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Wind Speed Analysis Study for Wind Power Plant in Kebumen

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Abstract

Reserves of fossil energy sources are starting to run low, so the government has launched renewable energy sources. The National Energy Policy (KEN) targets Indonesia by 2025 to use renewable energy sources of 23% of its energy needs. Because of this, the government has started opening places that have the potential for generating renewable energy, especially the areas where PLN electricity cannot reach, withincluding the southern coastal area of Kebumen.. The wind potential in this coastal area of Java Island meets the criteria for a Wind Power Plant. The purpose of this research was to analyze the wind potential in the southern coastal area of Kebumen. The specific purpose of this study was to determine the wind speed and the location and calculate the power generated by the wind in the southern coastal area of Kebumen to determine the potential of PLTB in Kebumen area. The stages of this research consisted of retrieval of secondary data, analysis using Excel, and power analysis using HOMER. Based on wind speed data from NASA, the southern coastal area of Kebumen is suitable for making PLTB, especially Buayan and Ayah, because the wind speed between 2016-2020 is 2.15 m/s. Then, the power produced annually in these places, based on the HOMER application, was 86.50 kWh/year.

Keywords: Speed wind analysis, Wind power plant, Renewable energy

Abstrak

Cadangan sumber energi fosil mulai menipis, sehingga pemerintah mencanangkan sumber energi terbarukan. Kebijakan Energi Nasional (KEN) menargetkan Indonesia pada tahun 2025 dapat menggunakan sumber energi terbarukan sebesar 23% dari kebutuhan energinya. Oleh karena itu, pemerintah mulai membuka tempat-tempat yang berpotensi untuk menghasilkan energi terbarukan, terutama daerah yang tidak terjangkau listrik PLN, termasuk di pesisir selatan Kebumen. Potensi angin di pesisir Pulau Jawa ini memenuhi kriteria. untuk Pembangkit Listrik Tenaga Angin. Tujuan dari penelitian ini adalah untuk menganalisis potensi angin di wilayah pesisir selatan Kebumen. Tujuan khusus dari penelitian ini adalah untuk mengetahui kecepatan angin dan lokasi serta menghitung daya yang dihasilkan oleh angin di wilayah pesisir selatan Kebumen untuk mengetahui potensi PLTB di wilayah Kebumen. Tahapan penelitian ini terdiri dari pengambilan data sekunder, analisis menggunakan Excel, dan analisis daya menggunakan HOMER. Berdasarkan data kecepatan angin dari NASA, wilayah pesisir selatan Kebumen cocok untuk pembuatan PLTB, khususnya Buayan dan Ayah, karena kecepatan angin antara tahun 2016-2020 adalah 2,15 m/s. Kemudian, daya yang dihasilkan setiap tahun di tempat-tempat tersebut, berdasarkan aplikasi HOMER, adalah 86,50 kWh/tahun.

***Kata-kata kunci**: Analisis kecepatan angin, Pembangkit listrik tenaga angin, Energi terbarukan*

1. Introduction

Reserves of non-renewable natural resources in Indonesia are running low, so the government has begun to intensify the use of non-oil and gas alternative energy **[1]**. This action aims to reduce the dredging rate of non-renewable energy resources, especially oil and natural gas. The solution attempts to maintain the stock of energy resources in Indonesia. Based on the National Energy Policy (KEN), in 2025, Indonesia can use energy sources with the composition: 23% new renewable energy, 25% oil, 30% coal and 22% natural gas **[2]**. Law No. 25 of 2000 on Propenas (National Development Program) reiterates that the government places a high priority on electricity generation programs, especially renewable energy **[3]**. This Propenas proves that we can use domestic experts and project materials for new and renewable electricity **[4]**.

Kebumen Regency can play a role in utilizing renewable energy, especially wind energy on the south coast. Kebumen Regency has 26 sub-districts, and the eight sub-districts are bordering the Indian Ocean. The sub-districts include: Mirit, Ambal, Buluspesantren, Klirong, Pentanahan, Puring, Buayan, and Ayah. The area located on the southern coast of Kebumen functions as a tourist attraction. The tourist attraction is the beach. The management of the coast around the southern coast of Kebumen is the district and village governments. Only one Kebumen Regency government-run beach, Suwuk Beach, while the other beaches are independently by the village government.

