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Analysis of the Potential for Wind Power Generation in the Cermin Beach Area as An Energy Reserve

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Abstract

The establishment of PLTB, which can offer the Pantai Cermin population reliable and affordable electricity, is made possible by the wind energy potential in Tim Beach Tourism Park, Deli Serdang Regency, North Sumatra. In certain Indonesian coastal regions, energy is an issue. PLTB can be constructed due to the ideal wind speed and geographic position. For precise design outcomes, the HOMER tool is utilized to assist in calculating PLTB capacity based on the computed load. The planning of a wind power plant (PLTB) at Cermin Beach, a popular tourist destination in PT. Serdang Bedagai, will be examined in this study. To supply the existing load, PLTB planning technical analysis will be employed. The maximum wind speed recorded at the study site in December was a comparatively modest 3.18 m/s. At the study site, the mass flow rate was 133.46 kg/s, the average wind speed was 2.63 m/s, the potential power was 2001 watts, the efficiency power was 1600 watts, and the system power was 18.9 watts/m2. Therefore, a wind turbine with a capacity of 10 kW—equivalent to a turbine with an output power per turbine of 2001 watts—is required to supply a kilowatt load every day of 1144 kilowatts.

Keywords: *PLTB, Wind Potential, Turbine, Homer*

Abstrak

Potensi energi angin di Taman Wisata Pantai Tim, Kabupaten Deli Serdang, Sumatera Utara, memungkinkan pengembangan PLTB yang dapat memberikan masyarakat Pantai Cermin akses listrik yang stabil dan murah. Energi adalah masalah di beberapa wilayah pesisir Indonesia. Karena lokasi geografis dan kecepatan angin mendukung, PLTB dapat dibangun. Aplikasi HOMER digunakan untuk membantu menghitung kapasitas PLTB sesuai beban yang dihitung untuk hasil perancangan yang akurat. Penelitian ini akan menyelidiki perencanaan pembangkit listrik tenaga angin (PLTB) di Pantai Cermin, kawasan wisata PT. Serdang Bedagai. Analisis teknis perencanaan PLTB akan digunakan untuk mensuplai beban saat ini. Di lokasi penelitian, kecepatan angin tertinggi adalah 3,18 m/s pada bulan Desember, yang relatif kecilDi lokasi penelitian, kecepatan angin rata-rata sebesar 2,63 m/s, laju aliran massa sebesar 133,46 kg/s, daya potensial sebesar 2001 watt, daya efisiensi sebesar 1600 watt, dan daya sistem sebesar 18,9 Watt/m2. Dengan demikian, dapat disimpulkan bahwa untuk menyediakan beban kilowatt per hari sebesar 1144 kilowatt, diperlukan turbin angin berkapasitas 10 kW sebanding dengan turbin dengan daya keluaran per turbin sebesar 2001 watt.

Kata kunci*: PLTB,Potensi Angin, Turbin, Homer*

Introduction

As a renewable energy source, wind energy has enormous potential to be produced sustainably without reducing existing natural resources[1]. Generating electricity through wind does not produce carbon dioxide emissions or air pollution that damages the environment[2]. Therefore, the construction of a wind power plant in Pantai Cermin can be a solution to meet long-term energy needs without damaging the ecosystem. Because Pantai Cermin is one of the tourist destinations that relies on the natural beauty and appeal of the beach. The need for electrical energy in Deli Serdang Regency increases every year due to the increase in community infrastructure. So far, the need for electrical energy has been supplied by the State Electricity Company (PLN). Therefore, to reduce dependence on PLN, the community must be able to utilize renewable energy as an alternative energy. One of the alternative energy sources that is very abundant and environmentally friendly is wind energy [3][4]. By introducing environmentally friendly renewable energy technology [5], this area can also be an example for tourists and other communities about the importance of sustainability in energy and environmental management. It is hoped that with a power plant located in Pantai Cermin, a diversified energy supply is expected to reduce dependence on a single energy source and strengthen the national energy system [6].

