WIND ENERGY AS RENEWABLE ENERGY IN WEST JAVA, INDONESIA

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Abstract

Solar and wind energy have grown rapidly, with cost reductions occurring on a regular basis. However, in Indonesia, this technology accounted for less than 5% of installed capacity. According to the National Energy Policy, the national renewable energy share should reach 23 percent by 2025 and 30 percent by 2050. West Java;s desenly populated province benefit from the abundant of renewable energy sources, one of which is the large wind potential along the border coastline. This research will attempt to discuss renewable energy from wind power, including policy, supporting infrastructure and wind potential in West Java. The research will also estimate the future demand for electrical and the use of renewable energy, as well as analyze the wind energy development scenarios. As a result, the challenge of developing wind energy in Indonesia will be a concern for promote in this zero-emission energy.

Keywords
Strategy Development, Renewable Energy, Wind Energy, West Java.

1. Introduction
Energy is most important in human life for variety activites transportation, electricity, industrial, and household. Indonesia has various kinds energy resources, both non-renewable resources such as oil, coal and natural gas as wellas renewable energy sources such as solar, wind, water, geothermal and biomass. Since the beginning of the industrial revolution, the use of fossil as an energy source has dominated other energy sources, potentially leading to resource scarcity in the future and contributing to environmental degradation. Renewable energy has the advantage of not running out of energy as long as the natural cycle continues, environmental sustainable and can reduce pollution to the environment.

Indonesia continues to encourage renewable energy development, with the goal of increasing the country's renewable energy to 23 percent by 2025 and 30 percent by 2050 in accordance with KEN (National Energy Policy) as defined in

Government Regulation No. 79/2014. The General Nation Energy Plan (RUEN) is a derivative of the KEN, as stipulated by Presidential Regulation No. 22/2017, where the government's target is stated that at least 92,3 mtoe of energy comes from renewable energy sources out of total national energy of 400.3 mtoe to achieve the target of 23 percent use renewable resources by 2025. RUEN, in addition to regulating the target for the use of renewable energy, focuses on improving energy efficiency, which has so far not been focused on implementation. One of them is by conduction energy conservation, which aims to maintain energy availability in order to achieve long-term national security. The Regional Energy Plan (RUED) is the RUEN elaboration and implementation plan. Exploitation and utilization of renewable energy resources has become one of West Java province's top priorities.

West Java province is located in western java, with the central java sea to the east, the Indian ocean to the south, and banten and DKI Jakarta to the west. West Java is Indonesia's most populous province, with the population of 48,27 million people. According to the Central Statistic Agency (BPS) 2021, the rate of economic growth and population data in West Java reach 57.137,30 million people until 2035. It must be supported by the potential for abundant renewable energy sources as solar, water, geothermal and has great wind potential along the border's coastline. West Java met its electrical energy needs of 58,095 GWh in 2018 by relying primarily in fossil. In 2018, the capacity of renewable energy power plants was 3.184 MW form a potential of 29.764,1 MW, in the other words only 11,3 percent of the total renewable energy potential that has been utilized.

In contrast to the International situation, where solar and wind has developed rapidly, with continuous cost reductions, these technology accounted for less than 5% of installed capacity in Indonesia by 2019 (IEA, 2020). Currenty, national discussion increasing about transition from conventional energy to renewable energy. The utilization of national wind energy is 147 MW, with 75 MW located in Sidrap and 72 MW located in Jeneponto (the both of South Sulawesi) (Firsta Zukhrufiana Setiawati, 2020). The generated wind energy is still low from the total wind potential of 60,6 GW, only 0,2 percent is generated. According to the Meteorologu, Climatology and Geophysics Agency (BMKG) observation station, the average wind speed in West Java by 2019 was 4,3 m/s and 2020 the average was 3,8 m/s. Based on the wind energy potential analysis and mapping, areas with significant potential are also found in Sukabumi of 170 MW and Garut of 150 MW with an average wind speed of 6,6 m/s in those areas which is are also part of the West Java province (MEMR, 2019). With the wind power potential, strategic planning is needed in West Java. This study will try to discuss renewable energy form wind power including the policy, supporting infrastructure and the potential of wind in West Java.

