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Study of Effect Changing the Blade Shape and Lift Angles on Horizontal Wind Turbine

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Abstract: The lack of energy commodities such as coal and petroleum makes the cost of these commodities soar. This event shows how much countries in the world are still very dependent on fossil fuels, and it is fitting that the transition to new renewable energy can be realized soon, low emission and environmentally friendly energy is the hope in the future. Indonesia has a supply of renewable energy sources that are abundant is a great force for this clean energy revolution. The momentum of the presence of the first wind farm in Indonesia operating in Mattirotasi Village, Sidrap Regency, Central Sulawesi in Indonesia with a wind power plant capacity (PLTB) of 75 MW is positive evidence that the government is starting to pay more attention to the development of renewable energy technology in Indonesia. Turbine technology that is able to optimize wind speed in Indonesia must be the answer so that this energy is more useful. In this study, the idea for an experimental analysis of "Study of the Effect of Blade Shape Change and Lift Angle on Horizontal Wind Tubin using Nvis 6009 Experimentation with Solar and Wind Energy props. The Nvis 6009 is a prop used by vocational schools to understand the concept of a DC power plant based on solar and wind energy. To optimize low wind speed, on Nvis 6009 horizontal axis wind turbine (HAWT) with different type 3 Blade and changes in lift angle, so that we can know the effect of the resulting voltage change, so that we can know the effect of the resulting voltage change. Simple illustrations using the Solidworks application are done as validation of the results of previous research and to obtain preliminary data of research experiments. The final results of the test on Type Blade II obtained maximum data at a Blade angle of 13 ° with a wind speed of 3.9 m / s, Blade Rotation 2587 Rpm produces a voltage of 2.8 V.

Keywords: wind, turbine, renewable, blade

1. Introduction

The current energy scarcity is due to the increase in the cost of energy commodities which is simultaneously followed by the demands of a surge in global demand, starting with the start of the economic impact of the effects of the Covid-19 pandemic that occurred in the last two years. Shortages of energy commodities such as coal and petroleum make the cost of these commodities soar.

This event shows that how much countries in the world still rely on and depend on fossil fuels, and it is fitting that the transition to renewable energy can be realized soon, low emission and environmentally friendly energy will be the focus of energy driving in the future. Indonesia has a supply of renewable energy sources that are abundant is a great force for this clean energy revolution.

The Government's move through Government Regulation (PP) Number 79 of 2014 on National Energy Policy (KEN) plans the use of renewable energy in order to improve energy security. Through Presidential Regulation (Perpres) Number 22 of 2017 Indonesia also targets the renewable energy mix of 23% of the total primary energy supply (TPES) in 2025 and 31% in 2050.

In the reputation of renewable energy that is ongoing today, there are two technologies that in the development of research and its application shot up significantly, namely solar panels and wind turbines. Solar panel growth is about 27%, wind turbine construction reached 36%, water turbines 22% and bioenergy 12% in 2017. The total capacity for wind turbines reaches 510 GW and solar panel installations are close to 400 GW worldwide, and it is predicted that the development of world renewable energy capacity for solar panels and

Wind turbines in the next five years reaches 80%, this shows that renewable energy plays an important role in the growth of the global economy The momentum of the presence of the first wind farm in Indonesia operating in Mattirotasi Village, Sidrap Regency, Central Sulawesi in Indonesia with a wind power plant capacity (PLTB) of 75 MW is positive evidence that the government is starting to pay more attention to the development of renewable energy technology in Indonesia.

Generally, as in the tropics, the wind that occurs in the territory of Indonesia is a local wind caused by differences in pressure from each region. This difference in pressure is caused by temperature differences due to the effects of warming the Earth's surface by solar energy. In general, the average wind speed range is measured in Indonesia in the range of 2.5 - 5.5 meters / second at an altitude of 24 meters above ground level. While wind turbine technology is generally designed for relatively higher wind speeds, the most active institutions engaged in wind energy development in Indonesia, namely the National Aeronautics and Space Administration (LAPAN). The institute conducts activities ranging from data monitoring programs and measurement of wind energy, technology development, to pilot projects. Turbine technology that is able to optimize wind speed in Indonesia must be the answer so that this energy is more useful.