a. Wind Power Plant

Wind power plants are ecologically neighborly control plants and have great work productivity when compared to other renewable vitality control plants [7]. Wind Power Plant (PLTB) is a system that is capable of producing electrical power by converting kinetic energy from air into mechanical energy [8]. This mechanical energy then drives the generator, producing an electric current as the final result. When the rotor rotates, the generator automatically produces a flow of electrical energy [9].

b. Wind Energy

Wind is air the movement of air caused by differences in pressure, with air flowing from areas of high pressure to areas of low pressure [10]. The variation in air pressure is affected by sunlight. Areas that are exposed to a lot of sun will have a higher temperature than those that are exposed to little sunlight. According to the ideal gas law, temperature is inversely proportional to pressure, where a higher temperature will have a lower pressure and a lower temperature will have a higher pressure. Air that has mass *m* and speed *v* will produce kinetic energy of:

$$E = \frac{1}{2}mv^2 \quad (1)$$

The volume of air per unit time moving at speed v and passing through an area of area A is:

$$V = v.\,A \quad (2)$$

The mass of air that moves in unit time with a density ρ is:

$$m = \rho V = \rho v A \quad (3)$$

So the kinetic energy of the wind that blows in unit time (wind power) is:

$$P_w = \frac{1}{2}(\rho v A)v^2 = \frac{1}{2}(\rho A)v^3 \quad (4)$$

Description:

P_w = wind power (watt)

ρ = air density (ρ= 1,225kg/m^3)
A = turbine cross-sectional area (m^2)
v = air speed (m/s)

The amount of power above is the power that the wind has before it is converted or before it passes through the wind turbine [11]. Not all of this power can be converted into mechanical energy by the windmill. The main components consist of a windmill and generator. The windmill functions as a converter of wind kinetic energy into mechanical energy, while the generator functions as a converter of mechanical energy into electrical energy.

c. Homer

Hybrid Optimization of Multiple Energy Resources (HOMER) is software developed by the US National Renewable Energy Laboratory (NREL) to help design hybrid power generation systems that utilize renewable energy technologies [12][13]. HOMER simulates and optimizes hybrid generating systems that are stand-alone or connected to the main electricity network (grid connected). HOMER also allows modelers to compare many different design options based on technical and economic benefit s[14]. The HOMER software provides many power generation options consisting of PV, wind turbines, micro-hydro, kinetic hydro, biomass, generators (diesel, petrol, biodiesel, biogas), fuel-cells, batteries, and others [15].

Literature Review

The research by Syamsuarnis and colleagues, titled " Wind Power Plant as Alternative Electrical Energy for the Muaro Ganting Fishing Community, Parupak Village, Koto Tengah District", stated that the installed wind power generator has a capacity of 400 watts so that it can be used for lighting in youth halls, community or youth gathering places, as well as water pumps for the surrounding community [16]. In the research by Widyanto and colleagues "Utilization of Wind Power as a Solar Energy Coating in Hybrid Power Plants on Wangi-Wangi Island" stated that the maximum wind speed was 2,847 m/s, which has a maximum electrical power potential of 37,160 watts. The highest wind speed at night was 2,877 m/s and the average wind speed per year during the rainy season was 2,405 m/s. In other words, the wind speed throughout the day in 2017 in this area did not reach the minimum standard wind speed that can generate electricity, 3.3 m/s. Thus, the potential electrical power generated by the wind [17].

Zidan Afidah and colleagues through his research entitled" Analysis of the Potential of Wind Power Plants with Vertical Axis Wind Turbines in Sangkapura District, Gresik Regency" examines that Bawean Island, the coast of Gresik Regency, is where Sangkapura Regency is located. In 2020, there were 117,112 electricity consumers in Sangkapura Regency. On the same island, there are several areas that do not receive daily electricity. Hence, additional research is needed to determine the local potential of wind as a wind power plant (PLTB) using vertical axis wind turbines, taking into account the advantages and disadvantages of each type of turbine. Analysis of published works and the online database of the Meteorology, Climatology and Geophysics Agency is the research technique used. Based on the analysis, the average wind speed was measured at 1.5 m/s and the wind power was 10.47 watts. Dim LED lights can light up with that much energy. Sangkapura Regency has poor wind power generation potential because the amount is lower compared to many related studies and employs a limited number of households. Therefore, a different strategy is needed that can utilize low wind speeds to generate electricity [18].

