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| RESEARCH ARTICLE

Utilization of Exhaust Fan from Air Conditioner for Horizontal Axis Wind Turbine with Differences in the Number of Blades

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| ABSTRACT
Energy needs are increasing every year in line with the increase in population, economic growth, and high energy consumption. Indonesia's fossil energy reserves continue to decline; therefore, it is necessary to increase the non-fossil energy used. Indonesia, which has an abundant supply of renewable energy sources, is a major force in this clean energy revolution. As a renewable energy source, wind energy is a good form of energy that can be developed using wind turbines. The wind source to drive the wind turbine can come from natural wind sources or exhaust wind from equipment. In addition to utilizing natural wind energy, there is also artificial wind, which is the result of waste energy from exhaust fans, as an alternative energy source option for wind power plants. In this study, the idea emerged to conduct an experimental analysis of AC exhaust fans as a wind source for horizontal wind turbines to understand the concept of wind-based DC power generation and optimize low wind speeds in horizontal axis wind turbines with a different number of blades. The numbers were 2, 3, and 5, so the effect of the resulting voltage change could be known. The final result of testing on a horizontal turbine with 5 blades was that the wind speed was 3.63 m/s, the blade rotation was 1170.8 rpm, and the turbine was able to generate a voltage of 23.50 V.

| KEYWORDS
Wind, turbine, Blades, Horizontal

| ARTICLE INFORMATION
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1. Introduction
Energy needs are increasing every year in line with the increase in population, economic growth, and high energy consumption. Indonesia's fossil energy reserves continue to decline; therefore, it is necessary to increase the non-fossil energy used. (Arifin et al., 2022; Firmansyah et al., 2021; Ploetz et al., 2016; Tran & Kim, 2019).

Government pace through Government Regulation Number 79 of 2014 concerning the National Energy Policy plans the usage of renewable energy in order to increase energy resilience. Through Presidential Regulation (Perpres) Number 22 of 2017, Indonesia is also targeting a renewable energy mix of 23% of the total primary energy supply (TPES) in 2025 and 31% in 2050 (Astanto et al., 2022).

Renewable energy is an alternative to reducing dependence on fossil energy. One of the rapidly growing renewable energies in the world nowadays is wind energy (Dinata et al., 2022; Nugraha et al., 2021; Praditya et al., 2019; Syahputra & Soesanti, 2021; Wardhana et al., 2019).

As a renewable energy, wind energy is a good form of energy to be developed using wind turbines. The wind source to drive wind turbines can come from natural wind sources and exhaust wind from equipment (Fauzih et al., 2021).

In addition to utilizing natural wind energy, there is also artificial wind, which is the result of waste energy from exhaust fans, as an alternative energy resource option for wind power plants (Ismail et al., 2021). Effective technology is needed to increase the possibility of using wind energy at low wind speeds (Susandi et al., 2021).

There are many modification options to optimize the extraction of the kinetic energy of the fluid flowing through it (Susandi et al., 2021; Yuliandi et al., 2018). Modified rotor blades are an option to optimize the energy extraction carried out by the Vertical Axis Wind Turbine (VAWT) (Kamal et al., 2021).

In this study, an idea emerged to carry out an experimental analysis regarding the effect of the number of blades on the performance of a horizontal turbine. Optimizing the exhaust fan from the air conditioner in order to know the effect of the resulting voltage change.

2. Literature Review

Several studies were conducted, including the research from Wardhana et al. 2019. regarding "Design of Mini Horizontal Wind Turbine for Low Wind Speed Area". That research was conducted to determine the output voltage and current generated by a design of the 3-blade horizontal wind turbine. Retrieval of the resulting output data was obtained by direct analysis using a fan. The results showed that the designed wind turbines could rotate with low wind speeds ranging from 1.5 - 2.4 m/s wind speed. Based on the research results, it was concluded that the designed wind turbine has the potential to be converted into electrical power in low wind speed areas with a cutting speed of 1.5 m/s. (Wardhana et al., 2019).

Astanto et al.'s research on ''Study of Effect Changing the Blade Shape and Lift Angles on Horizontal Wind Turbine''. Experiments were carried out to determine the performance of wind turbines by comparing three different blade shapes with their respective diameters (D 380 mm, 420 mm, and 330 mm and with variations in the angles used between 5˚, 9˚, 13˚, 17˚, 21˚, 25˚, and 29˚with a distance between blades and parallel blades of 1000 mm, with wind speeds of 3.2 m/s, 3.5 m/s, and 3.9 m/s. The experimental results can be seen in the tables and graphs, which show that wind speed affects blade rotation, so the resulting voltage increases. Variations in the angle of the wind turbine indicate that the angle affects the rotation of the blade. The conclusion from this experiment, Blade II provided maximum performance at a blade angle with a wind speed of 3.9 m/s, a blade rotation of 2587 Rpm, and was able to generate a voltage of 2.8 V. (Astanto et al., 2022).

