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Analysis of the Performance of The Four-Blade Darrieus Wind Turbine at the Jamik Bukit Asam Mosque Complex Tanjung Enim South Sumatra

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ABSTRACT

Several types of renewable energy have been developed, such as solar energy, biomass, hydro energy, geothermal, and wind energy. Wind energy is an up-and-coming alternative and renewable energy. Wind energy is more environmentally friendly than available energy sources and has more accessible operational and maintenance costs. Indonesia has a relatively small natural wind energy potential because the wind speed in Indonesia is on average 3-6 m/s due to its location. Geographically, it is located in the equatorial area, especially the Muara Enim area, South Sumatra. This study aims to design a prototype the four-blade darrieus type vertical axis wind turbine (VAWT) needed for the utilization of wind energy which is used for Coffee Shop electricity needs at the Jamik Bukit Asam Tanjung Enim Mosque complex, South Sumatra, with the conclusion that the wind turbine, wind turbine rotation, the magnitude of the output voltage and The current generated significantly affects the wind speed in the area.

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1. INTRODUCTION

One of the rapidly growing renewable energies in the world today is wind energy [1]. Wind energy has long been known and used by humans, for example, for power generation, but wind energy in the Indonesian region is classified as low wind speed. However, wind potential in Indonesia is available almost all year round, making it possible to develop small-scale power generation systems [2]. One of them is the manufacture of wind turbines, which will later help generate electricity and meet the community's electricity needs [3].

Energy has an essential role in developing a country if its availability and development are hand in hand and support national development [4][20]-[23]. The need for energy, especially electrical energy in Indonesia, is an inseparable part of the needs of people's daily lives, along with the rapid development in the fields of technology, industry and information. According to PT Perusahaan Listrik Negara, the number of customers during 2009-2013 increased from 39.9 million to 53.7 million or an average of 3 million annually (RUPTL 2015-2025) [5][13][14][16].

The availability of energy is not commensurate with the increasing demand, so renewable energy is needed to minimize the use of fossil energy. Renewable energy sources are expected to have an active role in

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the present and future energy diversification scenario [6][24]. Wind energy is renewable energy [6]. In most areas, the quality and quantity of wind have low speed where wind energy engineering is needed because of its significant and efficient potential in the future [7][25]. According to the latest Global Wind Report, the total global wind power installation was 318.105 GW at the end of 2013 [8][17][18].

Indonesia has a relatively small potential for wind energy naturally due to the average wind speed in Indonesia being 3-6 m/s due to its geographical location, which is located in the equator. However, some areas are wind areas due to the narrowing between two islands or the mountain slope area between two adjacent mountains, especially in the Muara Enim area, South Sumatra [9].

Effective technology is needed to increase the possibility of using wind energy at low wind speeds [10]. Therefore, it is necessary to develop a type of wind turbine suitable for use in areas with low wind speeds. Discussion on the use of low-speed wind is also considered necessary because it can increase Indonesia's electrification ratio. A prototype 4-blade vertical wind power plant based on Internet of Things (IoT) technology with a hybrid power system has been designed to optimize wind energy utilization in low-speed wind conditions. The utilization of IoT technology in hybrid power systems provides many advantages, namely controlling, monitoring, recording data, and analyzing to ensure efficient and optimal power delivery [11].

Wind turbines with an axis perpendicular to the wind direction have many modification options to optimize the extraction of the kinetic energy of the fluid flowing through it. Modification of the rotor blades is one option to optimize energy extraction carried out by a Vertical Axis Wind Turbine (VAWT) [12][15][19]. In this research, a study with turbine analysis with four blades Type Darrieus was conducted for the coffee shop electricity needs in the Jamik Bukit Asam Mosque complex, Tanjung Enim, South Sumatra.

2. RESEARCH DESIGN

The design of this research uses a Darrieus type H type vertical axis wind turbine with four blades as shown in Figure 1, which serves to capture the wind in converting mechanical energy into kinetic energy, which is connected to each FA 300 permanent magnet generator which has a maximum power of 3000 W with 24V current-voltage and generates Alternating Current (AC).