The study by Rosanti B and colleagues "Analysis of the Use of Wind Energy as an Alternative Power Generator in Palu City " resulted in the conclusion that Planning and simulation of a Wind Power Plant to help reduce the use of fossil energy and help the needs of the community in the Talise Beach area. From the research results, the average wind turbine production output is 1,180/hour with maximum wind turbine production per day of 5,665 kW and construction system costs (NPC) of Rp. 91,340,660,000. The electrical energy that can be produced from a wind turbine using an area of around 42,021.67 m2 is 10,332,498 kWh/year with a total unmet power of 1,416 kW/year. Lack of power or unmet loads can be overcome with a grid/network [19].

Revi Restanti Novrita and colleagues in their research entitled "Analysis of Wind Energy Potential in Ponds to Produce Electrical Energy" said that this type of experiment was conducted in the morning starting at 07.00 WIB and in the afternoon starting at 17.00 WIB. Where several measurements were taken at each position. The results of the study showed that the wind was stronger in the afternoon than in the morning. With efficiency values of 0.4, 0.95, 0.85, and 0.75 respectively, An energy can be generated between 89.3 and 1707 watts/m2. Electrical energy will be provided for approximately five hours [20].

Method

a. Research Flowchart

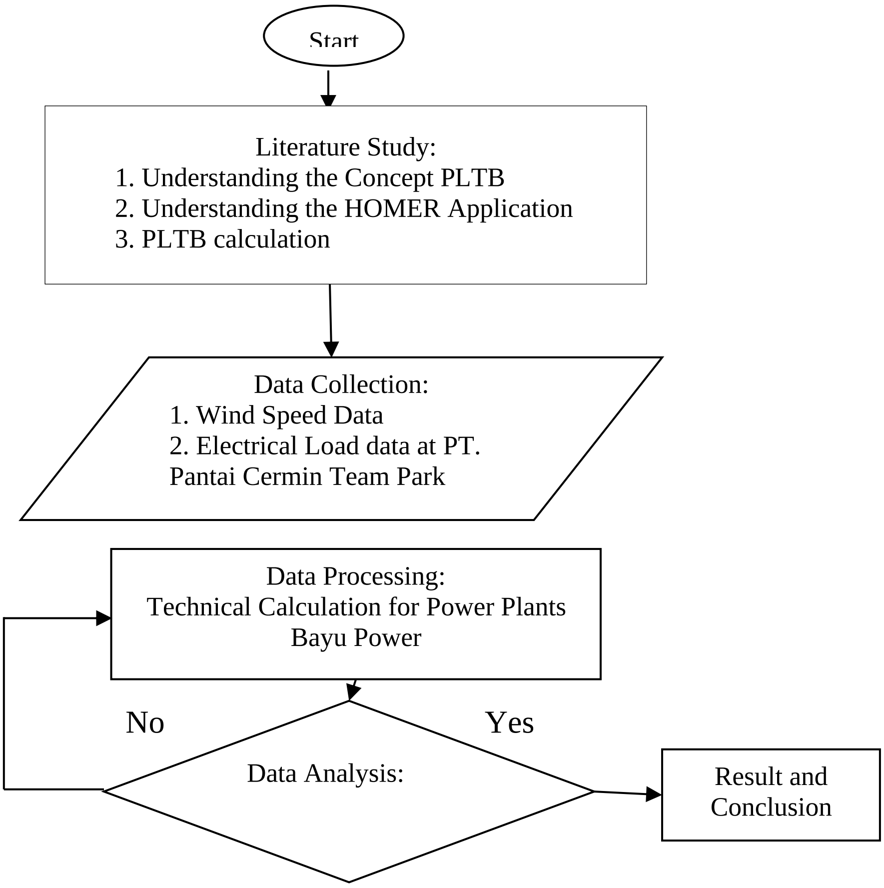


Figure 1 Research Flowchart

The steps of data analysis techniques in this study are as follows:

