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THE POTENTIAL USE OF MINI WIND TURBINES AT SEKOLAH TINGGI ILMU PELAYARAN AS AN ALTERNATIVE RENEWABLE ELECTRICAL ENERGY SOURCE

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ABSTRACT

The need for electrical energy from year to year is getting bigger along with the increasing growth of population and industry, especially in big cities in Indonesia. The need for electrical energy in Indonesia still depends on Electrical Energy provided by the Perusahaan Listrik Negara (PLN). the main source of PLN's electrical energy is Fuel oil and Coal (50.01%). Sekolah Tinggi Ilmu Pelayaran as an educational institution seeks to support the government to reduce dependence on electrical energy produced with fossil fuels by seeking the potential of electrical energy sourced from renewable energy sources. One of the energies that has the potential as alternative energy is wind energy, where kinetic energy from the wind is utilized into electrical energy using wind turbines. For this reason, it is necessary to calculate the potential of wind energy as a renewable alternative energy at Sekolah Tinggi Ilmu Pelayaran

Keyword : Wind Turbine, Renewable Energy, Electricity

1. INTRODUCTION

The demand for electrical energy in Indonesia has increased from year to year. According to the Ministry of Energy and Mineral Resources, the growth of electricity demand reaches 7.1% per year. The total installed capacity of the Electricity Network issued by BPS (Electricity Statistics,2017-2021) is 66.172 Mega watts with the proportion for each type of power plant is 8.55% Hydropower, Steam Power (power plants with Energy sources from Coal and petroleum) 50.01%, Gas power 7.7%, Steam gas power 18.78%, Geothermal Power 3.82, Diesel Power

6.35%, Gas Engine Power 4.06, Micro Hydro Power 0.72%, Solar power 0.13% and other sources of 0.4%. Electrical energy sources are still dominated by non-renewable fuel sources with high levels of pollution. The global demand for fossil fuels (coal and petroleum) will greatly affect the price and availability of these fuels. Even on January 31, 2022 the Indonesian government banned the export of coal, due to the state electricity company experiencing a shortage of coal supply, the prohibition and sanction guidelines were also outlined in the Decree of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 13.K/HK.021/MEM. B/2022, dated January 19, 2022, concerning guidelines for the imposition of Administrative Sanctions, Prohibition of coal sales abroad and the imposition of fines and compensation funds for meeting domestic coal needs.

The Indonesian government has made policies related to the development of renewable energy as stipulated in the Presidential Regulation of the Republic of Indonesia Number 112 of 2022 concerning the Acceleration of Renewable Energy Development for electricity supply. The use of wind energy as renewable energy in Indonesia is still relatively low, this is constrained by the average wind speed in Indonesia ranging from 10.2 Km / hour to 39.2 Km / hour. With these wind speeds it will be very difficult to produce electrical energy in a large scale. However, there is wind potential throughout the year which makes it possible to develop electrical energy from wind power on a smaller scale (Alfaridzi, 2020).

To support government programs, Sekolah Tinggi Ilmu pelayaran as an educational institution needs to conduct studies related to the potential use of renewable energy as an alternative energy source other than electricity sourced from the State Electricity Company. Some of the potential alternative energy that may be studied applied to the College of Shipping is solar energy considering that many areas in the College of Shipping are open areas and receive direct exposure to sunlight for a full day. Other energy that has potential as alternative energy is wind power, given the geographical location of the College of Shipping which is close to the beach / sea. The difference in temperature on land and at sea during the day and night will result in differences in airflow pressure, so that there is a flow of air flowing between land and sea.

2. METHOD

The method used in this research is to take data on the average wind speed every month in 2021 which comes from the Sectoral Statistical Data of the DKI Jakarta Provincial Government 2022 Volume 4 Year 2022. The average wind speed data is compared with several previous studies related to efforts to increase the efficiency of wind power and the potential electrical power generated at certain wind speeds.

3. RESULT AND DISCUSSION

To produce electrical energy using wind power, a tool is needed, namely a wind turbine. The wind that moves through the wind turbine will cause the wind turbine to rotate, the rotation of the wind is used to produce electrical energy through a dynamo connected to the wind turbine.

In general, wind Turbines that use propeller blades are divided into two types, according to their rotating axis, namely Horizontal Axis wind Turbine (HAWT) where the wind turbine has a central axis on the horizontal axis and Vertical Axis

Wind Turbine (VAWT) wind turbine have a central axis on the vertical axis. There are also wind turbines without propeller blades. bladeless wind turbines utilize the resonance of the wind from the aerodynamic effect of the wind passing through the mast to generate electrical energy.

