Monitoring the potential of horizontal axis wind power plants based on the internet of things

by Hartawan Abdillah

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Monitoring the Potential of Horizontal Axis Wind Power Plants Based on the Internet of Things

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Abstract. The need for renewable energy demand is currently growing very rapidly, and this very rapid development makes the exploitation quite large, one of which is wind energy. The need for monitoring the potential of wind energy to know the speed of wind energy that blows in a location in one day. The results obtained show that the faster the wind rotation (wind turbine blades), the greater the voltage generated, namely the wind speed is directly proportional to the voltage, in the measurement at 07.00 am to 05.00 pm the lowest wind speed is 1.31 m/s with an output voltage of 12.31 VDC. and a current of 0.26 A at 08.00 am and the highest wind speed is 5.13 m/s with an output voltage of 12.73 VDC and a current of 0.29 A.

INTRODUCTION

The need for renewable energy demand is currently growing very rapidly, this very rapid development makes exploitation quite large. Increasing sources of renewable energy in the distribution network of electric power systems is the main goal of sustainable energy planning policies of several countries [1][2] . In this case, it is possible to reduce dependence on the use of fossil fuels or conventional energy as well as environmental problems caused by energy sources with fossil fuels such as environmental problems that occur today, namely the occurrence of pollution. In addition, the increasingly scarce fossil fuel reserves, the increasing world fuel or oil prices, and concerns about environmental conditions strongly support countries to continue to develop the use of renewable energy sources. One of the current renewable energies that are often used is wind energy, the total installed power capacity globally in 2019 is 60.4 GW of wind, this shows an increase of 19% compared to 2018 installations, with the total wind energy capacity exceeding 651 GW it is expected that more than 355 GW of capacity will be installed between 2020 and 2024 this number is subject to change. The operation of wind energy is based on the principle that the kinetic energy of the air is converted into electrical energy, considering that wind energy is abundant energy, free of charge, widespread, and free of pollution [3][4] .

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In developing countries such as Indonesia, wind energy is the right and attractive choice to make wind energy one of renewable energies as a distribution network for electric power systems. However, Indonesia's wind energy development is still low [5][6]. One of the underlying factors is the relatively low average wind speed, making it difficult to generate electricity continuously and on a large scale. Large-scale wind turbines have cut-ins ranging in wind speeds from 5 m/s to 7 m/s, wind speeds that are not high enough yet to build large-diameter wind turbines. Nevertheless, Indonesia has the fourth longest coastline in the world 99,093 km, and is estimated to have a potential power of 970 MW. The installed capacity of wind energy is only about 1.96 MW so the potential for wind energy in Indonesia remains high. In July 2018, President Joko Widodo inaugurated a wind power plant with an installed capacity of 75 MW. This location has a significant impact on the performance of the wind power generation system. Best utilization of wind energy potential that is directly influenced by the selected location. For example, areas with high wind levels, climatic characteristics, geographical characteristics of an area, and distance to highways and residential structures. The need for monitoring wind energy potential to know the speed of wind energy that blows in a location in one day [7][8] .

The implementation of wind power monitoring is still mostly done manually, namely by measuring using measuring instruments and recording data directly by the operator, so the data obtained is also limited and makes it difficult for operators to take measurements [9][10] . Monitoring is more efficient and effective if monitoring is carried out routinely and automatically without going directly to the location. Information and communication technology in monitoring is the Internet of Things (IoT) which is an effective and efficient technology in its use [9][11][12] . The use of IoT technology makes it easier for us to monitor electrical power consumption to get data related to electrical parameters, namely current, voltage, and power in real-time, we can control electrical equipment remotely, whenever, wherever we are without having to go to the intended location [13][14] .