1. The existing wind speed data is then input into the HOMER software to obtain the PLTB capacity that can be installed to supply the load at the research location.
2. In the HOMER application there is also a technical and economic design, the price of installing the PLTB capacity that has been determined according to the existing load requirements will be seen.

b. Potential For Wind Energy

The potential for wind energy in the Pantai Cermin, Deli Serdang Regency, North Sumatra, as an alternative energy for PLTB (Wind Power Plant) is very possible. Judging from the geographical location and average wind speed at the research location, it has the potential to build a PLTB. However, the use of PLTB because it is relatively expensive must be effective and efficient. In order to obtain more exact and precise design outputs, the HOMER program is required. The PLTB capacity that can support the calculated load will be designed and determined with the aid of the application. Judging from the HOMER application, the wind data at Cermin Beach, Deliserdang Beach can be seen in Figure 2

Figure 2. Wind Data at Pantai Cermin Sergai

c. Wind Speed

Wind speed data at the research location was taken via the HOMER application which is also used as an application to calculate the power requirements for wind power plants later, while wind speed data taken from NASA sources via the HOMER application can be seen in Table 1.

Table 1. Wind Speed at Research Locations Using Homer

Month	Wind Speed (m/s)
Jan	2.990
Feb	2.860
Mar	2.750
Apr	2.500
May	2.300

Month	Wind Speed (m/s)
Jun	2.310
Jul	2.330
Aug	2.420
Sep	2.410
Oct	2.650
Nov	2.850
Dec	3.180
Average	2.63

Wind speed data at the research location was taken in the field using an anemometer. Taken as a sample for 1 fill day can be seen in Table 2.

Table 2. Data From Manual Speed Measurements

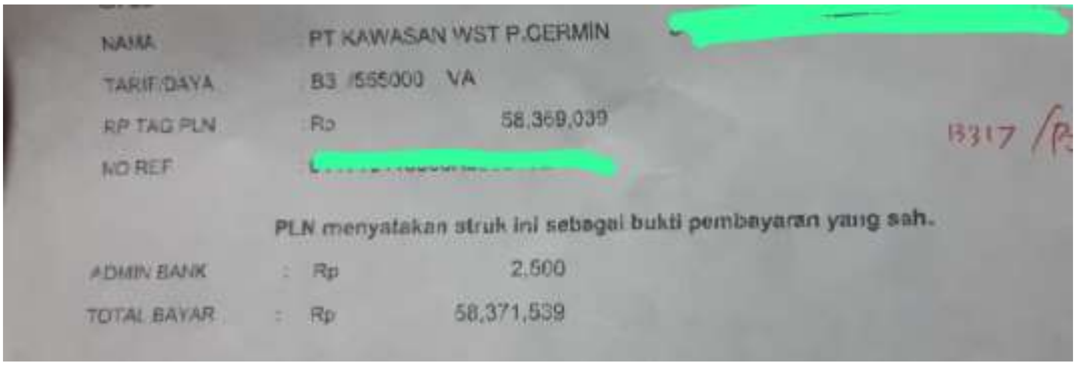
Time	Wind Speed (m/s)
01.00	2,9
02.00	3,2
03.00	3,2
04.00	3,5
05.00	3,3
06.00	3,2
07.00	3,2
08.00	2,9
09.00	2,7
10.00	3,3
11.00	3,4
12.00	3,5
13.00	3,8
14.00	3,3
15.00	3,2
16.00	3,8
17.00	4,1
18.00	4,3
19.00	4,0
20.00	3,5
21.00	3,4
22.00	3,4
23.00	2,9
24.00	3,1
Average	3,38

In Table 2 the wind speed data measured manually for 1 full day has an average level of 3.38 m/s where the wind speed value resulting from manual conversion is much higher than the results obtained from the Homer software with a value of 2.63 m /s

Result and Discussion

a. Electrical Load Data

Electricity load data at the research location, namely the Cermin Beach tourist area, with a base rate of Rp. 1114,74 for class B-3/TM with a power capacity of 555 kVA obtained from monthly payment slips for electricity usage. The monthly payment slip for electricity usage at the research location can be seen in Figure 3.