1.1 Objectives

West Java is Indonesias most populous province, with a population of 48,27 million people. The province met its electrical energy needs of 58,095 GWh in 2018 by relying primarily on fossi. In 2018, the installed capacity power plant of renewable energy was 3.184 MW from a potential of 29.764,1 MW, in the other words only 11,3 percent of the total renewable energy potential that has utilized. According to the Meteorologu, Climatology and Geophysics Agency (BMKG) observation station, the average wind speed in West Java by 2019 was 4,3 m/s and 2020 the average was 3,8 m/s. Based on the wind energy potential analysis and mapping, areas with significant potential are also found in Sukabumi of 170 MW and Garut of 150 MW woth an average wind speed of 6,6 m/s in those areas which is are also part of the West Java province (MEMR, 2019). With the wind power potential, strategic planning is needed in West Java. This study will try to discuss prioritizes renewable energy form wind power and the challenges that will be faced in the future.

2. Literature Review

2.1 Policy for Energy Development

The general national energy plan will be used as guidline by the provincial government to draw up a general regional energy plan (RUED). A long-term goal is a strategic plan. Although its alignment with business opportunities and challenges is reviewed on regular basis, it is not as dynamic as a tactical plan in the overall strategic plan(D. D. Y. J. A. K. M. H. Rahmat Nurcahyo, 2019). RUED will be a long-term and sustainable direction for regional energy energy development by optimizing regional energy potential because each region has its own advantages and disadvantages in terms of geography and natural conditions. Regulation No. 30 of 2017 concerning energy mandataes that regional energy planning be delegated to regions in accordance with their authority, taking into account the nature and condition of each region and compiled based on RUEN. As a result, local government must involve cross-regional work units (SKPD) and universities in the preparation of the RUD, which is then submitted to the local DPRD for inclusion in the form of a regional regulation (PERDA). The aim of this plan is to make energy area competitive and affordable to the people who live there. If basic energy cannot be priced competitively, the industry will become uncompetitive and Indonesia's internal competitiveness will suffer. People should be able to buy electricity based on their ability, and this is a collaborative effort.

The government agency has different characteristics that profit-oriented organization, interms of finansial aspects, activities and culture (A. D. W. R. E. P. Rahmat Nurcahyo, 2015). In order to improve national energy security, The government enforces a number of energy-related regulations. Table 1. Renewable energy regulations and energy conservation describes the regulations enacted by the government through various ministries to support the national energy policy (KEN) and the General Energy National plan (RUEN).