Beach attractions in Kebumen are high in visitors. Based on the interviews with beach managers in Buluspesantren sub-district, it reaches 500 people every Saturday and Sunday. Most of them are locals. The coastal area is used as a vehicle for sports, such as cycling, running, or walking.

The residents around the coast earn their livelihood from food trading and fishing. Food traders around the coast are not free from the need for electrical energy such as rice cooker for rice cooking, dispensers for water heating, sound systems for loudspeakers, and other equipment that requires electrical energy. They use generators as a source of electrical energy due to the limitations of the PLN electricity network, which has not yet reached the area. Therefore, residents who need electricity must buy or rent a generator. Genset fuel is gasoline so they need to buy fuel to turn on the generator.

The southern coastal area of Kebumen is directly adjacent to the Indian Ocean, so the wind potential in this area is quite high and stable. This is evident from BMKG data stating that

the average wind speed in mid-2019 to mid-2020 is 3-6 m/s **[5]**, **[6]**. Based on the data from BMKG, the southern coastal area is a potential source of electrical energy, but BMKG currently does not have a monitoring unit in Kebumen Regency. Therefore, conducting a specific analysis of wind speed in the southern coastal area of Kebumen is necessary.

The southern coastal area of Kebumen has quite strong winds. Wind refers to the air that moves because of the difference in pressure on the earth's surface **[7]**. Something that moves always produces energy. This energy can be measured by the magnitude of the speed of a movement. The wind speed level consists of classes 1 to 12. Based on data from BMKG, the southern coast of Java Island has an average wind speed of 3-6 m/s.

The southern coast of Kebumen does not yet have PLN, so it is essential to develop the renewable energy. One of the renewable energy sources is wind. The wind that is potential for producing electrical power has a speed of 1.6 to 17.1 m/s or from class 3 to class 8 **[2]**.

Wind energy is alternative energy that has good prospects because it is always available in nature and is a clean and renewable energy source. The process of using wind power goes through two conversion stages, namely: the wind flow moves the rotor (propeller), which makes the rotor rotate according to the blowing wind, and the rotor rotation is connected to a generator so that electricity can be generated **[8]**.

The electrical energy produced by the wind must be taken into account the power generated in order to find out how much potential it has. The formulation of the power generated by wind energy is as follows **[2]**.

$P = k.F.A.E. v3$

with P = power (kw)

K = constant = $1{,}37. 10^{-5}$

F = factor = 0,5926

E = efficiency of rotor and other equipment

v = wind speed (m/det)

The formula is manual. Currently, there is HOMER (Hybrid Optimization Model of Electric Renewable) software [9]. HOMER is a software developed by the U.S. National renewable energy laboratory (NREL) in collaboration with Mistaya Engineering, which is copyrighted by the Midwest Research Institute (MRI) and used by the United States Department of Energy (DOE). HOMER has several advantages over similar software such as hybrid2, RETScreen, PV SOL, etc. The privileges of HOMER are: (1) being able to find out the

optimal results of the system configuration (simulating several system configurations based on the Net Present Cost), (2) being able to show the analysis of sensitivity values, (3) being able to model the electricity transmission network system, (4) hybrid components to be used are complete, (5) can model the available natural resources, and (6) very detailed input parameters, such as natural resources, emissions, fuel prices, economic factors, and others **[10]**.

2. Method

This research was conducted in eight sub-districts in the southern coastal area of Kebumen. The sub-districts are: Mirit, Ambal, Buluspesantren, Klirong, Pentanahan, Puring, Buayan, and Ayah. The selection of the samples was random. The data collected in this study were secondary data, obtained from NASA.

The analysis of wind speed data employed Microsoft Excel and HOMER. Microsoft Excel software analyzed the average wind speed and identified potential PLTB locations. Meanwhile, HOMER software analyzed the power generated. The research flow chart is presented in **Figure 1.**

Figure 1. Research Flowchart

3. Results and Discussion

Wind speed data from NASA in 2016 to 2020 retrieved from **https://power.larc.nasa.gov/data-access-viewer/** is presented in **Table 1.**

