdown limit voltage which in this case is 23.4 V.

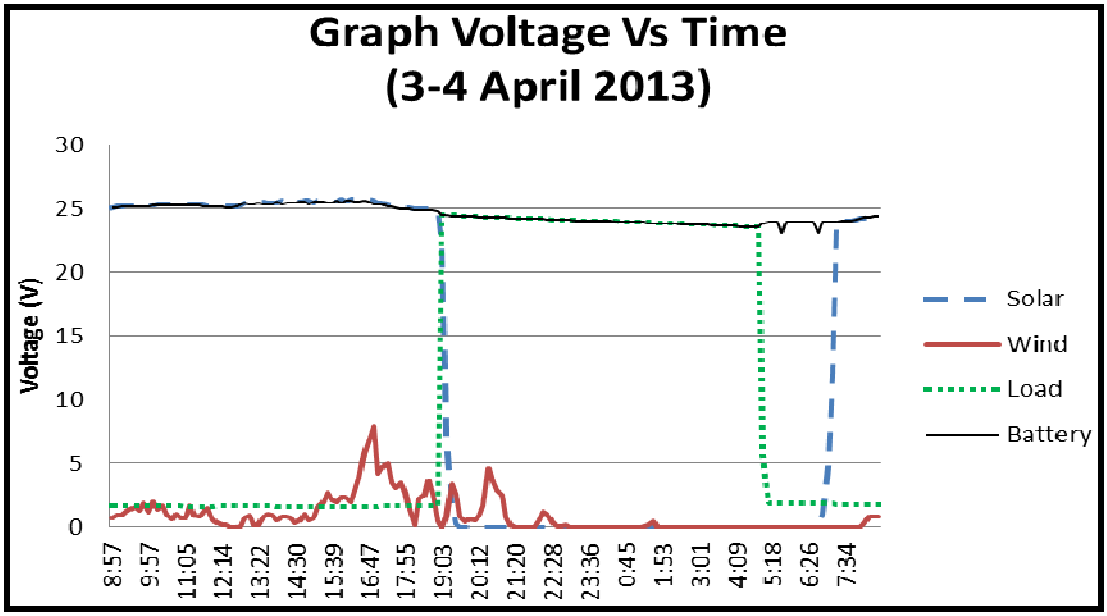

Fig. 3. Graph voltage versus time on 3rd and 4th April 2013

Fig. 3 shows graph power versus time for Hybrid PV- wind system on 3rd to 4th April 2013. Based on the graph the highest power was produced by the PV system. The highest of the power that were produced is 82 W at 1704 by PV source.

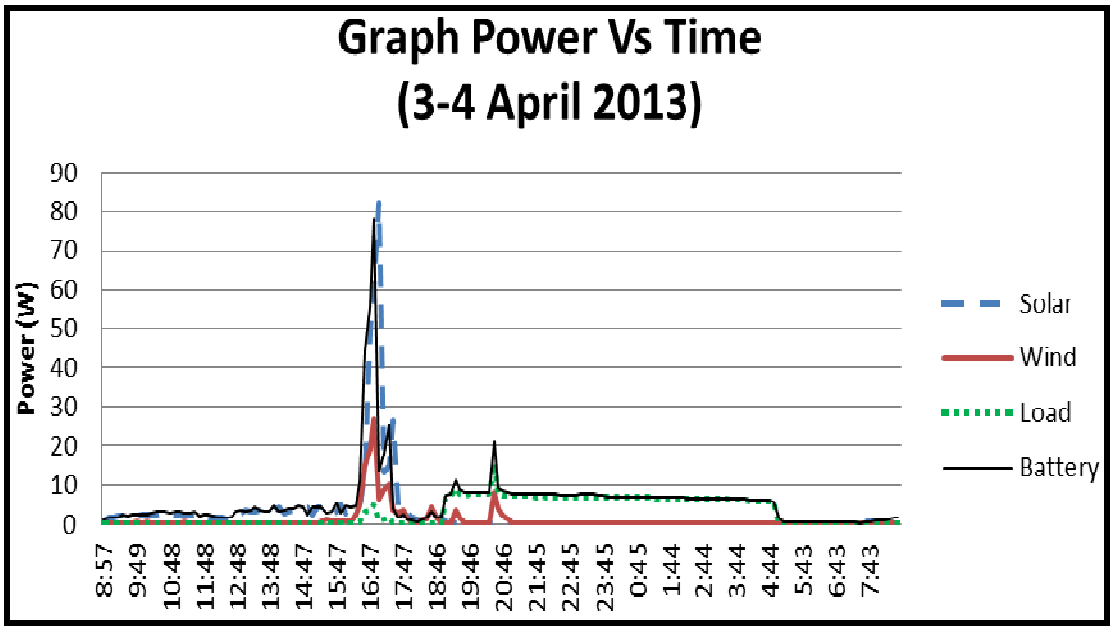

Fig. 4. Graph power versus time for Hybrid PV-wind system on 3rd to 4th April 2013

For the PV system, the power only produced in daylight because the voltage and the current of the solar system were exist because of the sun radiation. Wind system is not much contributing to the power of the system because the speed of the wind at that day is not consistently high. Power for both load and battery systems are depends on each other. Based on the graphs the power for both system is related each other. If the load system is operated, the power that will produce on the load and at the same time the battery also supply the same power to the load. The battery system also produced the power without depends on the load during the daylight. In this case the effect of power that produced by solar and wind system will affect the power on battery system.

Table 2 shows the performance summary of PV-wind system. Based on the table, PV system produced higher voltage in one day which is about 2117.21 V and the wind system produced more current than solar system in one day which is about 33.815 A. In this case it affects the value of power produced by the system. Wind system produced low power than solar and its not reliable for the system because the power produced at certain time and only based on the factor of wind speed.

Table 2. Performance summary of hybrid PV-wind system

Output	**Solar System**	**Wind System**
Voltage[V]	2117.3	156.9411
Current[A]	20.29	33.815
Power[W]	444.4863	142.9797

Conclusions

There are several conclusion can be made based on the Hybrid PV-wind system especially in the main part system which are PV system, Wind system, Load system, Battery system, solar charger controller and hybrid controller. Based on the data that analyzed, the best system that will produce energy is the PV system because it suitable for condition in Melaka area in term of radiation of sunlight in daylight. For the Wind system, it's not reliable to be used in this area because the wind speed in this are not suitable for generate the energy, it can only be reliable to a certain time and not fixed as the PV system. As the conclusion the PV system is the best system to produced energy in this whole system. To maximise the utilisation of wind system, the hybrid charger needs to design specifically to suit the wheather and surrounding environment of the system.

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