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Analysis of wind speed effect on voltage in wind power plant performance

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Abstract. Utilization of new renewable energy has received special attention from the Indonesian government today because new renewable energy has several benefits from fossil energy, including environmentally friendly, non-polluting, abundant and will not run out throughout the ages. The growth of energy consumption is an average of 6.5 percent year, not yet balanced with sufficient energy supply, energy prices are increasingly expensive, energy subsidies are getting bigger, energy use is still wasteful. One way to overcome the problem of electricity is wind energy. Wind energy is a very abundant source of energy and there is no end of the year. At wind speeds of 1.5 to 3.0 m/sec, the voltage produced by wind power plants is linearly increased from 1.8 to 4.2 volts AC, from speed 3.0 to 4.0 m /sec, the voltage generated is in range from 5.0 to 6.5 volts AC. The DC voltage characteristic is equal to wind speed function. At wind speeds of 1.5 to 2.5 m/s, the voltage generated by wind power plants is linearly increased from 6.0 to 10 DC volts, from speeds of 2.5 to 4.0 m/sec the resulting voltage is stable 11 to 12 volts DC.

1. Introduction
Electricity limitations and high dependence on fossil fuels that have begun to dwindle, make the government have to look for other alternatives as an energy source. The abundant potential of natural resources, both water, wind, and the sun are an alternative opportunity that should be utilized as well as possible by the government. The wind is one of the natural resources that can be used to generate electricity and can be renewed. Therefore, wind energy is alternative energy that has good prospects to meet the shortage of electrical energy in addition to its existence which is always available. Wind energy is also environmentally friendly energy [1]. Renewable energy resources like solar radiation and wind energy are desirable to solve environmental problem (e.g. greenhouses gas reduction) and it considered as a great alternative for conventional power resources [2, 3].

2. Literature review
Basically, the wind occurs because of the temperature difference between hot and cold air. In the equatorial region, which is hot, the air becomes hot, expands and becomes light, rises upward and moves 30 to 60 degree Celsius to cooler regions such as the Polar region. On the other hand, in the cold pole region, the air becomes cold and drops down. So that there is an air circulation in the form of air movement from the North Pole to the equator along the earth's surface around 30 to 60 degree Celsius,

and vice versa an air displacement from the Equator Line back to the North Pole. through a higher air layer [4, 5].

Wind power plants are a power plant that uses wind as an energy source to produce electricity. This plant can convert wind energy into electrical energy using wind turbines or windmills. The electricity generation system using wind as an energy source is an alternative system that is very rapidly developing, considering that wind is one of the unlimited energies in nature of all time. Technology is matured in case of HAWT (Horizontal Axis Wind Turbine) compared to VAWT (Vertical Axis Wind Turbine), as aerodynamic theory of aircraft is applied HAWTs. Less attention was paid on VAWTs [5, 6].

Wind turbines are divided into two groups, horizontal axis turbines, horizontal axis wind turbines usually have two or three modules. Another type is the vertical axis turbine. This three-bladed turbine is operated against the wind, with the module facing the wind [6-8]. The utility-scale turbines have a variety of sizes, from 100 kilowatts to several megawatts. Large turbines are grouped in the direction of the wind, which gives mass power to the electricity network. small single turbines, below 100 kilowatts and used in homes, telecommunications, or water pumping. Small turbines are sometimes used in connection with diesel generators, batteries, and photovoltaic systems. This system is called a hybrid wind system and is often used in remote locations outside the network, where there is no connection to the utility network.

Constraints on the use of wind turbines are wind speed and wind direction that change over time. Therefore, a good wind turbine is a turbine that can receive wind from all directions other than that it is also able to work in low-speed winds, one of them is the VAWT. This turbine has a smaller efficiency compared to horizontal axis wind turbines [8-10]. Various types of VAWT are often used, among them are Type Savonius, Type Darrieus, and Type H-Rotor.