NAMA PT KAWASAN WST P.CERMIN [redacted]
TARIF/DAYA B3 /555000 VA
RP TAG PLN Rp 58,369,039
NO REF [redacted]
PLN menyatakan struk ini sebagai bukti pembayaran yang sah.
ADMIN BANK : Rp 2,500
TOTAL BAYAR : Rp 58,371,539

Figure 3. Electricity Bill Payment Account for the Cermin Beach Tourist Area Company Serdang Bedagai Regency

$\frac{58369030}{1114,74}$ = = 52 363 kWh/Bulan

The load that PLTB will supply is part of the total existing load, namely the daily usage load. The load classification and total load that will be supplied by the PLTB that will be designed can be seen in Table 3.

Table 3 Load Data to be Supplied by PLTB

No	Tools	Amount	Capacity(Watt)	Total Power(Watt)	Time (hour)	Total Kapasitas (Wh/Day)
1	Lamp	38	50	1900	14	26600
2	Lamp	83	60	4980	14	69720
3	Garden Water Pump	8	3000	24000	12	288000
4	AC in Room	50	950	47500	12	570000
5	AC in Office	22	1700	37400	12	448800
6	Computer	8	1000	8000	6	48000
7	Refrigerator	6	400	2400	24	57600
8	Fan	14	250	3500	12	42000
9	TV	50	200	10000	5	50000
10	Water Heater	50	300	15000	3	45000
11	Washing Machine	5	450	2250	5	11250
12	CCTV	20	20	400	24	9600
13	Sound Sistem	2	3000	6000	6	36000
14	Iron	50	300	15000	3	45000
15	Printer	5	20	100	5	500
16	Infokus	5	100	500	5	2500
Total				178.930		1.750.570

Given that the Cermin Beach Tourist Area has a total installed load of 178,930 watts and uses 1750,570 Wh of electricity each day and 72,940 Wh of electricity per hour, or 72,94 kWh per hour. If the PLTB supplies the total load at the research location, the PLTB requires large capacity and a large area of land, so based on these considerations the load that will be supplied by the PLTB is limited to only supplying the lighting load at the research location. The total lighting load is 96,320 Wh/day, so the power used for one hour is 4,013 Wh/hour. This value will be input into HOMER as the load to be supplied by PLTB. The load graph after input into HOMER in Figure 4

Figure 4. Load to be Suplied

b. General Design

In the technical design, it will be determined how much PLTB capacity is capable of supplying the load. Where the turbine used is a turbine with a capacity of 10 kW. The turbine specifications are in accordance with Table 4.

Table 4. Wind Turbine Specifications

Turbine Type	Vertical
Maximum Output Power	10 Kw
Minimum Wind Speed	2.0 m/s
Best Wind Speed	10 m/s
Maximum Wind Speed	50 m/s
Generator Efficiency	80%
Noise	< 45 Db
Turbine Weight	78 kg
Propeller Material	Aluminium Alloy
Number of Propellers	2
Turbine Diameter	9,2 m
Turbine Sweep area	84,64 m
Turbine Density	0,6 kg/m^3
Turbine Weight	42 Kg

To determine the output power that can be produced by a turbine by utilizing the wind potential at the research location, equation 4 is used. So from the existing turbine specifications it can be seen that the output power that can be produced by a 10 kW PLTB is:

$$Pa = \frac{1}{2}\, p\, A\, v^3$$

$$= \frac{1}{2}\ 1{,}225\ x\ 84{,}64\ x\ 3{,}38^3$$

= 2001,85 Watt (2 kW)

In one day, a wind turbine with a capacity of 10 kW can produce electrical power of 2kW x 24 hours, namely 48 kW 1 day. So to supply a load with an installed load capacity of 96.32 kW, the number of turbines needed is as follows:

Number of turbines = $\frac{96{,}32\ kW}{48\ kW}$

$= \frac{178.930}{965{,}36}$

= 2,06 ≈ 3 turbines

Therefore, there are three turbines with a capacity of 10 kW each to supply the load with an installed total load of 96,32 kW. A battery is used to store the energy generated by the turbine.

c. PLTB Output Power

The PLTB output power in the simulation carried out on HOMER can be seen in Figure 5.