Research on the potential of new renewable energy, namely wind energy, in this paper uses a horizontal wind turbine and is carried out at an unobstructed location, namely beside the railroad tracks adjacent to the rice fields, without obstacles in question is an area or location where the blade position of the horizontal wind turbine is not blocked by anything, any objects such as houses, trees, and other objects. In measuring the potential of wind energy, a monitoring tool is also made in the form of a module using the Internet of Things for real-time data retrieval, the data taken is in the form of voltage and current from the turbine and wind speed, this variable will be measured using voltage, current and wind speed sensors as parameters [3][15][16] . These parameters will be used to determine the wind speed at that location and how much power is generated by the horizontal wind turbine.

TECHNICAL APPROACH

The research started by making designs, designs, and wiring diagrams, namely determining the specifications and components needed for the manufacture of tools [17][18]. After making the design, design and determining the specifications of the tool, the next step is to determine the parameters of the wind power plant to be measured. In the block diagram below is the flow process of the research made including the wind power generation measurement module as the object to be studied as well as the object to be measured and the Monitoring module as the monitoring center to retrieve data from the parameters contained in the Wind Power Plant as detailed in Figure 1.

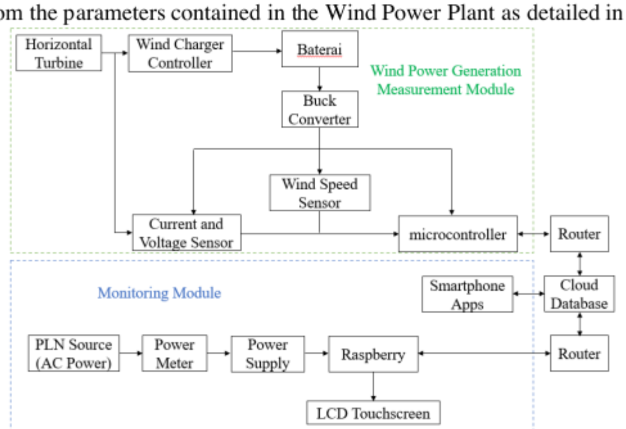

FIGURE 1. Block Diagram Of Wind Power Generation Measurement Module And Monitoring Module

In the first wind power generation measurement module, the wind turbine will rotate when there is wind blowing, the turbine rotation driven by the wind like a propeller converts wind energy into mechanical energy, and the wind blows sweeping the turbine blade area to move or rotate the electric generator rotor in it, in the electric generator the process where mechanical energy is converted into electrical energy with a wind turbine capacity of 400 watts, the output or power from the wind turbine enters the wind charger controller and then is converted to 12 V and stored in a 12 V 5 Ah battery. In the wind turbine, there are three sensors, namely current, voltage, and wind speed sensors, the three sensor parameters will be measured. The measurement readings made by the sensors are then processed by the microcontroller and the reading data from the sensors is sent by the router to the cloud database.

In particular, The monitoring module is designed according to the working principle of the Internet of Things, namely Cloud database with Smartphone Apps using Raspberry. Raspberry is used as a datalog server, the data sent by the microcontroller from the wind power generation measurement module will be displayed on the LCD touchscreen. The LCD touchscreen functions to monitor data in graphs sent by the microcontroller from the wind power generation measurement module and data logging can be done anywhere and in real-time conditions as long as it is connected to the internet. To access the data, the steps shown on the flowchart are as follows in Figure 2:

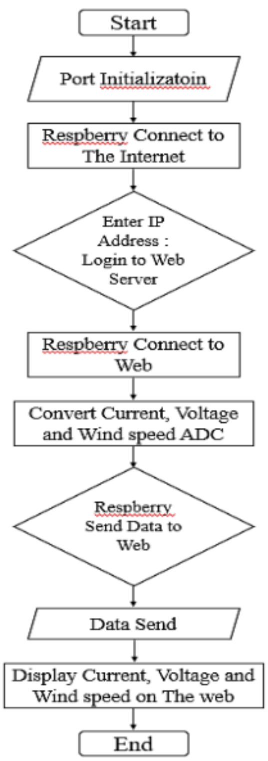

FIGURE 2. Flow chart monitoring module

Initial monitoring begins, namely setting up the network and connecting to the internet which will be used by logging in to the web server by filling in the user name and password, after successfully logging into the web server the data obtained from the measurement of voltage, current and wind speed sensors will be displayed on the web page. The web page also displays each measurement parameter in the form of graphs and data. The displayed measurement parameters such as wind turbine voltage and current and wind speed can also be downloaded, the downloaded data is automatically entered on a computer device in the form of an excel file. Retrieval of data that is downloaded and entered on a computer device is routinely carried out once an hour.

RESULT AND DISCUSSION

The testing of wind power plant monitoring tools has several stages including (1) Horizontal turbine testing; (2) Testing the wind power generation measurement module; (3) Monitoring modules. Each test is carried out individually and as a whole, the test results are in the form of measurement parameters from the calibration results and measurements from each sensor [19][20]. Figure 3. is a horizontal test of the turbine in a field near the railroad tracks, the intended field is where the area is free from wind resistance from the front side of the wind turbine. The test is carried out without a load and can be seen in the image of the measurement results using an AVO meter with the results of measuring voltages of 14.9 V DC with a wind speed of 5.1 m/s, measuring wind speed using an anemometer in Figure 4 below.

FIGURE 3. Horizontal turbine test

FIGURE 4. Wind speed measurement with Anemometer

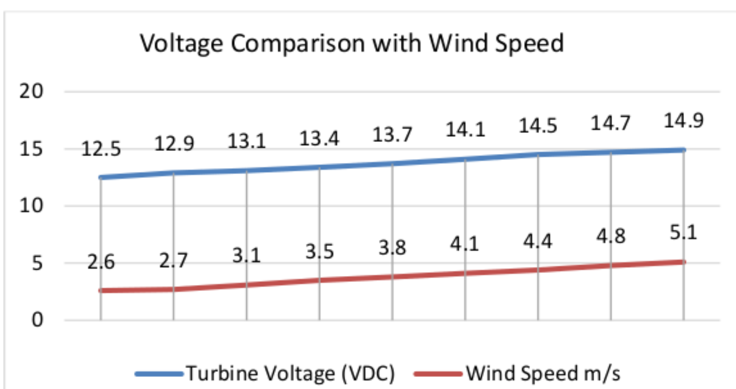

FIGURE 5. Comparison of voltage with wind speed

The measurement of wind speed in Figure 4 above is to determine the output voltage of a vertical turbine without using a load. The measurement results of the no-load wind turbine test can be seen in Table 1 below. The measurement of wind voltage and speed above is carried out on a vertical turbine without a load before being given a wind controller (auto buck-boost), from that value the highest voltage is 14.9 VDC with a wind speed of 5.1 m/s. Measurements can also be seen in Figure 3 the following graph of the comparison of voltage and wind speed measurements. Figure 5 above shows the faster the wind rotation (wind turbine blades), the greater the voltage generated, namely the wind speed is directly proportional to the voltage.

TABLE 1. Measurement voltage and wind speed

Voltage (VDC)	Wind Speed (m/s)
12.5	2.6
12.9	2.7
13.1	3.1
13.4	3.5
13.7	3.8
14.1	4.1
14.5	4.4
14.7	4.8
14.9	5.1