Table 1. Regulations Renewable and Conservation Energy

Government Regulation			
No	Year	Title	Description
79	2014	Energy Policies	
18	2015	Income Tax Facility for Investment in Specific Business Field and/or Regions	Hydrogen, Gas, Methane, Coal, Liquefied Coal, Gaseous Coal, Geothermal Power Plant, Hydroelectric Power Plant, Solar Power Plant, Wind Power Plant, Seawave Power Plant
Presidence Decree			
4	2010	Assignment to PLN to Accelerate the Construction of Power Plants Using Renewable Energy, Coal and Gas	
22	2017	General Plan of National Energy	
Regulation Minister of Energy and Mineral Resources			
38	2016	Electrificaation Acceleration in Rural Areas, Remote, Border and Small Inhabited Islands through the Implementation of Electricity Supply Business for Small-Scale	Solar Power Plant, Wind Power Plant, Hydroelectric Power Plant, Biomass Power Plant, Gas Power Plant, Garbage Power Plant, Geothermal Power Plant, Nuclear, Hydrogen, Gas, Hydrogen, Gas, Methane, Coal, Liquefied Coal, Gaseous Coal.
39	2017	Implementation of Utilization Activities New Energy and Renewable Energy and Energy Conservation	Solar Power Plant, Nuclear Power Plant, Mikrohydro Power Plant, Wind Power Plant, Biomass Power Plant, Biogass Power Plant, Garbage Power Plant, Biofuels etc.
50	2017	Utilization of Renewable Energy Sources for Supply of Electricity	Photovoltaic, Solar Power Plant, Wind Power Plant, Hydroelectric Power Plant, Mikrohydro Power Plant, Biomass Power Plant, Biogass Power Plant, Garbage Power Plant, Geothermal Power Plant and Seawave Power Plant
4	2020	Amandment Regulation of The Minister Energy and Mineral Resources No. 50/2017 Concerning Utilization of Sources Renewable Energy for Electricity Supply	Wind Power Plant, Hydroelectric Power Plant, Seawave Power Plant, Solar Power Plant, Garbage Power Plant
20	2020	Electric Power System Network Rules (Grid Code)	
Regulation Minister of Industry			
54	2012	Guidelines for Using the Local Product for the Development of Electricity Infrastructure	Hydro Power Plant, Geothermal Power Plant, Steam Power Plant (Coal, Biomass), Solar Power Plant
Regulation Ministry of Home Affairs			
96	2016	Payment of Service Availability in The Framwork of Cooperation Local Government and Business Entities in The Provision of Infrastructure in The Regions	

2.2 Wind Energy

Wind power is the use of wind turbines to provide mechanical power to turn electric generators and, historically, to do other work such as milling or pumping. Wind power is a plentiful, renewable, widely distributed, and clean alternative to burning by fossil. During operation, it emits no greenhouse gases, uses no water, and occupies little land. The net environmental effects of wind power are far less problematic than those of fossil fuel sources. The amount of wind energy required to generate electricity is the same as the amount of fossil energy required to do the same (MEMR, 2020). The wind speed relative to the earth's surface is zero right at the earth's surface. Then, in proportion to the height of the earth's surface, this speed increases. The two most common wind shear profiles used to calculate energy are the exponential wind shear profile and the surface roughness wind shear stress profile (Y. Daryanto, 2007). Wind energy is proportional to wind speed. As wind speed increases, so does energy output until it reaches the maximum amount of energy that can be generated. Large-scale wind turbine technology can operate effectively at speeds ranging from 5 to 20 m/s. Wind speeds of less than 5 m/s are better suited for small-scale wind power generation. Wind energy is proportional to wind speed. As wind speed increases, so does energy output until it reaches the maximum amount of energy that can be generated.

Wind speed and direction can be used to determine the terms and conditions of wind speed. Besides from measuring tools, the following Table 2. on the Beafort scale can be used to measure or estimate it:

Table 2. Wind Speed Classification 10 meters above ground level

Class	Speed (m/s)	Condition
1	0,00 – 0,02	-
2	0,30 – 1,50	Calm wind, smoke straight up
3	1,60 – 3,30	Smoke moves in the direction of the wind
4	3,40 – 5,40	The face feels the wind, the leaves sway slowly, the direction of the wind
5	5,50 – 7,90	Road dust, flying paper, tree branches swaying
6	8,00 – 10,70	Tree branches away, Flags flutter
7	10,80 – 13,80	Big tree branches swaying, small choppy plumping water
8	13,90 – 17,10	The tip of the tree bends, the wind blows in the ear
9	17,20 – 20,70	Can break tree
10	20,80 – 24,40	Can break tree branches, houses fall
11	24,50 – 28,40	Can knock down trees, inflict damage
12	28,50 – 32,60	Inflict heavy damage
13	32,70 – 36,90	Tornado

Class 3 and class 8 wind speeds are the minimum and maximum wind speeds that can be userd to generate electrical energy. Surface wind at an altitude of 1-100 meters above ground level can be used in the energy conversion process. The shape of the surface and the type of land cover have a strong influence on the surface wind speed, where these two factors can inhibit wind speed.

