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A Hybrid Wind Generator Design for Low Wind Speed Application

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Abstract: Electricity can be generated from renewable energy sources such as wind, solar, hydro, biomass and much more. Using renewable energy in generating electricity can reduce the carbon dioxide emission. Nowadays, generation electricity technology is growing rapidly. It shows the combination of source energy to form hybrid is more reliable especially in country at equatorial region like Malaysia which has two seasonal shifts. Malaysia receives abundant of sunlight in a year but the wind speed in this country is too low which is around 3m/s. A hybrid wind generator converts the wind and solar sources into electricity for domestic usage and capable in supplying AC and DC loads. Many factors that need to consider wisely in designing a hybrid wind system to have better performance. The wind turbine has three blades and employs VAWT that able to detect slow wind speed. The solar radiation captured by solar panel, then converted into electrical energy. The wind turbine and solar panel are connected in series. Lead acid battery is used to store excess energy and also as back up during shortage supply. The output system is varying based on the solar radiation and wind speed. The output of this project is depending on the availability of the source. Higher in wind speed and solar radiation gives better output.

Keywords: PV, Hybrid wind generator, AC, DC, VAWT.

1. INTRODUCTION

The renewable energy sources e.g. solar, wind and biomass etc. has great contribution in generating electricity and require less maintenance also low operating costs. During last decades, many researchers worldwide conducted so many experiments to verify the feasibility, design, and control strategy of renewable energy application (Khan, 2005). The result is, solar and wind energy are better in generating electricity than other sources. But, wind and solar are non constant variable, it depend on seasons. By combining both wind and solar sources to form hybrid energy system, will lead to effectiveness in terms of cost, efficiency and reliability (Khan, 2005). Hybrid energy system is free air pollution and also cheaper. This system can operate effectively in both off-grid and on-grid applications. The photovoltaic (PV) wind parallel hybrid system indulges to the conditions where sunlight and wind has seasonal shifts. In Malaysia, there are two main weather seasons which is southwest monsoon and northwest monsoon. Malaysia's mean annual wind speed is 1.8 m/s (Sung, 2013). Some towns in Malaysia such as Kota Bharu, Kuala Terengganu, Kota Kinabalu, and Labuan experience stronger winds which their mean monthly can exceed 3 m/s (Sung, 2013).

In designing wind turbine, there are several factors i.e. number of blades, blade shapes, blade length and tower height to consider to maximize the aerodynamic efficiency in terms of the power extracted from wind that must be look into in order to maximize the aerodynamic efficiency, or power extracted from the wind. Malaysia naturally has abundant sunshine but cloudy sky. When the solar radiation enter the earth's atmosphere, a part of the incident energy is removed by scattering or absorption by air molecules, clouds and particulate matter usually referred to as aerosols (Daut, *et. al.,* 2011). Beam radiations refer to the radiation that is not reflected or scattered and reaches the surface directly in line from the PV module, while diffuse radiation is scattered radiation that reaches the ground. Some of the radiation may reach after reflection from the ground, it is called albedo. Based on Malaysia Meteorological Department, on the average, Malaysia receives about six hours of sunshine per day. Malaysia's average temperature during daytime is between 24^{o}C to 32^{o}C and during night time is from 21^{o}C to 24^{o}C (Mekhilef, *et. at.,* 2012). Besides, the average solar radiation at Malaysia is between 400 - 600 MJ/m^2 per month (Mekhilef, *et. at.,* 2012). Malaysia is suitable for large scale solar power installation due to its location in equatorial region. This solar radiation will be higher during the northeast monsoon but lower during the southwest monsoon.

2. BACKGROUND

The hybrid wind-PV system consists of a few components such as wind turbine, PV (18V, 5W),

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battery (12V, 1.2Ah), power inverter (output 240VAC and 5VDC) and also solar controller (12V) shown in **(Fig-1)**. The wind turbines and PV modules are connected in parallel for reliable and continuous power. Both source energy has seasonal shifts. If one of the sources energy is not available, the system still generates and supply power to the load by the other source energy. As the wind does not flow throughout the day and the sun does not shine for the entire day with the same intensity, using a battery as backup can be much more reliable and realistic power source. Therefore, during the unavailability of the sun, the load can still be supplied from the battery.

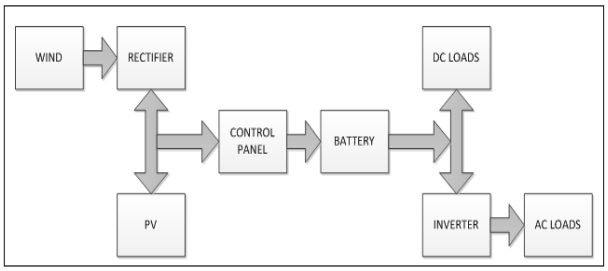


Fig 1. System modelling

3. MATERIALS AND METHODS

To determine the energy potential of renewable energy resource, the data for solar radiation and wind speed are collected at different locations. A hybrid model system is set up by components described in the following.

3.1 Solar Panel

Malaysia is positioned on the South China Sea and lies between 1° and 7° in North latitude and 100° and 120° in East longitude (Mekhilef, *et. at.,* 2012). Malaysia is crescent shaped. It consist of Peninsular Malaysia and East Malaysia (Sabah and Sarawak). Malaysia has high levels of temperature and humidity. The humidity varies from 80% to 90% except for highlands (Mekhilef, *et. at.,* 2012). Throughout the year, the temperature ranges between 22 °C and 33 °C (72–91 °F) and the average daily temperature is 26.5 °C. It goes higher during the Northeast monsoon period and lowers during the Southwest monsoon (Mekhilef, *et. at.,* 2012). The specification of the solar panel that suitable for is application is presented in **(Table 1)**.