Table 1. Wind Speed Data in 2016 to 2020 in Kebumen

NO	YEAR	MONTH	SUB-DISTRICT							
			AYAH	BUAYAN	PURING	PETANAHAN	KLIRONG	BULUSPESANTREN	AMBAL	MIRIT
1	2016	JANUARY	2,54	2,54	2,32	2,32	2,32	2,32	2,32	2,32
2		FEBRUARY	2,50	2,50	2,28	2,28	2,28	2,28	2,28	2,28
3		MARCH	2,02	2,02	1,94	1,94	1,94	1,94	1,94	1,94
4		APRIL	2,08	2,08	2,01	2,01	2,01	2,01	2,01	2,01
5		MAY	2,01	2,01	1,94	1,94	1,94	1,94	1,94	1,94
6		JUNE	2,05	2,05	1,84	1,84	1,84	1,84	1,84	1,84
7		JULY	1,65	1,65	1,62	1,62	1,62	1,62	1,62	1,62
8		AUGUST	1,98	1,98	1,94	1,94	1,94	1,94	1,94	1,94
9		SEPTEMBER	2,03	2,03	1,87	1,87	1,87	1,87	1,87	1,87
10		OCTOBER	2,14	2,14	1,99	1,99	1,99	1,99	1,99	1,99

NO	YEAR	MONTH	SUB-DISTRICT							
			AYAH	BUAYAN	PURING	PETANAHAN	KLIRONG	BULUSPESANTREN	AMBAL	MIRIT
11		NOVEMBER	2,27	2,27	2,05	2,05	2,05	2,05	2,05	2,05
12		DECEMBER	2,54	2,54	2,58	2,58	2,58	2,58	2,58	2,58
13	2017	JANUARY	2,29	2,29	2,29	2,29	2,29	2,29	2,29	2,29
14		FEBRUARY	2,24	2,24	2,38	2,38	2,38	2,38	2,38	2,38
15		MARCH	1,95	1,95	2,08	2,08	2,08	2,08	2,08	2,08
16		APRIL	1,80	1,80	1,74	1,74	1,74	1,74	1,74	1,74
17		MAY	1,56	1,56	1,60	1,60	1,60	1,60	1,60	1,60
18		JUNE	1,56	1,56	1,56	1,56	1,56	1,56	1,56	1,56
19		JULY	1,70	1,70	1,86	1,86	1,86	1,86	1,86	1,86
20		AUGUST	1,83	1,83	1,98	1,98	1,98	1,98	1,98	1,98
21		SEPTEMBER	2,09	2,09	2,36	2,36	2,36	2,36	2,36	2,36
22		OCTOBER	1,73	1,73	1,63	1,63	1,63	1,63	1,63	1,63
23		NOVEMBER	2,37	2,37	2,12	2,12	2,12	2,12	2,12	2,12
24		DECEMBER	2,15	2,15	2,20	2,20	2,20	2,20	2,20	2,20
25	2018	JANUARY	2,35	2,35	2,53	2,53	2,53	2,53	2,53	2,53
26		FEBRUARY	1,85	1,85	1,93	1,93	1,93	1,93	1,93	1,93
27		MARCH	2,47	2,47	2,24	2,24	2,24	2,24	2,24	2,24
28		APRIL	2,19	2,19	1,92	1,92	1,92	1,92	1,92	1,92
29		MAY	1,43	1,43	1,51	1,51	1,51	1,51	1,51	1,51
30		JUNE	1,57	1,57	1,60	1,60	1,60	1,60	1,60	1,60
31		JULY	1,71	1,71	1,90	1,90	1,90	1,90	1,90	1,90
32		AUGUST	1,68	1,68	1,91	1,91	1,91	1,91	1,91	1,91
33		SEPTEMBER	2,49	2,49	2,58	2,58	2,58	2,58	2,58	2,58
34		OCTOBER	2,46	2,46	2,31	2,31	2,31	2,31	2,31	2,31
35		NOVEMBER	2,04	2,04	1,97	1,97	1,97	1,97	1,97	1,97
36		DECEMBER	1,97	1,97	1,90	1,90	1,90	1,90	1,90	1,90
37	2019	JANUARY	2,19	2,19	2,25	2,25	2,25	2,25	2,25	2,25
38		FEBRUARY	1,78	1,78	1,71	1,71	1,71	1,71	1,71	1,71
39		MARCH	2,24	2,24	1,98	1,98	1,98	1,98	1,98	1,98
40		APRIL	1,95	1,95	1,92	1,92	1,92	1,92	1,92	1,92
41		MAY	1,53	1,53	1,63	1,63	1,63	1,63	1,63	1,63
42		JUNE	1,47	1,47	1,60	1,60	1,60	1,60	1,60	1,60
43		JULY	1,80	1,80	2,06	2,06	2,06	2,06	2,06	2,06
44		AUGUST	2,08	2,08	2,34	2,34	2,34	2,34	2,34	2,34
45		SEPTEMBER	2,50	2,50	2,52	2,52	2,52	2,52	2,52	2,52
46		OCTOBER	2,84	2,84	2,80	2,80	2,80	2,80	2,80	2,80
47		NOVEMBER	2,51	2,51	2,31	2,31	2,31	2,31	2,31	2,31
48		DECEMBER	2,04	2,04	1,86	1,86	1,86	1,86	1,86	1,86
49	2020	JANUARY	2,32	2,32	2,49	2,49	2,49	2,49	2,49	2,49
50		FEBRUARY	2,17	2,17	2,16	2,16	2,16	2,16	2,16	2,16