Calculation of wind energy using the following formula (Sam, 2005) :

$$(Psys/A)wp = c_p.\eta_{tr}.\eta_g.\eta_b.\frac{1}{2}.\rho.V^2$$

Description:

c_p	=	Coefficient (0,4)	η_g	=	Generator Efficient (0,85)	ρ	=	Air Density (1,2 Kg/m^3
η_{tr}	=	Efficient Trnms (0,95)	η_b	=	Battery Efficienty (0,75)	V	=	Wind Velocity (m/s)

2.3 Wind Potential in West Java

West Java is bounded on the west by the Sunda Strait, on the north by the Java Sea and the Special Capital Region of Jakarta, on the east by the Province of Central Java, and on the south by the Indonesian Ocean.

Longitude : 104°9' – 108°41' East
Latitude : 5°50' – 7°50' South

West Java Province has a total area of 35.377,76 km^2. According to Central Statistics Agency data, the total population in 2020 will be 48.274.162 people, making it the largest in Indonesia with a population of 1.365/km^2. West Java's topography is very diverse, with lowlands in the north, mountainous highlands in the middle, and hilly areas and beaches in the south. The economic growth of West Java Province's Gross Regional Domestic Product (GRDP) at current prices (ADBH) in the 2013-2020 period is expected to continue. West Java's GDP in 2020 is estimated to be 1,472,826.14. (in billion rupiah).

West Java has a lot of renewable energy potential, including geothermal, water, bioenergy, sunlight, and wind. In 2015, fossil energy accounted for 90% of the province's energy mix, with renewable energy accounting for 10%. In West Java, renewable energy accounts for approximately 11.3 percent of total potential. The utilization-to-potential renewable energy ratio serves as the foundation for the KEN's goal of developing renewable energy that accounts for at least 23 percent of total primary energy mix in 2025 and at least 31 percent of total primary energy mix in 2050. According to the Meteorologu, Climatology and Geophysics Agency (BMKG) observation station, the average wind speed in West Java by 2019 was 4,3 m/s and 2020 the average was 3,8 m/s. Based on the wind energy potential analysis and mapping, areas with significant potential are also found in Sukabumi of 170 MW and Garut of 150 MW woth an average wind speed of 6,6 m/s in those areas which is are also part of the West Java province (MEMR, 2019).

Garut, based on the findings and assessments of a 1.5 year wind campaign to ensure wind potential and annual production are met, 29 towers as tall as 130 meters will built in the Pameungpeuk sub-districk, is expected to generate 120 MW. To maintain the existing land use, the tower building area mus be at least 20x20 meter. The Government of West Java also develop wind turbine towers in Cibalong and Cisompet, which will have more than 30 wind turbine towers with roughly the same capacity (GOWJ, 2021) .

The potential wind locations in Sukabumi, will be designated as a priority project for the development of PLTB in West Java Province by the Investment Service and One Stop Integrated Service (DPMPTSP). The highlands of Ciletuh, Sukabumi, are proven to have very good wind potential. After measuring wind data for 6 years from several poles installed as high as 100 meters, the data accumulated for 23 years. This project is estimated to to cost IDR 3.3 Trillion. There are several loading and unloading terminals nearby, including one on Cikeueus beach in Girimukti Village, Ciemas District, Sukabumi Regency. In addition, security, safety, geology, and seabed profile must all be considered. Installing 50-55 wind turbines with 150 blades PLTB Sukabumi is expected to generate 150 MW.

3. Methods

The research method is carried out through observation and to show the steps to be used, made systematically to make it easier understand the research being conducted. A process flow chart can be seen in the below Figure 1 showing flowchart methodology.