To increase the efficiency of Electric energy production generated from wind energy using Horizontal Axis Wind Turbine (HAWT), several ways are done, among others:

1. **Increasing the height of the wind turbine and changing the shear attack.**

   Wind speed at higher altitudes faster than wind speed at closer the surface of the earth (Michigan University, 2022). Research conducted on the East Coast Peninsullar of Malaysia showed that by changing the height of the wind trubine and shear attack showed the following results:

Table 1 Wind Speed

	Wind Speed (m/s)		
High	15 m	60 m	60 m
Shear attack		α=0.4	α=0.90
Month			
Jan	2,2	3,8	7,5
Feb	2,2	3,8	7,5
Mac	2,1	3,6	7,1
Apr	1,6	2,8	5,5
May	1,4	2,5	4,9
Jun	1,5	2,6	5,2
Jul	1,6	2,8	5,5
Aug	1,5	2,6	5,1
Sep	1,4	2,5	4,9
Oct	1,2	2,1	4,2
Nov	1,2	2	4
Dec	1,8	3,1	6,1

Table 2 Pearson Correlation Table

Correlations

		Average monthly Wind Speed		
		(15 M)	(60 m, α=0.4)	(60 m, α=0.9)
(15 m)	Correlation	1	.998**	.998**
	Sig.		.000	.000
	N	12	12	12
(60 m, α=0.4)	Correlation	.998**	1	1.000**
	Sig.	.000		.000
	N	12	12	12
(60 m, α=0.9)	Correlation	.998**	1.000**	1
	Sig.	.000	.000	
	N	12	12	12

Correlation test of wind speed at 15 meters and 60 meters, with hypothesis:

H_0 : The wind speed at 15 meters has a correlation with the wind speed at 60 meters.

H_1 : Wind speed at 15 meters has no correlation with wind speed at 60 meters.

H_0 is rejected if the significance value <0.05. Since the significance value of Pearson Correlation is 0.000 <0.05, the wind speed at a height of 15 meters has a correlation with the wind speed at a height of 60 meters with α=0.4 and α=0.90. with a positive correlation value of 0.998 (close to 1).

Hypothesis Test Linear regression of wind speed at 15 meters height and 60 meters height with α=0.4

Table 3 Anova Table

ANOVA

Model		Df	Mean Square	F	Sig.
1	Regression	1	4.071	2088.35	.000[b]
	Residual	10	.002		
	Total	11			

a. Dependent: Wind speed (zx=60m, α=0.4)
b. Predictors: (Constant), Wind speed (15m)

Table 4 Regression Linier

Coefficients[a]

Model		Unstandardized B	Unstandardized Std. Error	Standardized Beta	t	Sig.
1	(Constant)	.060	.062		.960	.360
	Wind speed (15m)	1.700	.037	.998	45.69	.000

a. Dependent Variable: Average monthly Wind speed (zx=60m, α=0.4)

The F test results show a significance value of 0.000 <0.05, mean that H_0 is accepted or there is an effect of wind speed at a height of 15 meters on wind speed at a height of 60 meters with α=0.4 with the equation

$y = 1.700\ x + 0.06$

then at a height of 60 meters with α = 0.4 has a wind speed 1.700 faster than the wind speed at a height of 15 m

Hypothesis Test Linear regression of wind speed at 15 meters height and 60 meters height with α=0.9

Table 5 Anova Table

ANOVA					
Model		df	Mean Square	F	Sig.
1	Regression	1	15.593	3128.522	.000[b]
	Residual	10	.005		
	Total	11			

a. Dependent: Wind speed (zx=60m, α=0.9)
b. Predictors: (Constant), Wind speed (15m)

Table 6 Regression Linier

Coefficients[a]

Model		Unstandardized B	Unstandardized Std. Error	Standardized Beta	t	Sig.
1	(Constant)	.164	.100		1.645	.131
	Wind speed (15m)	3.326	.059	.998	55.93	.000

a. Dependent Variable: Average monthly Wind speed (zx=60m, α=0.9)

The Significance value in the F test shows a value of 0.000 <0.05, so there is an effect of wind speed at a height of 15 meters on wind speed at a height of 60 meters with α = 0.90 with a linear regression equation is y = 3.3226 x + 0.164.

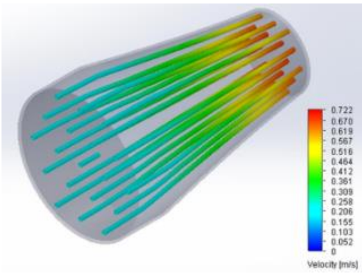
To increase the wind energy potential of the low wind speed area, modifications and developments can be made, namely increasing the installation position of wind turbines (Basrawi, 2017). The higher the place of installation of the wind turbine, the greater the wind speed passing through the installed turbine.