The Savonius VAWT type as shown in the image below was created by a Finnish engineer, SJ Savonius, in 1929. This VAWT wheel is the simplest type and is a large version of an anemometer. Savonius Ferris wheel can rotate because of the thrust of the wind, so the rotors will not exceed the wind speed [11]. Although the coefficient for turbine wind of type varies from 30 percent to 45 percent, according to many researchers for the Savonius type it is usually not more than 25 percent. This type of turbine is for low power applications and is usually used at different wind speeds as shown in Figure 2.

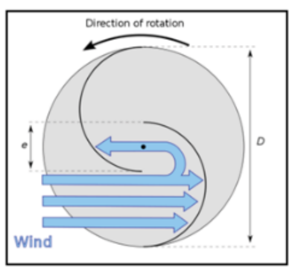

Figure 2. Principles of working of vertical turbine.

VAWT is an up-right axis wind turbine which moves the shaft and rotor parallel to wind of the direction, so that the rotor can rotate in all wind directions. There are three types of rotors in this type of wind turbine, namely: Savonius, Darrieus, and H rotor [3, 11]. The Turavonius turbine utilizes the drag force, while Darrieus and the H rotor utilize the lift force. Just like HAWT, VAWT also has several advantages and disadvantages. The advantage is that it has high torque so that it can rotate at low wind speeds, the dynamo or generator can be placed at the bottom of the turbine so that it facilitates maintenance, is not noisy, and turbine work is not affected by wind direction The disadvantage is that the wind speed at the bottom is very low so that if you don't use the tower it will produce a low rotation, and efficiency is lower than HAWT [5], [12, 13]. Vertical Axis Wind Turbine (VAWT) was initially more developed for mechanical energy conversion, but along with the development of design, this type of turbine is widely used for small-scale electrical energy conversion. Figure 3 shows the types of VAWT windmill designs.

3. Methodology and materials

The material used in this study is a windmill used vertical generator type with specifications as follows:

- Vertical windmill 12 Volt, 200 W.
- Anemometer
- Digital voltmeter
- Charge Controller wind solar hybrid (MPPT)

Retrieval of data on windmills is done by giving wind gusts from the blower, the amount of wind blowing speed is measured by an anemometer, as well as the amount of voltage produced by windmills measured by digital voltmeter.

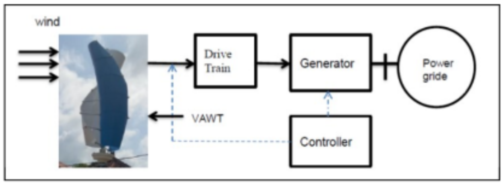

Figure 3. Wind power generators system.

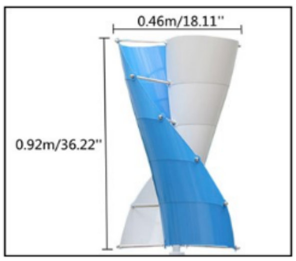

Figure 4. Savonius VAWT.

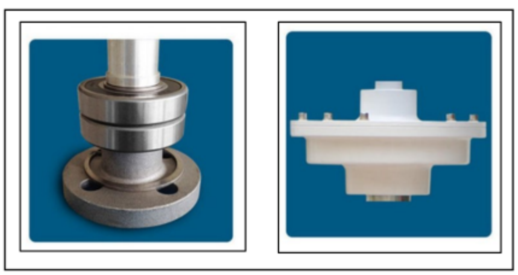

Figure 5. Dual bearings and permanent magnet generators.

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Figure 6. Wind solar hybrid charge controller.

The controller is designed specifically for a wind-solar hybrid system. It can make the wind-solar hybrid system of various resources to Achieve the best configuration in charging from two generators, solar power and wind power both separately or simultaneously, high wind speeds and low wind speeds that will enter through the charger controller. Thus, the amount of power can be adjusted According to the amount of power from the two plants between solar panels and wind power plants.

Figure 7. Anemometer.