Figure 5. PLTB Output Power

It can be seen in Figure 6 in the power output graph at the PLTB. The largest PLTB power output occurs in December. Then in January it was also relatively large. However, from April to October, the PLTB output power is relatively small compared to the output power produced in December and January.

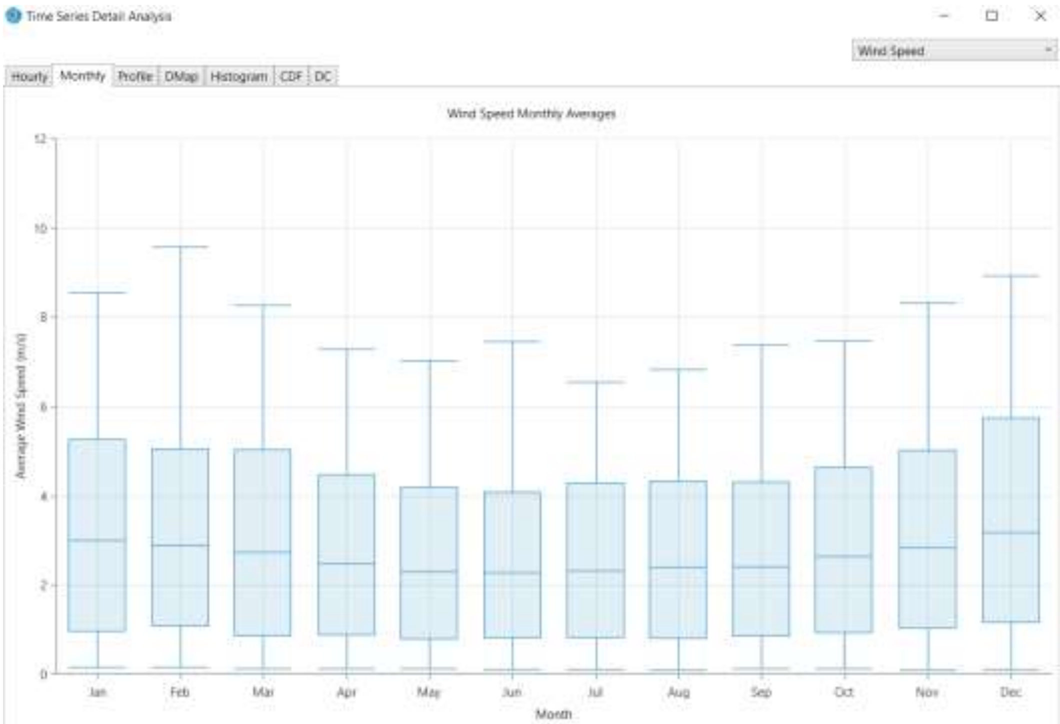


Figure 6. Output Power Every Month

In December, PLTB can produce maximum power in December, namely 8,92 kW and the average daily output of PLTB in December is 5,73 kW. Meanwhile, the smallest occurred in May, namely the power output this month was 7,46 kW and the average daily power output was 4,11 kW.

d. Wind Speed Below 5m/s

If the calculation of potential effective power and electrical energy per unit area is reviewed based on the potential wind speed in Table 1 below 5 m/s at the research location, to find out the power and energy that can be produced if the turbine use assumptions are applied according to the specifications in Table 4 then the formula employed for these tests is follow as:

$$m = \rho\ v\ a$$
$$= 0{,}6 \text{ x } 2{,}63 \text{ x } 84{,}64$$
$$= 133{,}46 \text{ kg/s}$$