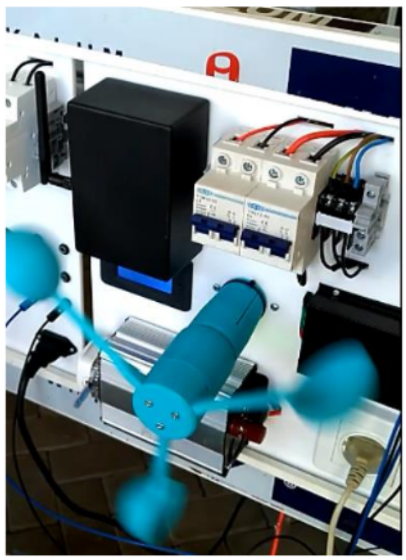

FIGURE 6. Wind power generation measurement module

The next testing stage is testing the wind power generation measurement module, at this testing, stage measurements are made on each sensor installed on the module including current, voltage, and wind speed sensors which can be seen in Figure 6 below. The wind power generation measurement module test was carried out in Figure 6 above to measure the power from the horizontal turbine and wind speed, the measurement test was carried out using current, voltage, and wind speed sensors for one day using a load. The test results can be seen in Table 1 below. The measurement test in table 2 above is carried out for one hour for one day starting at 07.00 until 17.00. Tests are carried out to measure the current, voltage, and wind speed variables to determine the potential of the wind energy produced every hour and how much power is produced by the turbine by comparing the wind speed and power of the turbine in one day. The results of Table 2 testing are the greater the wind speed produced, the greater the power from the turbine, at 11.00 the speed is 5m/s with the voltage and current generated by the turbine of 12.73 Volts, 0.29 Ampere. Measurement data of voltage, current, and wind speed variables can also be seen on the web that is displayed in the Monitoring module.

TABLE 2. Wind turbine voltage, current measurements, and wind speed

O'clock	Turbine Voltage (VDC)	Turbine Current (A)	Wind Speed
7:00:00	12.4	0.29	3.02
8:00:00	12.31	0.26	1.31
9:00:00	12.33	0.26	1.91
10:00:00	12.38	0.28	2.51
11:00:00	12.73	0.29	5.13
12:00:00	12.33	0.26	1.66
13:00:00	12.33	0.27	1.56
14:00:00	12.33	0.28	1.66
15:00:00	12.33	0.25	1.61
16:00:00	12.35	0.28	1.81
17:00:00	12.32	0.26	1.76

FIGURE 7. LCD and web monitoring module

The measurement test in Table 2 above is carried out for one hour for one day starting at 07.00 until 17.00. Tests are carried out to measure the current, voltage, and wind speed variables to determine the potential of the wind energy produced every hour and how much power is produced by the turbine by comparing the wind speed and power of the turbine in one day. The results of table 2 testing are the greater the wind speed produced, the greater the power from the turbine, at 11.00 the speed is 5m/s with the voltage and current generated by the turbine of 12.73 Volts, 0.29 Ampere. Measurement data of voltage, current, and wind speed variables can also be seen on the web that is displayed in the Monitoring module.

The monitoring module test is carried out by connecting and integrating the vertical turbine and wind power generation measurement module. After everything is connected and the sensors measure the reading data from the sensors sent through the router to the raspberry, the data from the sensor readings are displayed on the LCD and the web as shown in Figure 7 below. The image data above is obtained from logging data from the web monitoring module, measurement data is obtained from measurements of sensors sent from the wind power generation measurement module every hour starting from 07.00 am to 5.00 pm. The data displayed is in the form of graphs and also numbers for each measurement parameter. The image data above is obtained from logging data from the web monitoring module, measurement data is obtained from measurements of sensors sent from the wind power generation measurement module every hour starting from 07.00 am to 5.00 pm. The data displayed is in the form of graphs and also numbers for each measurement parameter.

CONCLUSION

Research on the potential of new renewable energy, namely wind energy, in this paper uses a horizontal wind turbine and is carried out at an unobstructed location, next to the railroad tracks adjacent to the rice fields. The results obtained show that the faster the wind rotation (wind turbine blades), the greater the voltage generated, namely the wind speed is directly proportional to the voltage, in the measurement at 07.00 am to 05.00 pm the lowest wind speed is 1.31 m/s with an output voltage of 12.31 VDC. and a current of 0.26 A at 08.00 am and the highest wind speed is 5.13 m/s with an output voltage of 12.73 VDC and a current of 0.29 A at 11 am.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8