The function of the anemometer is as a device or measure wind speed. By using an anemometer, we can estimate the weather on that day. The anemometer also has a function that is as a means of detecting bad weather such as hurricanes or storms. In determining speed, the anemometer detects changes in some physical properties, namely fluids and fluid effects. The rotation of the propeller will be converted into a scale in the language of mathematics. Propellers on the anemometer are used as receptor devices or that capture a stimulus in the form of wind gusts. After the propeller rotates, this will move a device that will measure the speed of the wind that blows through the rotation of the propeller on the anemometer. Anemometer is used to measure wind speed; the pressure thermometer serves to measure wind pressure. When the wind blows, the propeller or bowl contained in the anemometer will move According to the direction of the wind.

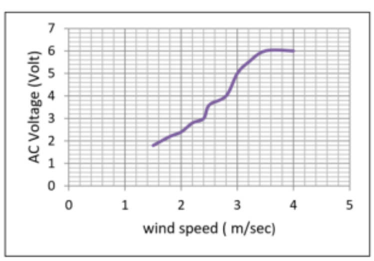

Figure 8. Characteristics of AC voltage = F (wind speed m/sec).

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The testing of AC voltage wind power plants without load is to find out the energy produced by the windmill and to find out how much voltage flows both the minimum voltage and the output voltage without maximum load. This test is carried out the magnitude of the voltage against wind speed. The AC voltage characteristic is equal to wind speed function, when wind speeds are 1.5 to 3.0 m/sec the voltage generated by wind power plants is linearly rising from 1.8 to 4.2 volts, from speeds of 3.0 to 4.0 m/sec voltage generated is cash 5.0 to 6.5 volts.

Table 1. Measuring the amount of AC voltage and wind speed m /sec.

No	Wind speed (m /sec)	AC Voltage
1	1.5	1.8
2	1.8	2.2
3	2.0	2.4
4	2.2	2.8
5	2.4	3.0
6	2.5	3.2
7	2.8	3.5
8	3.0	4.2
9	3.2	5.0
10	3.5	5.5
11	4.0	6.5

Table 2. Measuring the amount of DC voltage and wind speed m /sec.

No	Wind speed (m/sec)	DC voltage
1	1.5	6.0
2	1.8	7.0
3	2.0	8.0
4	2.2	9.0
5	2.4	9.5
6	2.5	10
7	2.8	11
8	3.0	12
9	3.2	12
10	3.5	12
11	4.0	12

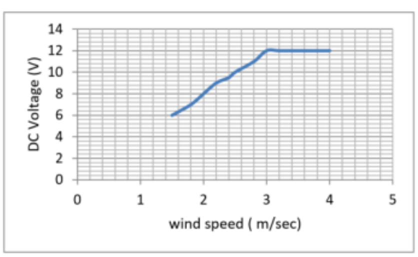

Figure 9. Characteristics of DC voltage and wind speed m/sec.

The testing of DC voltage without wind power plants is to find out the energy produced by the windmill and to find out how much DC voltage flows both the minimum voltage and the output voltage without maximum load. This test is carried out the magnitude of the voltage against wind speed. At DC voltage characteristics is equal to wind speed function, when wind speed is 1.5 to 2.5 m/sec, the voltage generated by wind power plants is linearly rising from 6.0 to 10 volts DC, from speeds of 2.5 to 4.0 m/sec the voltage generated is stable 11 to 12 volts.

4. Conclusions

The characteristic of AC voltage is equal to function of wind speed, at wind speeds of 1.5 to 3.0 m/sec, the voltage produced by wind power plants is linearly increased from 1.8 to 4.2 volts AC, from speed 3.0 to 4.0 m /sec, the voltage generated is in cash from 5.0 to 6.5 volts AC. The DC voltage characteristic is equal to wind speed function, at wind speeds of 1.5 to 2.5 m/s, the voltage generated by wind power plants is linearly increased from 6.0 to 10 DC volts, from speeds of 2.5 to 4.0 m/sec the resulting voltage is stable 11 to 12 volts DC.

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