3. Methodology

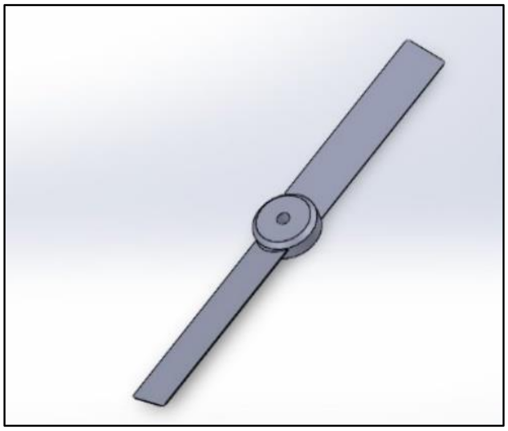
This study aims to utilize the exhaust fan from the air conditioner to obtain wind speed which is used as a source of wind energy in determining the effect of the optimal number of blades and distance to produce a maximum voltage in a horizontal turbine.

(a) **(b)**

Fig 1. Turbine test scheme, (a) as a 3D drawing ; (b) actual HAWT turbine

Using aluminium material had a thickness of 1 mm with a blade size of Length P = 300 mm, Width L = 70 mm, and a slope angle of 15 ˚ with three variations in the number of blades made with conditions suitable for research tools. The three variations in the number of blades are shown in Fig. 2-4.

(a)



(b)

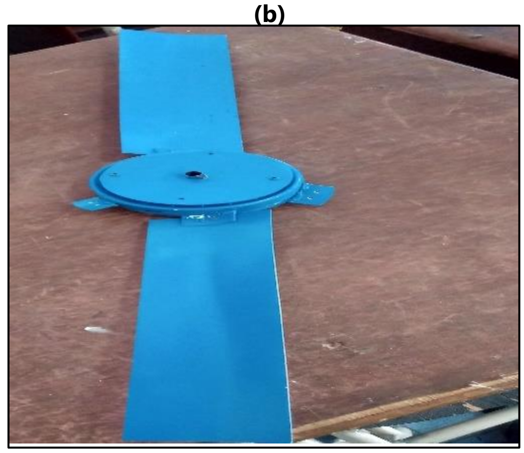
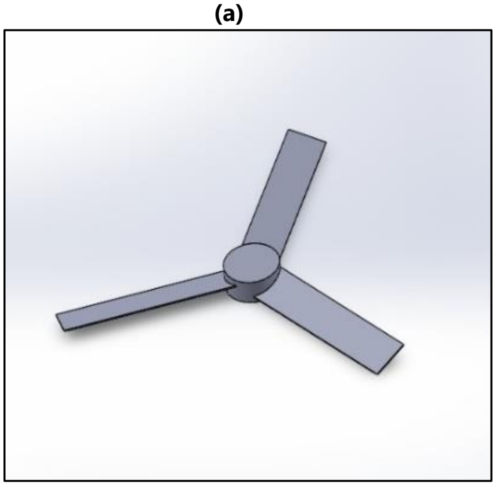


Fig 2. Turbin Horizontal 2 blade, (a) as a 3D drawing ; (b) actual HAWT turbine

In Fig 2. The turbine was designed to have 2 horizontal blades and was made according to the design that had been carried out. This turbine was the model I in the experiment to be carried out.

(a)

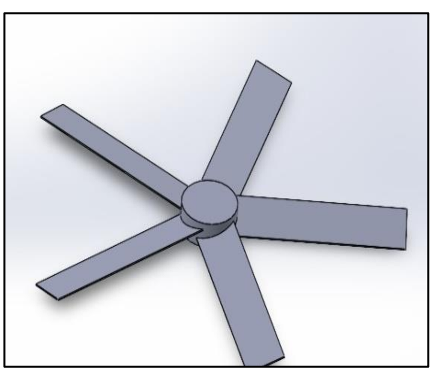


(b)

Fig 3. Turbin Horizontal ; 3 blade, (a) as a 3D drawing ; (b) actual HAWT turbine

Model II Horizontal turbine was designed with 3 blades, then made based on the design for further testing.