NO	YEAR	MONTH	SUB-DISTRICT							
			AYAH	BUAYAN	PURING	PETANAHAN	KLIRONG	BULUSPESANTREN	AMBAL	MIRIT
51		MARCH	2,34	2,34	2,20	2,20	2,20	2,20	2,20	2,20
52		APRIL	2,23	2,23	1,93	1,93	1,93	1,93	1,93	1,93
53		MAY	2,25	2,25	2,09	2,09	2,09	2,09	2,09	2,09
54		JUNE	1,55	1,55	1,55	1,55	1,55	1,55	1,55	1,55
55		JULY	1,53	1,53	1,64	1,64	1,64	1,64	1,64	1,64
56		AUGUST	1,83	1,83	1,90	1,90	1,90	1,90	1,90	1,90
57		SEPTEMBER	1,90	1,90	1,91	1,91	1,91	1,91	1,91	1,91
58		OCTOBER	1,75	1,75	1,71	1,71	1,71	1,71	1,71	1,71
59		NOVEMBER	2,27	2,27	2,19	2,19	2,19	2,19	2,19	2,19
60		DECEMBER	2,29	2,29	2,31	2,31	2,31	2,31	2,31	2,31

The data were processed using Ms. Excel to find the average wind speed each year. The results of the average wind speed are shown in **Figure 2**.

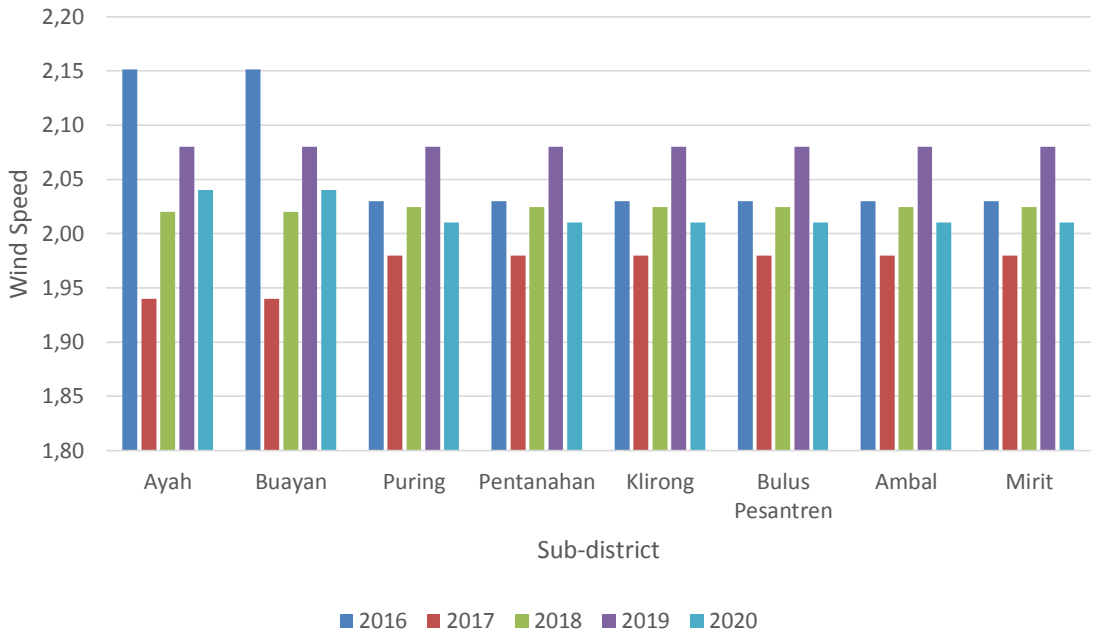

Figure 2. Average Wind Speed in 2016-2020 at Kebumen

Based on **Figure 2**, Ayah and Buayan areas have the same wind speed, and Puring, Petahan, Klirong, Buluspesantren, Ambal, and Mirit areas have the same wind speed. The wind speed data were processed using HOMER to determine the power generated every year. **Figure 3** shows a schematic image of a wind power plant in the HOMER application.