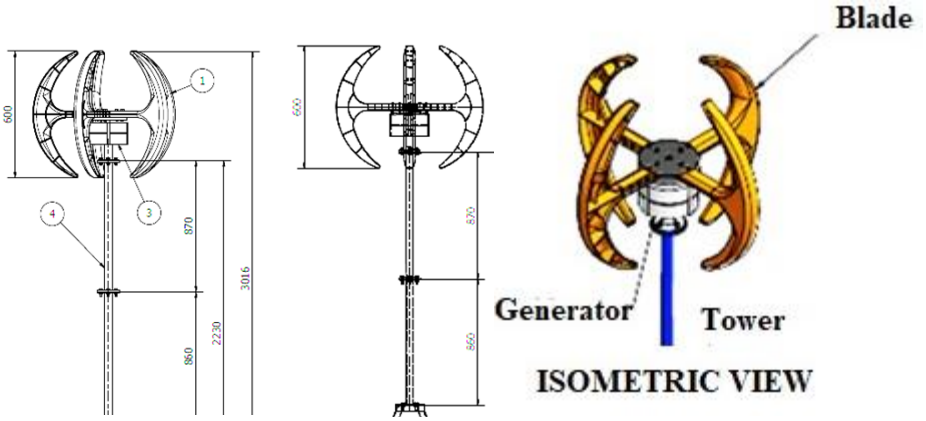

Figure 1. Vertical Axis Wind Turbine (VAWT) design

Actual conditions conducted this research. The turbine is installed in the tower building at the Jamik Bukit Asam Mosque tower, Tanjung Enim, as shown in Figure 2. Because the building uses a tower, it is possible to change the installation height. The material used in the blades is nylon fibre with a blade length of 600 mm and a wheel diameter of 900 mm. The turbine blades are connected to the rotor using galvanized pipe material with a diameter of 20 mm and a mild steel plate with a thickness of 2 mm. In this tower construction, generator sets, measuring instruments, panel boxes, lights, proximity sensors and electrical installations will be placed.

Figure 2. Location of Darrieus wind turbine installation at Jamik Bukit Asam mosque, Tanjung Enim

The research design used in collecting data is shown in Figure 3. Namely, the output of the wind generator is measured by voltage and current metering. Furthermore, the wind generator output is converted from Alternating Current (AC) to Direct Current (DC) through the wind charge controller and then supplies the battery and LED lights. The voltage and current of the LED lamp are measured using a meter. RPM on the wind generator is measured using a proximity sensor that reads the rotation of the wind generator. Voltage and current metering data used to measure wind generator output and load and RPM data from proximity produce RS 485 Modbus communication data. They will be converted to TCP/IP Modbus communication data to retrieve the data in real-time and stored in a database that will then be processed as test data.