2. Adding wind Tunnels

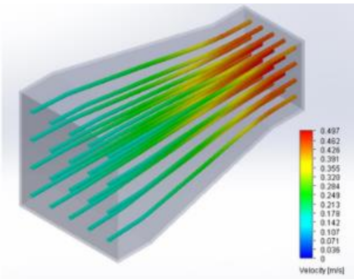
To increase the speed of the wind passing through the wind turbine so that better electrical energy is obtained is to make a wind channel before the wind passes through the propeller blades. The basic principle used is the basic principle of fluid continuity. The air continuity equation is an equation about fluid flow velocity at different cross-sectional areas. On each cross-sectional surface area the fluid has the same flow rate. The fluid continuity equation can be written

$$Q_1 = Q_2$$
$$v_1 a_1 = v_2 a_2$$

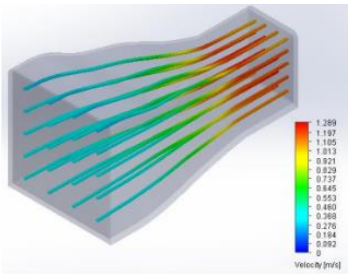
Where
Q_1 = is the fluid discharge at the inlet tunnel
Q_2 = is the fluid discharge in the outlet tunnel
v_1 = is the fluid flow velocity in the inlet
v_2 = is the fluid flow velocity in the outlet
a_1 = is the cross-sectional area at the inlet
a_2 = is the cross-sectional area of the outlet



Picture 1: Wind Tunnel Model 1



Picture 2: Wind Tunnel Model 2



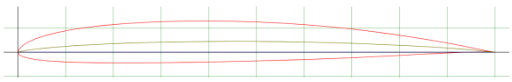
Picture 3: Wind Tunnel Model 3

By using 3 (three) different forms of wind tunnel, it was found that the air ducts were able to provide better efficiency compared to the initial design of the wind turbine (Aldhufairi. et al, 2022). The air flow velocity in the otlet tunnel is influenced by the ratio of the cross-sectional area of the Inlet tunnel and the cross-sectional area of the outlet tunnel, the shape (design) of the air duct used and there is that the greater the angle at the inlet channel the greater the wind speed at the outlet tunnel (Danish et al, 2023).

Adding a conventional wind turbine wind tunnel will disrupt the air flow on the outside of the wind tunnel and change the wind speed on the inside of the wind tunnel. The wind tunnel will accelerate the air flow which will result in increasing the kinetic energy of the air that the wind turbine will convert into electrical energy. (Gui, X et al, 2022)

3. Shrouded wind turbine

a. By using the SD2030 airfoil and the number of propeller blades is three, it is found that at wind speeds starting from 1m/s the lens wind turbine produces 66% more rotation than the turbine without a casing. As for the wind speed of 4 m/s, it produces 186% more rotation than the turbine without a casing (Takeyeldein et al 2022).



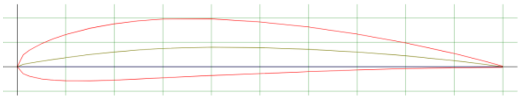
Picture 4: SD2030 low Reynold airfoil

Spesification

Max thickness 8.6% at 35.5%chord

Max camber 2.2 % at 45.3% chord

b. By using NACA 4412 airfoil and the number of propeller blades as many as 3 pieces and a diameter of 1.6 meters.



Picture 5 : NACA 4412 *Airfoil*

Spesifikasi

Max thickness 12% at 30% chord

Max camber 4 % at 40% chord

The results of the comparison between the conventional propeller and the Shrouded propeller obtained as follows:

Wind Speed (m/s)	Conventional Wind Turbine (watt)	Shrouded Wind Turbine (watt)
2	2,21	4,25
3	7,28	13,79
4	15,24	25,44
5	22,74	31,56
6	30,37	37,35

Based on experimental data, it was found that Shrouded wind turbine can increase the electrical power generated compared to conventional windmills at low wind speeds (Nasrul et al, 2021).

The potential of wind energy to produce electrical energy based on average wind speed data at Tanjung Priok and Kemayoran observation stations according interpolated data of monthly electrical energy production mini wind turbine on the East Coast Peninsular of Malaysia.