Some researchers have been carried out for wind turbine applications in the low wind speed area. Based on Indonesia Wind Prospecting data, Tanjung Enim, the research area in South Sumatra, is categorized as a low wind speed area because it has an average wind speed of 3.4 m/. Gupta et al., 2006 investigated the performance of the vertical 2-stage combined Savonius and Darrieus turbines illustrated in Fig. 1 with three Savonius blades and three Darrieus blades. The Savonius turbine is placed on top of the Darrieus turbine. The results show that Cp max is 51% when the Savonius turbine overlap is 0. Turbine efficiency will decrease with the increase in the blade overlap percentage. Because the tip speed ratio (λ) of the Savonius turbine is meager, the correlation dimension is very small, so it needs to be in a reasonable size to generate the maximum possible Cp from the turbine.

As the research [3] compares two types of vertical wind turbines to find the optimum type of blade using wind from the exhaust tunnel area, in the result of the study show that the performance of blades of the 3 blades wind turbine combination of savonius and darrieus is more optimal than the 4 blades combination of savonius and darrieus. The output voltage and current produced by a variety of 3 blades Sovonius and Darriues is 14% and 109% higer than the combination of the 4 blades of Savonius and Darrieus.

Gumilar's (2020) HAWT simulation conclude that it was concluded that the greater pitch angle, the maximum power produced by the turbine would decrease. The maximum power of the highest wind turbines between wind turbines with different pitch angles is 1608.45 W at 32 rpm wind turbine rotor rotation speed and 20 m/s wind speed. Increasing wind speed, the power of the wind turbine will also increase. In addition, the increase in horizontal wind turbine rotor speed is not followed by an increase in wind turbine power. At the limit of the turbine rotor speed range the wind turbine power increases but at the other range the wind turbine power decrease. So that the speed of the wind turbine rotor with turbine power forms a nonlinear relationship. Wind turbines with pitch angle 00 have the highest power coefficient value compared to other pitch angles. Increase the power coefficient, wind turbine power will increase too. For further research, it can use more detailed change in pitch angle to obtain higher maximum power from this research. Pitch angle more detail, for example in pitch angles from 0.10 to 39.90 with intervals of 0.10 at each change in pitch angle.

In this study, the idea for an experimental analysis of "Study of the Effect of Blade Shape Change and Lift Angle on Horizontal Wind Tubin using Nvis 6009 Experimentation with Solar and Wind Energy props. The Nvis 6009 is a prop used by vocational schools to understand the concept of a DC power plant based on solar and wind energy. To optimize the low wind speed on the Nvis 6009 horizontal axis wind turbine is made by using a different type 3 Blade and changes in its lift angle, so that we can know the effect of the resulting voltage change. Simple illustrations using the Solidworks application are done as validation of the results of previous research and to obtain preliminary data of research experiment.

2. Methodology

The research aimed to determine the optimum angular, blade shapes and wind velocity to generate maximum voltage. In this study conducted using Nvis 6009 horizontal axis wind turbine props, Nvis 6009 is a prop used by vocational schools to understand the concept of DC power generation based on wind energy. Measurements with minimal and maximum wind speeds generated from fans with anemometers obtained speeds of 3.2 m/s – 3.9 m/s, all installations are connected on-board, via digital multimeters that are also connected to on bord output of voltage and current produced by wind turbine rotation can be measured.

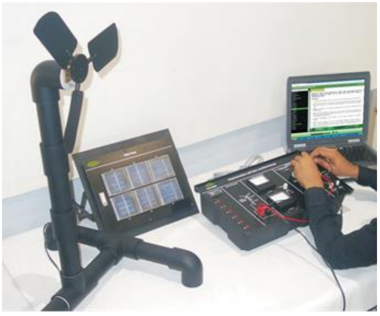

Figure 1. *Nvis6009 experimentation tool HAWT www. Nvis Tech.com*

Using solidwork applications a variation 3 Blade of wind turbines of different shapes and sizes are designed as shown on Fig 2, Fig 3, and Fig 4. The type of turbine used is Horizontal Axis Wind Turbine (HAWT). Each of the Blade diameter is: D = 380 mm, D = 420 mm, and D = 330 mm, aluminum metal sheet material thickness of 0.7 mm