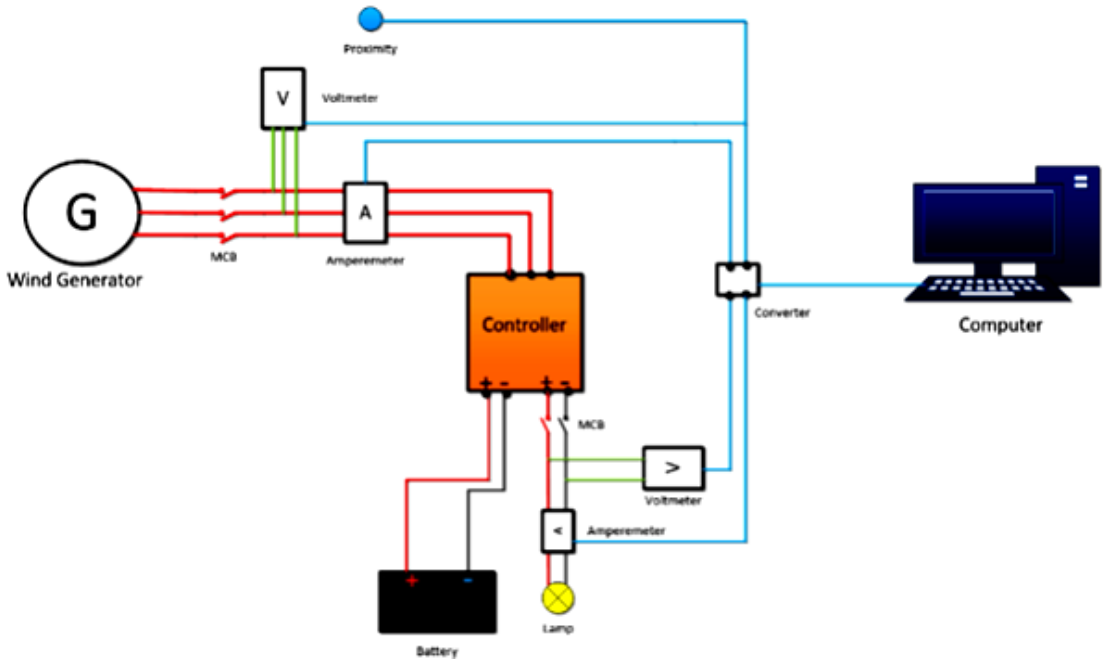

Figure 3. Electrical system

3. RESULTS AND DISCUSSION

This study takes data and writes research results in a tabular form with the format shown in Table 1. The table format will be used in the daily data collection starting at 09.00 WIB until 16.00 WIB with time intervals every 30 minutes within three days of testing. in the Jamik Bukit Asam Mosque area.

Table 1. Measurement wind data in the Jamik Bukit Asam mosque area

Data taken on June 19, 2021 – Day 1					
Time	**Wind Speed (m/s)**	**Curved H Type 4 Blade Darrieus Vertical Wind Turbine**			
		Output Voltage (V)	**Rate (A)**	**Turbine Rotational Speed (rpm)**	**Power Load (Watt)**
09:00	1,21	1,9	0	96,77	0,000
09:30	1,44	1,81	0	115,38	0,000
10:00	2,88	1,66	0	230,76	0,000
10:30	1,60	1,56	0	127,65	0,000
11:00	1,53	1,46	0	122,44	0,000
11:30	1,50	1,37	0	120	0,000
12:00	6,00	8,13	5,4	120	43,902
12:30	4,95	5,69	0	115,38	0,000
13:00	1,47	4,1	0	117,64	0,000
13:30	4,90	3,34	0	111,11	0,000
14:00	4,70	3,27	0	8	0,000
14:30	3,40	2,78	0	60,60	0,000
15:00	3,20	2,29	0	23,62	0,000
15:30	1,21	1,95	0	8	0,000
16:00	1,42	1,76	0	8	0,000
Data taken on June 20, 2021 – Day 2					
09:00	1,21	1,9	0	96,77	0,000
09:30	1,44	1,81	0	115,38	0,000
10:00	2,88	1,66	0	230,76	0,000
10:30	1,60	1,56	0	127,65	0,000
11:00	1,53	1,46	0	122,44	0,000
11:30	1,50	1,37	0	120	0,000
12:00	6,00	8,13	5,4	120	43,902
12:30	4,95	5,69	0	115,38	0,000
13:00	1,47	4,1	0	117,64	0,000
13:30	4,90	3,34	0	111,11	0,000
14:00	4,70	3,27	0	8	0,000
14:30	3,40	2,78	0	60,60	0,000
15:00	3,20	2,29	0	23,62	0,000
15:30	1,21	1,95	0	8	0,000
16:00	1,42	1,76	0	8	0,000
Data taken on June 21, 2021 – Day 3					
09:00	1,21	1,9	0	96,77	0,000
09:30	1,44	1,81	0	115,38	0,000
10:00	2,88	1,66	0	230,76	0,000
10:30	1,60	1,56	0	127,65	0,000
11:00	1,53	1,46	0	122,44	0,000
11:30	1,50	1,37	0	120	0,000
12:00	6,00	8,13	5,4	120	43,902

12:30	4,95	5,69	0	115,38	0,000
13:00	1,47	4,1	0	117,64	0,000
13:30	4,90	3,34	0	111,11	0,000
14:00	4,70	3,27	0	8	0,000
14:30	3,40	2,78	0	60,60	0,000
15:00	3,20	2,29	0	23,62	0,000
15:30	1,21	1,95	0	8	0,000
16:00	1,42	1,76	0	8	0,000

From the data collection results as shown in Table 1, the data obtained is then processed and analyzed to produce a graph presented as shown in Figure 4 as follows.