Table-1: Specification for solar panel

Pmax	**5W**	**Isc**	**0.29A**
Tolerance	**±5%**	**Maximum system voltage**	**750V**
Vmp	**18V**		
Imp	**0.27A**	**Size**	**185mmx285mmx18mm**
Voc	**21.4V**	**Test condition**	**1000W/m^2,AM1.5,25˚C**

3.2 Wind turbine

The average wind speed in Malaysia is varies depending on location and month. Some towns in Malaysia facing stronger wind such as Kota Kinabalu, Kuala Terengganu and Labuan. Since the wind speed below than 3m/s, VAWT is implemented in this system. The wind turbine specification as stated in **(Table 2)**.

Table-2: Wind turbine specification

Types of turbine: VAWT	Parameter
Height from the ground	**25cm**
Radius of the blade	**6cm**
Number of blades	**3**
Number of turbines	**1**

3.3 Battery

The types of battery used is lead acid battery. This battery is the most suitable for hybrid system. It is easy to handle and also the most matured technology. This battery will store excess energy. The specification of battery as shown in Table 3.

Table-3: Battery specification

Specifications	
Voltage	**12 V**
Capacity	**1.2 AH**
Initial current	**< 2.36 A**

3.4 Inverter

The specification of the inverter employed in this system is based on the specification states in **(Table 4)**.

Table-4: Inverter specification

Shell material	**Al-Mg alloy**	**USB**	**DC 5V**
Input voltage	**DC 12V**	**Over load protection**	**Yes**
Output voltage	**AC 220V**	**Short circuit protection**	**Yes**
Power rating	**100W**	**Low voltage protection**	**9.5V - 10.5V**
Power for long use	**80W**	**Over voltage protection**	**14.5V-15.5V**
Output frequency	**50Hz**	**Ambient temperature**	**-550**

4. RESULTS & DISCUSSION

The experiments conducted to determine the factors affecting the voltage reading. All the data collected and recorded during testing as shown in **(Table 5)**. The output power generated wholly depends on the availability of wind and sunlight. The wind speed is measured using anemometer. Each readings taken for three times for verification purposes.

Table-5: Average output voltage

Average Wind Speed (m/s)	Average Output Voltage (V)
1	0.12
2	0.36
3	0.84
4	1.07
5	1.23
6	1.58

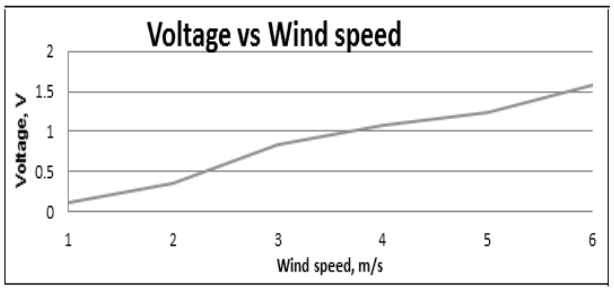


Fig 2. Relation between voltage and wind speed

Fig-2 shows the output voltage varies as the wind speed increases. The least output voltage produced is 0.12V when the wind speed is 1m/s. While, the higher output voltage is about 1.6V at the wind speed 6m/s. Also, the number of rotation of the blade increases too as the wind speed increases. The number of blade tested is three. Therefore, the output voltage and current are fully depending on wind speed. If wind speed not available, then, there will no output at all. The solar panel is tested for open circuit (Voc) only. The data recorded is for three days continuously.

Table-6: Results from solar panel

Times (Hours)	Average Temp (^oC)	Average V_{OC} (V)
0700	27	12.01
0800	27	12.96
0900	28	13.5
1000	30	18.75
1100	31	20.01
1200	31	20.73
1300	34	21.29
1400	31	20.45
1500	31	19.67
1600	31	18.56
1700	31	17.93
1800	31	17.74

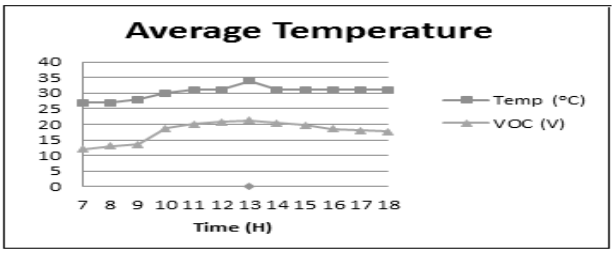


Fig 3. Average temperature versus time taken

Based on **(Table 6 and Fig. 3)**, it can be seen that as temperature increases, Voc increases too. The highest Voc is 21.29V at 34^{o}C. The highest temperature is at 1300 hours. The output voltage from solar panel is based on temperature of the day and the irradiance of sunlight. The power is the product of voltage and current. The power increases as the voltage and current increases. When the PV connected to the solar charge controller, the battery is charging as long as there are sunlight hits the panel. Shorter time taken for the battery to be fully charged is at highest temperature. Meanwhile at cloudy day, the battery at discharging mode and supplies to the load.

5. CONCLUSION

It can be concluded that the hybrid wind-PV system able to generate electricity even in area with slow wind speed and cloudy sky. The wind turbine uses is VAWT design that capable to capture slow wind speed and detect wind from any directions. This design suitable for urban area since it can create turbulence wind. The higher turbulence can be found at the edge or top of the building. While, for rural places such as in Sabah and Sarawak, the wind turbine can be installed at high places and must away from the trees. This system can be secondary source of electricity for domestic usage. Besides, it reduces the cost of electricity bills. In addition, this system is environmental friendly and free pollution. The emission of CO_2 from both source is about 2% to 4%. Reducing the emission of CO_2, may also reduce the greenhouse effect.

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