Figure 2. *Blade I HAWT*

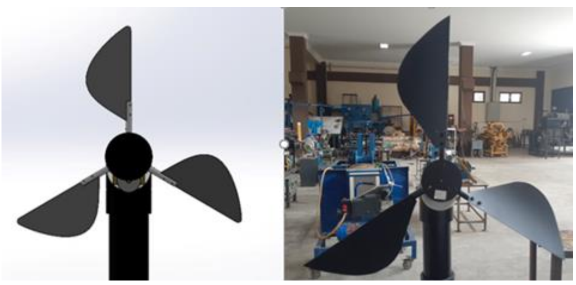

Figure 3. *Blade II HAWT*

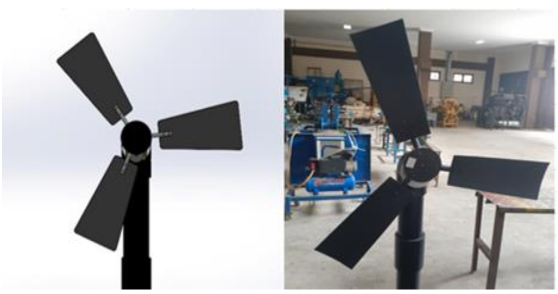

Figure 4. *Blade III HAWT*

3. Results and Discussion

The wind turbines were tested by comparing three different type of turbine Blade shapes and with different pitch angle 5°, 9°,13°,17°,21°,25°, and 29°, the distance between the turbine and the fan was 100 mm parallel, with wind speeds of 3.2 m/s, 3.5 m/s and 3.9 m/s. Test results showed the turbine's rotation speed, and voltage are presented in table and Figures.

Table 1. *Measurement of I HAWT Blade data*

No	Blade Angle (°)	Wind Speed (m/s)	Blade rounds (rpm)	Voltage (v)
1	5	3.2	0	0
2	5	3.5	0	0
3	5	3.9	0	0
4	9	3.2	938	2.2
5	9	3.5	1700	2.3
6	9	3.9	2974	2.2
7	13	3.2	421	1.6
8	13	3.5	648	2.0
9	13	3.9	995	2.1
10	17	3.2	674	1.9
11	17	3.5	865	2.0
12	17	3.9	1156	2.0
13	21	3.2	339	1.7
14	21	3.5	403	1.9
15	21	3.9	457	2.0
16	25	3.2	325	0.6
17	25	3.5	542	1.1
18	25	3.9	620	1.4
19	29	3.2	165	0.2
20	29	3.5	235	0.2
21	29	3.9	387	0.2

From the results of the test of the variation of Blade 1 obtained the minimum data at the angle of the 5 °. Blade with a wind speed of 3.2 m / s Blade Rotation 0 Rpm and voltage 0 V, while the optimum data is obtained at a corner of Blade 9 ° with a wind speed of 3.9 m / s Blade Rotation 1700 Rpm and voltage of 2.3 V.

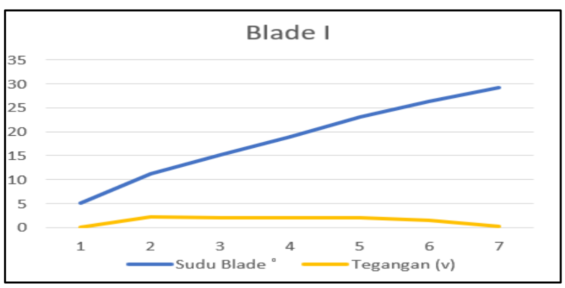

Figure.5 *Graph of Blade I Testing*

Table 2. *Measurement of Blade II HAWT data*

No	Blade Angle (°)	Wind Speed (m/s)	Blade rounds (rpm)	Voltage (v)
1	5	3.2	0	0
2	5	3.5	582	2.3
3	5	3.9	658	2.5
4	9	3.2	1475	2.4
5	9	3.5	1055	2.6
6	9	3.9	1867	2.7
7	13	3.2	1857	2.4
8	13	3.5	2085	2.6
9	13	3.9	2587	2.8
10	17	3.2	1068	2.3
11	17	3.5	1659	2.5
12	17	3.9	2075	2.6
13	21	3.2	1406	2.0
14	21	3.5	2084	2.2
15	21	3.9	2135	2.5
16	25	3.2	805	1.7
17	25	3.5	1189	2.1
18	25	3.9	1289	2.1
19	29	3.2	487	1.2
20	29	3.5	648	1.6
21	29	3.9	866	1.9

From the results of the Blade II variation test, the minimum data was obtained at a 5° angle with a wind speed of 3.2 m / s Blade Rotation 0 Rpm and voltage 0 V, while the maximum data was obtained at a corner of Blade 13 ° with a wind speed of 3.9 m / s Blade Rotation 2587 Rpm and voltage of 2.8 V.

