

Investigation Wind Speed Characterization Over West Lampung Area For Wind Power Potential Application

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Abstract

Lampung it's a one province in Sumatera who have wind power potential especially over west lampung area. The observation potential wind speed has been studied to assess wind power potential. However, the wind speed observation over local area is limited due to transportation access. Thus, in this study aimed to characterize wind speed over West Lampung area using MTSAT observation and lognormal model. The wind speed observation taken from local observation, and MTSAT satellite to investigate wind speed characterization. Result shows West Lampung, Sumatera have potential wind power potential over Krui, Lampung area with strong correlation (R-sq value) 0.71 and 0.77 with 6.91 m/s of wind speed (local observation), and 7.09 m/s of lognormal wind speed model over 5.8m from above mean sea levels (AMSL), respectively. Based on the result we found the best location to install wind turbine in near future over Krui, West Lampung, Sumatera, Indonesia.

Keywords: Krui, Wind Power Potential, Wind Speed, Lognormal model

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1. Introduction

In the 21st century, the competition in renewable energy technology to assess potential energy has been studied with two types such as solar and wind energy. In order to assess potential energy over observation area, the in-situ assessment of solar and wind characterized was used to generate information from site survey. However, the wind speed observation over local area is limited especially in Krui, West Lampung, Sumatera. Krui it's a small city over West Coast Lampung province. This city has a problem electricity resource per year. The Lampung Governor has planned to develop wind turbine in near future. In order to develop wind turbine, the investigation of wind potential energy for wind turbine was proposed to capture characteristics wind speed in this area. However, the local observation to obtain wind speed data in this area has been limited due to transportation access.

Many researchers used satellite data to obtain wind speed information [1, 2]. The wind speed information can be captured over upper atmosphere (space) with resolution less than 200 km. However, the information from satellite data it's not clear due to resolution data. Thus, the wind speed model based lognormal distribution is used to validate satellite data [3, 4, 5].

The current studies showed the lognormal model was used to validate satellite data. However, the local observation was needed to characterize wind speed over local area. Thus, the local area with lognormal model and satellite data was performed in this study. The three type of data was analysed using correlation analysis to obtain strongest correlation between local study and satellite data also local study and lognormal model [6, 7]. This method it's very good to investigate wind speed characterized for wind power application especially over Krui, West Lampung, Sumatera in near future.

2. Methodology

2.1 Data and Location

Lampung province located over South Sumatera island which is have wind potential energy. The local observation was captured over Lampung province especially in Krui, West Lampung. We selected Krui area due to topology factor in this area is unique. Krui, West Lampung located between Mt. Bukit Barisan and Indian Ocean as a wind barrier and wind source, respectively. Based on local study in this area, Krui have potential wind speed source more than 3 m/s per-years. The forecast potential wind speed was tested in windy application (see Figure 1).

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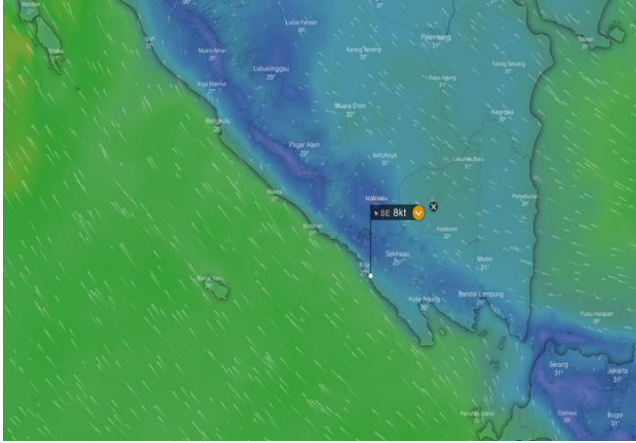


Figure 1. Windy forecast application
(<https://www.windy.com/?-4.741,104.205,8,m:dwnai2u>)

In order to assess wind speed potential, we collect wind speed data based on site survey in this area. During observation wind speed data, we collect wind speed data in hourly resolution over 4 to 7 July 2018. Furthermore, the satellite data from MTSAT was performed in this study to obtain characteristics in upper atmosphere (space). The local and upper observation was used to assess wind speed movements and wind direction. The distribution of wind speed movements and wind direction was analysed using lognormal model to obtain good position of wind power energy.

2.2 Lognormal Distribution

The lognormal distribution is a various model to assess wind speed distribution. This distribution was used in many applications such as agriculture, entomology, economics, geology, industry and quality control. In order to analyse wind speed distribution, the several parameters have been applied to obtain condition from lognormal distribution e.g. scale, shape, and location parameter. All the parameter was calculated using probability density function (see equation 1) [8]:

$$f(x) = \frac{1}{(x-\gamma)\sigma\sqrt{2\pi}} \exp\left[-\frac{\left[\ln\left(\frac{x-\gamma}{\mu}\right)\right]^2}{2\sigma^2}\right] \quad (2-1)$$

where, x , σ , μ and γ are wind speed, shape, scale, and location parameters. In this study, the two lognormal distribution parameters by setting the location parameter equal to 0. Therefore, the three parameters over lognormal model in equation (2-1) was modified to equation 2-2.