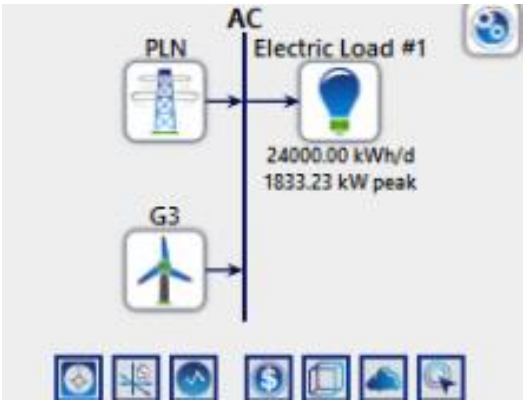

Figure 3. Schema of Wind Power Plant

Figure 4 Displays the results of power generated analysis using HOMER.

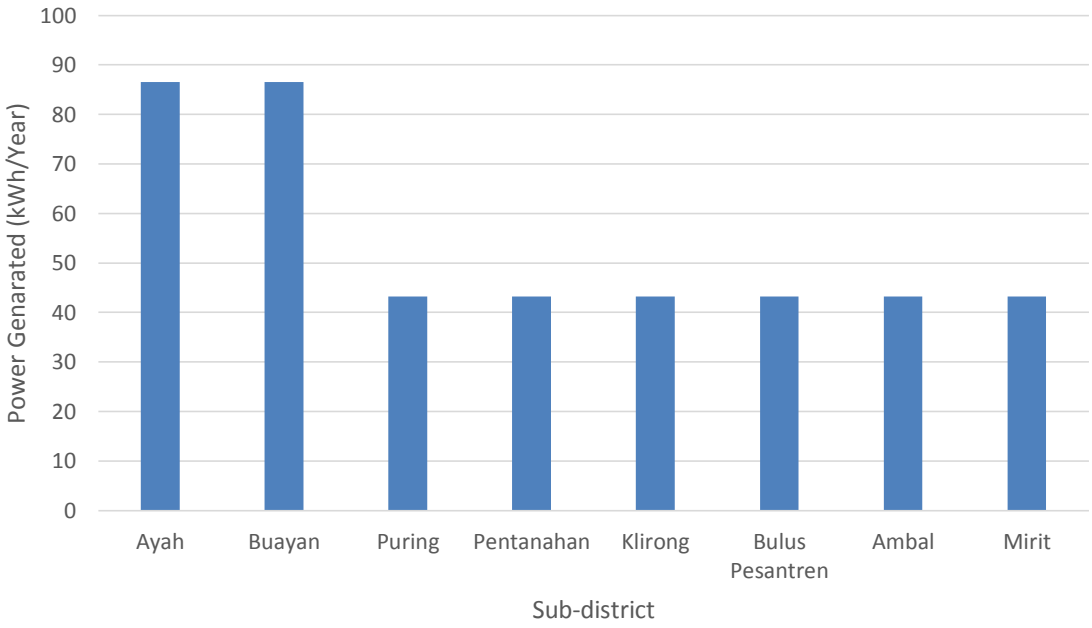

Figure 4. Results of Power Generated Analysis Using HOMER

Based on **Figure 4**, the power generated by the wind speed in Ayah and Buayan was 86.50 kWh/year while that of Puring, Petanahan, Klirong, Buluspesantren, Ambal, and Mirit was 43.20 kWh/year. Based on these data, the sub-districts suitable for PLTB were Ayah and Buayan.

4. Conclusion

Based on wind speed data from NASA, the southern coastal area of Kebumen was suitable for making PLTB, especially in Buayan and Ayah, because the wind speed between 2016-2020 was 2.15 m/s. The power produced annually based on the HOMER application was 86.50 kWh/year.

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