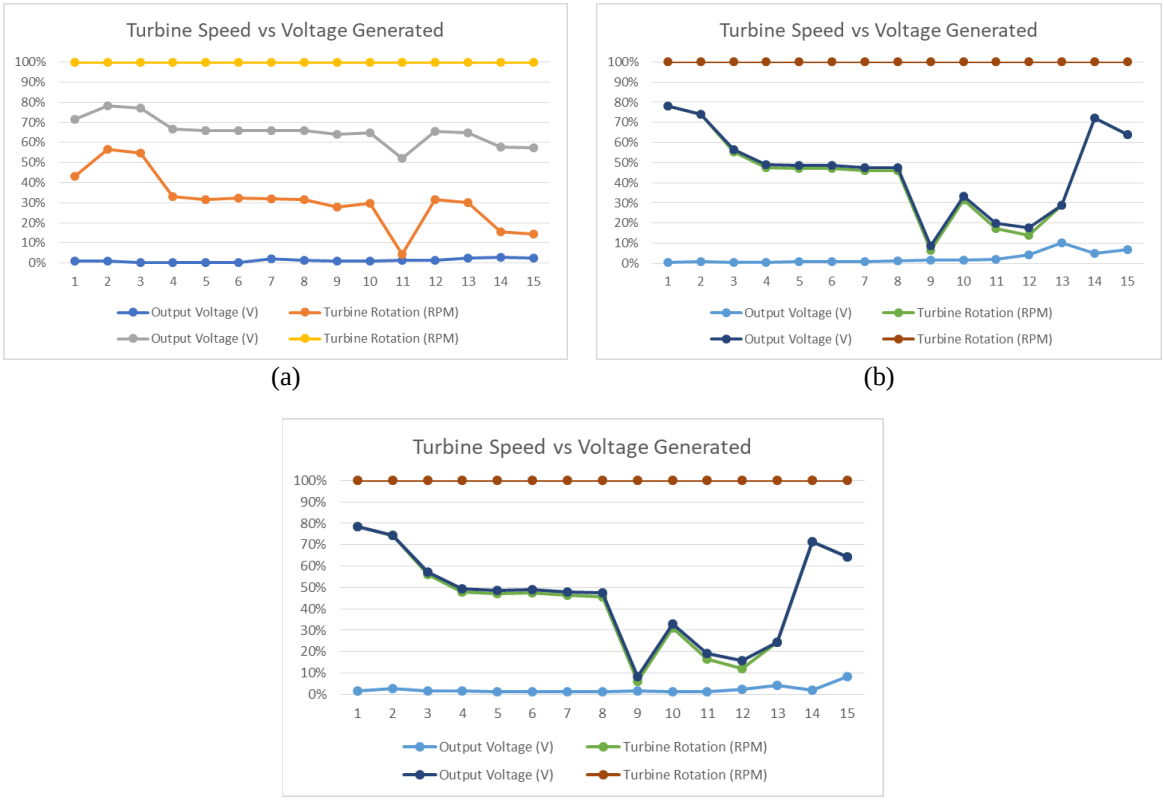

Figure 4. Comparison of 4 Blade and 5 Blade Turbine Speeds (Actual Conditions) vs Voltage generated from the turbine for 3 days, (a) Day 1 (b) Day 2 (c) Day 3

Turbine testing for three days proves that the resulting voltage affects the performance of the turbine rotation. It is seen that the difference in dimensions and the number of blades of the two types of turbines have an essential role in the design of the desired turbine design. Based on the graph presented in Figure 4 on the rotation of a four-blade wind turbine, it is known that the generated voltage influences the turbine rotation, the optimum condition can be seen when the turbine rotation is faster than the wind generator and produces a greater electrical voltage is supported by sufficient wind speed.

4. CONCLUSION

In the research analysis of the performance of the four-blade darrieus wind turbine at the Jamik Bukit Asam Mosque Complex, Tanjung Enim, South Sumatra, it is known that the results of the four-blade

turbine performance for Coffee Shop electricity needs that the wind turbine, wind turbine rotation, the value of the output voltage and the current generated significantly affect wind speed in the area.

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