(a)



(b)

Fig 4. Turbin horizontal 5 blades, (a) as a 3D drawing ; (b) actual HAWT turbine

The last study used 5 vertical blades, which were made with a design that had been planned as model III from testing the turbine research.

4. Results and Discussion

Wind turbines were tested by comparing three types with a different number of blades those were 2 blades, 3 blades and 5 blades turbines, using an exhaust fan from the air conditioner as the wind source. Measurement results are presented in tables and figures.

Table 1 Blade HAWT Turbine

Total of Blades	**Horizontal Wind Turbine**			
	Wind Velocity (m/s)	Voltage (V)	Turbine Speed (rpm)	Space from Exhaust Fan (Cm)
2	3,63	12,24	485,10	10
	3,24	11,38	473,50	20
	2,22	10,63	450,02	30
	1,80	10,01	197,06	40
	1,20	9,50	180,20	50

From the results of testing the 2-blade variation, the data was obtained with wind speeds of 1.20 - 3.63 m/s. Turbine rotation 180.20 - 485. 10 Rpm and voltage 9.50 - 12.24 V, for maximum data obtained when the wind turbine was placed 10 cm from the exhaust fan with wind speed 3.63 m/s turbine rotation of 485 Rpm and a voltage of 12.24 V.

Table 2 Blade HAWT turbine

Total of Blades	**Horizontal Wind Turbine**			
	Wind Velocity (m/s)	Voltage (V)	Turbine Speed (rpm)	Space from Exhaust Fan (Cm)
3	3,63	13,84	485,10	10
	3,24	13,38	473,50	20
	2,22	12,00	450,02	30
	1,80	10,12	197,06	40
	1,20	9,50	180,23	50

From the results of the 3-blade variation test, data were obtained with wind speeds of 1.20 - 3.63 m/s. Turbine rotation 180.23 - 485.10 Rpm and voltage 9.50 - 13.84 V, for maximum data obtained when the wind was placed 10 cm from the exhaust fan with a wind speed of 3 .63 m/s turbine rotation of 485 Rpm and a voltage of 13.84 V.

Table 3 Blade HAWT Turbines

Total of Blades	**Horizontal Wind Turbine**			
	Wind Velocity (m/s)	Voltage (V)	Turbine Speed (rpm))	Space from Exhaust Fan (Cm)
5	3,63	23,50	1170,8	10
	3,24	21,74	985,56	20
	2,22	15,49	734,70	30
	1,80	13,03	485,10	40
	1,20	11,89	473,50	50

From the results of the 5-blade variation test, data were obtained with wind speeds of 1.20 - 3.63 m/s. Turbine rotation 473.50 - 1170.8 Rpm and voltage 11.89 - 23.50 V, for maximum data obtained when the wind turbine was placed 10 cm from the exhaust fan with a wind speed of 3.63 m/s turbine rotation of 1170.8 Rpm and voltage of 23.50 V.