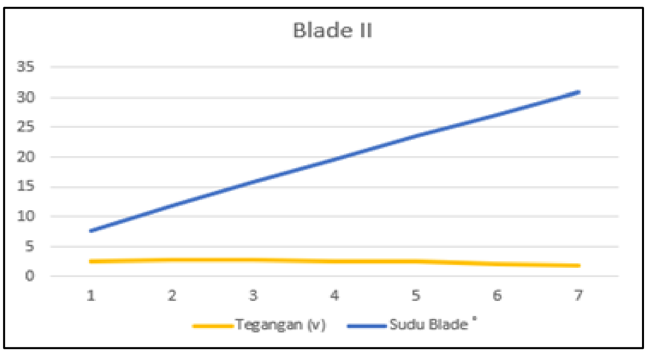

Figure 6*. Graph of Blade II*

Table 3*. Measurement of Blade III HAWT data*

No	Blade Angle (°)	Wind Speed (m/s)	Blade rounds (rpm)	Voltage (v)
1	5	3.2	0	0
2	5	3.5	0	0
3	5	3.9	0	0
4	9	3.2	873	1.9
5	9	3.5	845	2.1
6	9	3.9	1117	2.2
7	13	3.2	308	1.6
8	13	3.5	439	1.8
9	13	3.9	449	1.9
10	17	3.2	222	1.1
11	17	3.5	318	1.3
12	17	3.9	391	1.5
13	21	3.2	206	0.8
14	21	3.5	295	1.2
15	21	3.9	454	1.4
16	25	3.2	386	0.7
17	25	3.5	462	0.8
18	25	3.9	566	1.0
19	29	3.2	134	0.3
20	29	3,5	251	0,4
21	29	3.9	422	0.6

From the results of the Blade III variation test, the minimum data was obtained at a 5° angle with a wind speed of 3.2 m / s Blade Rotation 0 Rpm and voltage 0 V, while the maximum data was obtained at a corner of Blade 9 ° with a wind speed of 3.9 m / s Blade Rotation 1117 Rpm and voltage of 2.2 V.

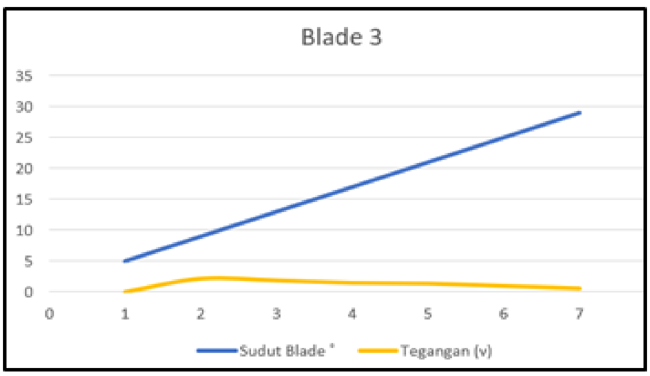

Figure 7*. Graph of Blade III Testing*

4. Conclusion

Experiment held for knowing the wind turbine performances with comparing three different shape of blade with each diameter (D 380 mm, 420 mm, and 330 mm and with angular variation applied between 5˚, 9˚, 13˚, 17, 21˚, 25˚, and 29˚ turbine space and blade parallel on 1000 mm, with turbine speed 3,2 m/s, 3,5 m/s and 3,9 m/s. The result of experiment can be seen in tables and graphics that show wind speed affects the rotation of the blade, so that the resulting voltage increases. The variation of angle of wind turbine show the angle affects the rotation of the blade. The conclusion for this experiment, Blade II gives maximum performance at blade angle with wind speed 3,9 m/s, the blade rotation is 2587 Rpm and it can generate voltage 2,8 V.

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