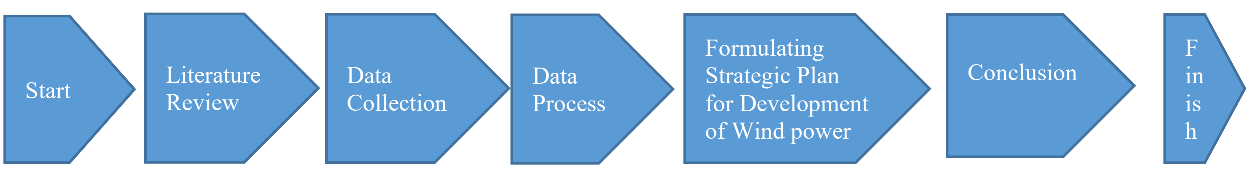

Figure 1. Flowchart methodology

4. Data Collection

Data is collected by utilizing information from a variety of book, review reports, regional annual reports. The data gathered is as follow:

4.1 Historical data, such as population data, population growth, number of customer by sector, and GDRP, is used to forecast model of electricity demand in West Java. According to the Table 3 below, the population of West Java in 2020 is 49.935.858 people and the number is the largest in Indonesia. Since 2014, economic activity has increased, but it fall in 2020 due to the covid-19 pandemic.

Table 3. Statistical Data History of West Java 2014-2020

Desc	Unit	2014	2015	2016	2017	2018	2019	2020
Population Total	People	46.029.668	46.709.569	47.379.389	48.037.827	48.683.861	49.316.712	49.935.858
Population Growth	%	1,50	1,46	1,41	1,37	1,33	1,28	1,24

Number of Customer by Sectors								
Household	Million	10.354.332	11.222.852	11.747.972	12.388.399	13.041.471	13.628.105	14.099.301
Industry	Million	12.926	13.481	13.999	14.590	15.142	15.439	15.827
Business	Million	328.638	356.805	426.509	506.173	568.019	589.240	635.049
Social	Milliion	216.443	231.665	247.926	265.362	282.150	297.856	313.867
Public	Million	12.584	13.368	14.178	15.131	16.615	17.708	18.418
Sales electricity per sector								
Household	Gwh	15.897,75	16,794.88	17.464,02	17,555.20	17.933,63	18.753,88	20.362,31
Industry	Gwh	20.910,42	20,716.98	22.187,93	22,956.68	23.903,66	24.051,64	21.427,96
Business	Gwh	4.739,88	4,605.88	4.921,16	5,231.90	5.644,72	6.080,21	5.797,60
Social	Gwh	709,10	787.79	878,54	951.15	1.058,78	1.181,34	1.142,95
Public	Gwh	332,42	355.68	378,48	393.52	417,98	456,40	433,73
GDP	Million IDR	1.154.391,70	1.206.891,27	1.277.312,17	1.350.879,84	1.430.710,19	1.504.776,35	1.472.826,14

Source : Badan Pusat Statistik, PLN

4.1 Site of wind resources assessment summary

The potential sites showed the possibilities for power development on a medium to large scale. The following Table 4 summarizes the results of the wind study

Table 4. Summary of wind potential

Site	V_{ave} m/s	Weibul Parameter		Wind Power Density
		C (m/s)	K	W/m^2
Baron, DIY	6,13	6,29	2,24	245
Lebak, Banten	5,58	6,3	2,06	198
Nusa Penida, Bali	2,73	3,1	1,66	30
Oelbubuk, NTT	6,1	6,9	1,6	301
Bantul, DIY	4	4,7	1,87	91
Sukabumi, West Java	6,27	7,1	2,08	272
Purworejo, Central Java	5,16	5,7	1,5	231
Garut, West Java	6,57	7,4	2,89	268
Selayar	4,6	5,2	1,83	143

5. Results and Discussion

5.1 Estimation Future Demands Electricity

Forecast model of population and GDRP wih time series trend predictions due to increase every year. Forecasting is performed using west java province's population and GRDP as independent variables based on time trends to predict the increase in the number of users and electricity load per sector. The results of the population and GRDP makes population growth and economic activity so that it can be used as a parameter or independent variable to determine the prediction of an increase in the electricity load in each sector in the province of west java. Linear regression was used to see the relationship between the independent variables and to have a straight-line relationship with the dependent variable. Linear regression of electricity users and population, as well as linear regression of electricity users, population and GRDP. Before regressing electricity usage data with population and GRDP, each sector is expected to see increase in the number of users until 2025 based on time trends. The below Table 5 shows the result trend prediction for the years 2021-2025.