The power that can be generated by the turbine at the research location is as follows:

$$P_a = \frac{1}{2}\ p\ A\ v^3$$
$$= \frac{1}{2}\ 1{,}225\ x\ 84{,}64\ x\ 3{,}83^3$$
$$= 2001 \text{ Watt}$$

The efficient power produced by the turbine is

$$P_{eff} = P_a \text{ x Eff Turbin}$$
$$= 2001 \text{ x } 80\%$$
$$= 1600 \text{ Watt}$$

The power in the turbine system is as follows

$$P_{syst} = P_{eff} \text{ x A}$$
$$= 772{,}288 / 84{,}64$$
$$= 18{,}9 \text{ Watt/m}^2$$

From the results of calculating the potential wind speed at the research location, the results can be seen in Table 5

Table 5. Wind Potential below 5 m/s

Average wind speed (v)	2.63 m/s
Mass Flow Rate (m)	133,46 kg/s
Potential Power Produced by Wind Turbine (P_a)	2001 Watt
Power Efficiency	1600 Watt
Power System	18,9 Watt/m^2

Conclusion

The wind speed at the research location was relatively small, namely the largest occurred in December with a speed of 3.18 m/s. while the average wind speed at the research location is 2.63 m/s, which is a relatively small speed for the construction of a wind turbine or PLTB. To supply a kWh load of 1,144 kWh/day, 3 wind turbines with a capacity of 10 kW are needed, with an output power of 2001 Watts per turbine.

References

[1] M. Hetharia, S. Hernowo, S. Irianto, and K. Wicaksono, "Pemanfaatan Energi Angin untuk Menghasilkan Listrik," *J. Voering*, vol. 6, no. 2, pp. 45–57, 2021.

[2] R. Saidur, N. A. Rahim, M. R. Islam, and K. H. Solangi, "Environmental impact of wind energy," *Renew. Sustain. Energy Rev.*, vol. 15, no. 5, pp. 2423–2430, 2011, doi: 10.1016/j.rser.2011.02.024.

[3] I. K. Parti, I. N. Mudiana, and N. W. Rasmini, "Analysis of wind speed effect on voltage in wind power plant performance," *J. Phys. Conf. Ser.*, vol. 1450, no. 1, pp. 1–6, 2020, doi: 10.1088/1742-6596/1450/1/012132.

[4] A. G. Olabi *et al.*, "Wind Energy Contribution to the Sustainable Development Goals: Case Study on London Array," *Sustain.*, vol. 15, no. 5, pp. 2–22, 2023, doi: 10.3390/su15054641.

[5] R. Effendi, S. A. Kartika, K. Rusba, and S. Darma Utama, "Enhancement of Public Awareness on Environmentally Friendly Energy Conversion," *Communnity Dev. J.*, vol. 5, no. 2, pp. 4031–4036, 2024.

[6] I. Susilowati, E. R. Azzahra, and R. A. Nurcahyani, "Strategi Diversifikasi Sumber Energi Sebagai Respons Terhadap Perubahan Iklim : Analisis Kerjasama China-Perancis," *J. Sos. dan Budaya Syar-i*, vol. 10, no. 4, pp. 1257–1270, 2023, doi: 10.15408/sjsbs.v10i5.34766.

[7] R. Kasner, W. Kruszelnicka, P. Bałdowska-Witos, J. Flizikowski, and A. Tomporowski, "Sustainable wind power plant modernization," *Energies*, vol. 13, no. 6, 2020, doi: 10.3390/en13061461.

[8] D. Arkka, G. Andre, and S. Rudy, "Efektivitas Penggunaan Pembangkit Listrik Tenaga Bayu (PLTB) di Wilayah Pesisir Pantai Sebagai Pendukung Kebutuhan Energi dalam Pertahanan Negara," *QISTINA J. Multidisiplin Indones.*, vol. 3, no. 1, pp. 121–128, 2024.

[9] S. Nisworo, D. Pravitasari, Z. A. Kusworo, A. Ashari, and N. A. Khan, "Study of Wind Power Plant for Alternative Energy in Vannamei Litopeneaus Shrimp Cultivation," *J. Renew. Energy, Electr. Comput. Eng.*, vol. 2, no. 2, p. 77, 2022, doi: 10.29103/jreece.v2i2.8565.