Wind Speed by Month at Kemayoran Observation Station (m/sec) and potential power generated (KWH) each month in 2021

Month	Wind Speed (m/s)	potential power generated (KWH)
January	3,10	34,68
February	3,80	56,02
March	3,20	37,73
April	2,90	28,58
May	2,60	24,93
June	2,50	23,72
July	2,40	22,50
August	3,10	34,68
September	2,70	26,15
October	2,60	24,93
November	3,10	34,68
December	2,50	23,72
Total		**372,32**

Wind Speed by Month at Tanjung Priok Observation Station (m/sec) and potential power generated (KWH) each month in 2021

Month	Wind Speed (m/s)	potential power generated (KWH)
January	5,50	107,86
February	5,50	107,86
March	4,50	77,37
April	4,60	80,42
May	4,80	86,52
June	3,80	56,02
July	4,40	74,32
August	4,20	68,22
September	4,50	77,37
October	3,50	46,88
November	5,00	92,62
December	4,20	68,22
Total		**943,68**

Based on tables from two wind speed observation stations and the potential power generated, there is a potential electrical power generated using wind energy in Jakarta of 372.32 to 943.68 KWH for one year.

4. CONCLUSION

Given the location of the Tanjung Priok observation station which is not far from the Sekolah Tinggi Ilmu Pelayaran as well as the geographical location in the coastal area, there is a possibility of potential electrical power from wind power of 943.68 KWH at the Sekolah Tinggi Ilmu Pelayaran.

Wind energy potential can be increased by using

1. Placing wind turbines at higher positions;
2. Adding a wind tunnels where the inlet tunnels has a wider surface area than the Inlet tunnels surface area;
3. Making Shrouded wind turbine.

REFERENCES

1. Understanding Descriptive Statistic. Australian Critical Care . (2009) Fisher M. Marshall A.
2. Gui, X., Xue, H., Su, S., Hu, Z., & Xu, Y. (2022). Study on aerodynamic performance of mine air duct horizontal axis wind turbine based on breeze power generation. *Energy Science and Engineering*, *10*(4), 1132–1152. https://doi.org/10.1002/ese3.1081
3. Danish, S. N., Almutairi, Z., & Alshareef, M. (2023). CFD studies of the effect of holes and angles of upstream duct of horizontal axis wind turbines. *AIP Advances*, *13*(3), 035326. https://doi.org/10.1063/5.0118914
4. Anthony. M.. Prasad. V.. Raju. K.. Alsharif. M. H.. Geem. Z. W.. & Hong. J. (2020). Design of rotor blades for vertical axis wind turbine with wind flow modifier for low wind profile areas. *Sustainability (Switzerland)*. *12*(19). https://doi.org/10.3390/su12198050
5. Aldhufairi, M., Muda, M. K. H., Mustapha, F., Ahmad, K. A., & Yidris, N. (2022). Design of Wind Nozzle for Nozzle Augmented Wind Turbine. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, *95*(1), 36–43. https://doi.org/10.37934/arfmts.95.1.3643
6. Basrawi. F.. Ismail. I.. Ibrahim. T. K.. Idris. D. M. N. D.. & Anuar. S. (2017). A study on the power generation potential of mini wind turbine in east coast of Peninsular Malaysia. *AIP Conference Proceedings*. *1826*. https://doi.org/10.1063/1.4979239
7. Johari. M. K.. Jalil. M. A. A.. & Shariff. M. F. M. (2018). Comparison of horizontal axis wind turbine (HAWT) and vertical axis wind turbine (VAWT). *International Journal of Engineering and Technology(UAE)*. *7*(4). https://doi.org/10.14419/ijet.v7i4.13.21333
8. Alfaridzi, M. A. (2020). Analisis Performa Bilah Taperless Dengan Airfoil NACA 4412 pada Horizontal Axis Wind Turbine TSD 500 di PT Lentera Bumi Nusantara. *Jurnal Teknik Mesin Dan Pembelajaran*, *3*(2), 64. https://doi.org/10.17977/um054v3i2p64-73
9. Takeyeldein, M. M., Ishak, I. S., & Lazim, T. M. (2022). Wind-lens turbine design for low wind speed. *Wind and Structures, An International Journal*, *35*(3), 147–155. https://doi.org/10.12989/was.2022.35.3.147
10. Nasrul, M., & Rizianiza, I. (2021). Shrouded wind turbine for low wind speed. *IOP Conference Series: Materials Science and Engineering*, *1034*(1), 012042.

https://doi.org/10.1088/1757-899X/1034/1/012042

11. Statistik Listrik (Statistic Electricity) 2017-2021, Badan Pusat Statistik Indonesia. https://www.bps.go.id ISSN 2354-6875
12. Dinas Komunikasi, Informatika dan Statistik Provinsi Daerah Khusus Ibukota Jakarta (Unit Pengelola Statistik), Data Statistik Sektoral Pemerintah Provinsi DKI Jakarta 2022, Volume 4 Tahun 2022, ISSN 2809-1841
13. Center for Sustainable Systems, U. of M. (2021). *Wind Energy Factsheet*.