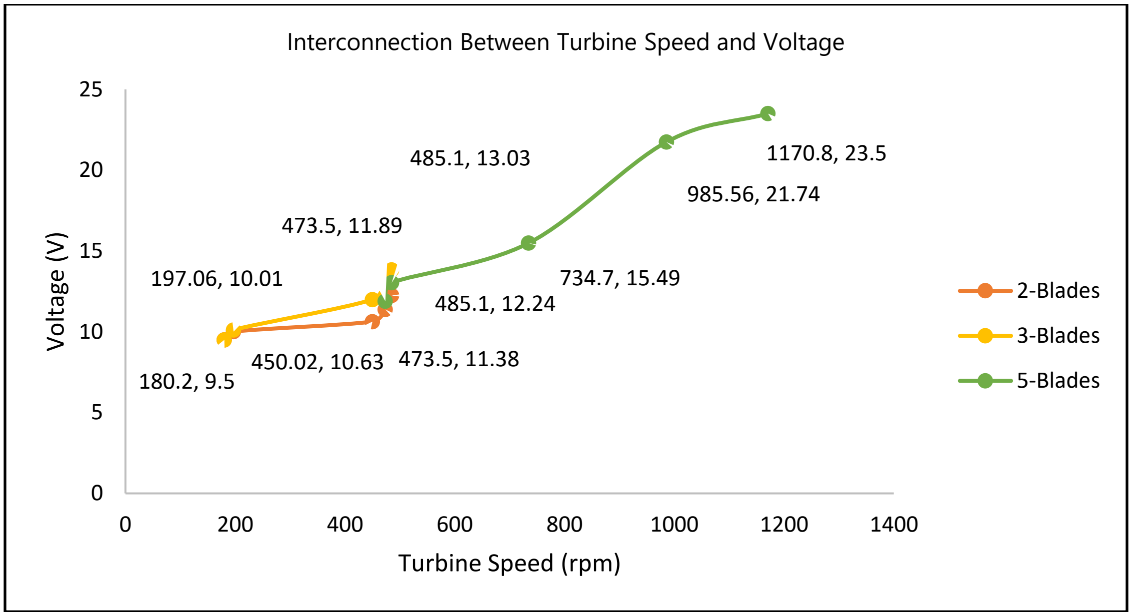


Fig 9 Graph Voltage of The Experiment Using 2,3, and 5-Blades HAWT Turbine

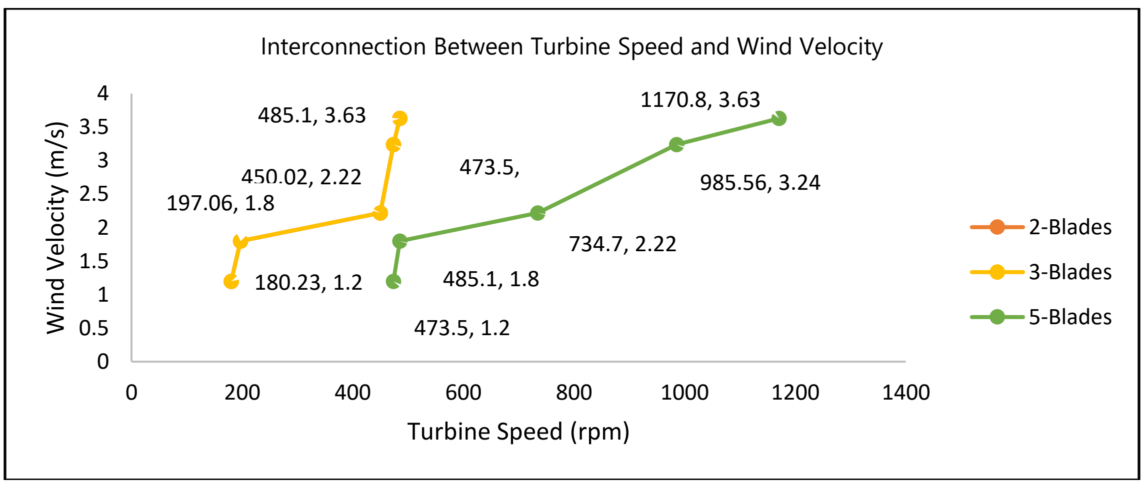


Fig 10 Graph Wind Velocity of The Experiment Using 2,3, and 5-Blades HAWT Turbine

From the graph of wind velocity above, it can be seen that wind velocity is directly proportional to the resulting spin, meaning that the greater the given wind speed, the greater the turbine rotation generated and the greater the energy exerted by the wind on the turbine. The energy that can limit the turbine becomes an ever-increasing cycle. The resulting rotation in the turbine horizontal axis wind by the number blade 5 is better by comparison with the number of blades 2 and 3. The greater the wind speed, the greater the resulting rotation, which is also increasing. The variation in the number of blades done also has a different power value, where the maximum power occurs on the number of blades 5, which is greater if compared to the number of other blades. For the use of the number of blades, less than 5 blades will yield smaller rounds because there is a gap between the blades, one with that blade and the other, so it generates low rpm due to the fact that a lot of energy is lost through the gaps between blades. For the number of blades, more than 5 blades will also reduce the rotation of the turbine because the wind seems to crash walls that are located precisely between the blades, causing a burden on the other blades because the distance between the blades is too tight.

5. Conclusion

Based on the findings of this study, it can be inferred that the wind energy generated by an AC source can be harnessed to create a laboratory-scale wind turbine. The turbines utilised in this experiment were of horizontal variety and featured varying numbers of blades. The experimental results indicate that there is a positive correlation between the number of blades and the voltage output, implying that the system performance benefits from an increase in wind speed. This is supported by the data presented in the tables and graphs. The device exhibits the capability to operate as an electric power generator at both laboratory and residential scales through the utilisation of an AC fan's velocity and the optimal blade three model comprising five blades. Despite the presence of certain challenges, determining the ideal distance for achieving maximum external voltage through the approach of a turbine towards the air source emitted by an AC remains a crucial consideration. Subsequent inquiries may employ vertical analysis and optimal configuration as methodologies to enhance performance. Hence, further collaborative research can be conducted to advance the development of air and enhance the efficiency of wind energy sources for external users.

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