[10] F. Munawaroh, Y. Masdya, M. A. Baqiya, and T. Triwikantoro, "Indonesian Physical Review," *Indones. Phys. Rev.*, vol. 7, no. 2, pp. 250–258, 2024.

[11] S. Markumningsih, B. Purwantana, and J. C. Gulo, "Development of savonius type windmill prototype as a learning medium about wind power plants," *IOP Conf.*

Ser. Earth Environ. Sci., vol. 355, no. 1, 2019, doi: 10.1088/1755-1315/355/1/012013.

[12] R. Ropiudin, T. Carollina, P. Priswanto, and K. Syska, "Performance Analysis of Horizontal Axis Wind Turbine as a Pump Energy Source for Agricultural Irrigation using Homer Software," *J. Keteknikan Pertan. Trop. dan Biosist.*, vol. 11, no. 3, pp. 231–243, 2023, doi: 10.21776/ub.jkptb.2023.011.03.01.

[13] L. Khalil, K. Liaquat Bhatti, M. Arslan Iqbal Awan, M. Riaz, K. Khalil, and N. Alwaz, "Optimization and designing of hybrid power system using HOMER pro," *Mater. Today Proc.*, vol. 47, no. July, pp. S110–S115, 2020, doi: 10.1016/j.matpr.2020.06.054.

[14] B. Afif, B. Merabet, A. Benhamou, and A. Chaker, "Standalone hybrid power system using homer software optimal case sizing of ferraguig (North West of Algeria)," *Int. J. Appl. Power Eng.*, vol. 8, no. 3, p. 287, 2019, doi: 10.11591/ijape.v8.i3.pp287-298.

[15] M. A. Rahmanta and P. A. Wibowo, "Kajian Pemanfaatan Potensi Energi Baru Terbarukan Setempat Untuk Meningkatkan Bauran Energi Baru Terbarukan di Pulau Pusong, Nangroe Aceh Darussalam," *Energi & Kelistrikan*, vol. 13, no. 2, pp. 231–241, 2021, doi: 10.33322/energi.v13i2.1496.

[16] S. Syamsuarnis and O. Candra, "Pembangkit Listrik Tenaga Angin sebagai Energi Listrik Alternatif bagi Masyarakat Nelayan Muaro Ganting Kelurahan Parupuk Kecamatan Koto Tangah," *JTEV (Jurnal Tek. Elektro dan Vokasional)*, vol. 6, no. 2, p. 44, 2020, doi: 10.24036/jtev.v6i2.108487.

[17] S. Widyanto, S. Wisnugroho, and M. Agus, "Pemanfaatan Tenaga Angin Sebagai Pelapis Energi Surya pada Pembangkit Listrik Tenaga Hibrid di Pulau Wangi-Wangi," *Semin. Nas. Sain dan Teknol. 2018*, pp. 1–12, 2018.

[18] Z. Afidah, Y. Yushardi, and S. Sudarti, "Analisis Potensi Pembangkit Listrik Tenaga Bayu dengan Turbin Angin Sumbu Vertikal di Kecamatan Sangkapura Kabupaten Gresik," *J. Engine Energi, Manufaktur, dan Mater.*, vol. 7, no. 1, pp. 08–14, 2023, doi: 10.30588/jeemm.v7i1.1325.

[19] R. B., S. Dewi, Y. Arifin, N. Amin, and B. Mukhlis, "Analisa Penggunaan Energi Angin Sebagai Pembangkit Listrik Alternatif Di Kota Palu," *Foristek*, vol. 13, no. 2, pp. 67–74, 2022, doi: 10.54757/fs.v13i2.145.

[20] R. R. Novri, "Analisis Potensi Energi Angin Tambak Untuk Menghasilkan Energi Listrik," *J. Res. Educ. Chem.*, vol. 3, no. 2, pp. 96–112, 2021, doi: 10.25299/jrec.2021.vol3(2).7165.