Table 5. Result Trend Prediction 2021-2025

Desc	Unit	2021	2022	2023	2024	2025
Population Total	People	50.635.386	51.292.314	51.949.242	52.606.170	53.263.098
Population Growth	%	1,38	1,28	1,26	1,25	1,23
Number of Customer by Sector						
Household	Million	14.831.621	15.450.867	16.070.114	16.689.361	17.308.608
Industry	Million	16.452	16.944	17.435	17.927	18.418
Business	Million	70.514	75.963	81.412	86.860	92.309
Social	Milliion	33.059	34.698	36.336	37.975	39.614

Public	Million	19.517	20.539	21.561	22.583	23.605

The results of population growth and GRDP in West Java Province use a linear trend approach, with an average annual increase of 1.2 percent and a 3.5 percent GRDP increase. In percentage terms, the population of West Java Province has increased by 4.93 percent over the last five years, while the GRDP has increased by 13.39 percent. Each year, the household sector grows by 3.79 percent on average, the industrial sector grows by 2.78 percent on average, the business sector grows by 6.51 percent on average, the social sector grows by 4.42 percent on average, and the public sector grows by 4.64 percent on average.

5.2 Policy and Support Infrastructure

One of the mandates of the 2020-2024 RPJMN is the use of domestic components in NRE power plants. Furthermore, the Minister of Energy and Mineral Resources Decree No. 1953K/06/MEM/2018 regarding the use of Operational Goods and Other Supporting Materials Produced Domestically in the Energy and Mineral Resources Sector regulates the use of components in the country. The Minister of Industry Number 54/M-IND/PER/3/2012 jo. Minister of Industry No. 5/2017 concerning Guidelines Use of Domestic Products for Electricity Infrastructure Development is another regulation that regulates the value of TKDN. Concerning the amount of TKDN PLTB not yet listed in those rules. In general, the regulation minister of industry No. 16/M-IND/PER/2/2011 concerning Provisions and Procedures for Rate Calculation Domestic Component can be used as a reference (TKDN).

The infrastructure that supports the growing wind industry includes every stage of the manufacturing and turbine installation processes. This includes selecting a turbine site, choosing the appropriate turbine design, acquiring all of the materials required for production and fabrication, manufacturing each component, transporting large components to installation sites, installing turbine components, connecting the turbine to the appropriate electrical grid, and maintaining each component throughout the turbine's lifetime. Streamlining this process will allow consumers across the country to access more affordable wind energy.

PLTB is a generator that uses intermittent energy sources, producing electricity in fluctuation amounts. It is widely acknowledge that the intermittent nature of wind energy has hampered its utilization, as intermittent wind energy cannot be integrated into the conventional electrical transmission network (Jung et al., 2019). A backup generator is required in its operation as a supporting generator to anticipate when wind speed drops below the turbine design limit, which is an assessment of the feasibility of large-scale PLTB projects in each region. Based on regulation Ministery of Energy and Mineral Resources No. 20/2020 concerning elerctricity power system rules (grid code) to accommodate the use of generation including intermittent renewable energy such as PLTS and PLTB. In addition to being safe, reliable, efficient, this regulation contains and renewable energy plants can enter the system in the future without interfering with the existing electricity.

The purchase price of electricity from PLTB is regulated in Minister of Energy and Mineral Resources regulation number 50/2017 concerning the use of renewable energy sources for the provision of electricity; with the enactment of this regulation, it is hoped that the trend of increasing BPP due to electricity prices from renewable energy can be avoided.

5.3 The Potential of Wind Energy

Wind potential was described using the Weibull statistical distribution. The average wind was calculated using the temporal distribution of the studied sites. The four locations in West Java despicted in the figure are Ciemas (Sukabumi district), Cibalong, Pameungpeuk and Cisompet (Garut district). It is important to note that the shape of the Weibull distribution closely represents the experimental data. However, as shown in Figure 2, depending on the Weibull parameters, the wind distribution can vary, the wind distribution takes the form of an exponential function. It has also been observed that the dominant sectors differ from one to another site.

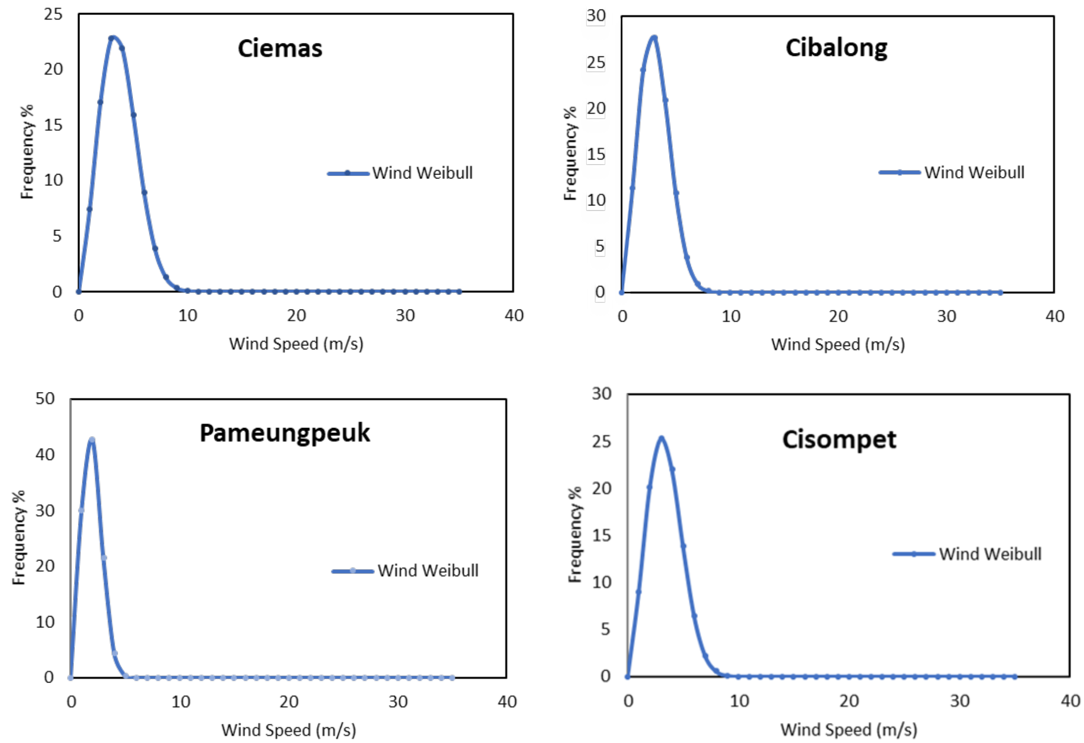

Figure 2. Wind Data by Weibull Distribution

It is critical to have reliable wind measurement data and assessents. The 4 assessed wind energy locations will be promoted to both the government and the private in order to build capacity in Indonesia's wind energy potential. This should alleviate concerns about availability of wind energy nation.

6. Conclusion

According to the above study of development for wind energy in west java, west java is abundant in wind energy resource and land resource, thus despite West Java's high demand in the future. A commitment to develop and use renewable energy, including wind energy should be made. Coordination between the government and regional with PLN as the sole buyer electricity, so that the renewable energy investment plan is dependent to buy electricity offered by investor. In general, regulation Minister of Industry's concerning the amount of TKDN PLTB not been included, so this regulation required to support in the development of future wind energy infrastructure and create an advocacy program for the development of wind energy generation due to scarcity of success stories about wind energy industry in Indonesia. As a result, it necessitates the cooperation and commitment of all parties involved. Wind energy will remain a potential source if it is not developed and utilized.

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Biography

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