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left[-\frac{\left[\ln\left(\frac{x}{\mu}\right)\right]^2}{2\sigma^2}\right] \quad (2-2)$$

where, the minus sign stands for wind direction movement.

2.3 Satellite Measurement

In order to investigate wind speed characteristic, the satellite measurement was proposed to obtain wind speed movements. The Multifunctional Transport Satellite (MTSAT) was performed in this study to investigate potential wind speed over Krui, West Lampung, Sumatera over 4 to 6 July 2018. During collecting data using MTSAT satellite, the wind speed and wind direction was processed using time series to identify from missing and error measurement over pre-processing data. Furthermore, the correlation analysis has applied in this study to obtain R-sq result between MTSAT satellite observation and lognormal distribution model. In order to obtain investigation result of wind speed parameter, we use validation for all the observation data. If the result is not good, we re-analysis wind speed parameter while the result is satisfied we calculate Root Mean Square Error (RMSE) and Percent Error (PE) statistical assessment (see Figure 2).

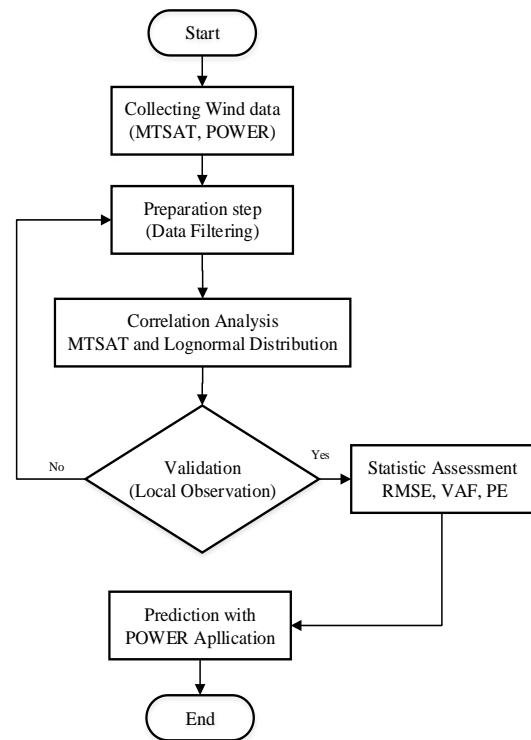


Figure 2. Flowchart investigation wind speed parameter

After the statistical assessment of wind speed data obtained, we analyse potential wind energy using Prediction Of Worldwide Energy Resource (POWER) by NASA. Here, wind speed parameter has investigated to find wind energy potential over Krui, West Lampung. Furthermore, the POWER application has been tested to identified solar and wind potential energy (based prediction model) and many studies to find meteorology parameter such as pressure, Temperature, Humidity, and Heat index during La Niña/El Niño event [9].

3. Result and Discussion

In order to investigate wind speed characterization, the MTSAT and local observation was performed in this study. The local observation has used as a validator data over MTSAT measurement and lognormal distribution model. Figure 3 shows the characteristic variation wind from MTSAT measurements and lognormal distribution model.

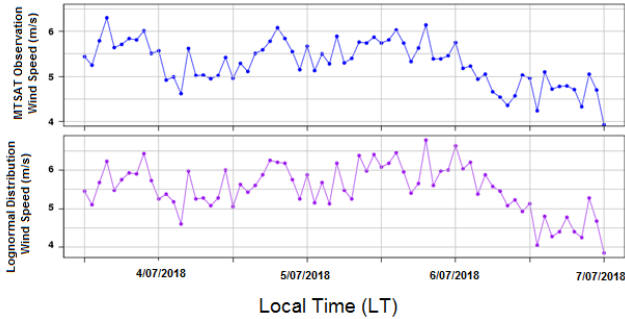


Figure 3. The characteristic variation wind speed from MTSAT measurements and lognormal distribution model

As can be seen in the figure 3, the variation of wind speed parameter over lognormal distribution model taken from local observation and wind speed measurement using MTSAT has been plotted over time series. The variation of wind speed parameter was analysed to obtain wind characteristics over time series. Here, we find the maximum wind speed reached 5 to 7 knots over south area while the minimum of wind speed reached 0 to 2 knots over southeast area. In addition, the lognormal distribution model was used to calculate wind speed potential based on location, shape, and scale parameter. However, the MTSAT wind speed measurement over upper atmosphere to seen in general view and geographic structure. Figure 4 shows the Krui, West Lampung, Sumatera located between Indian Ocean and Mt. Bukit Barisan.

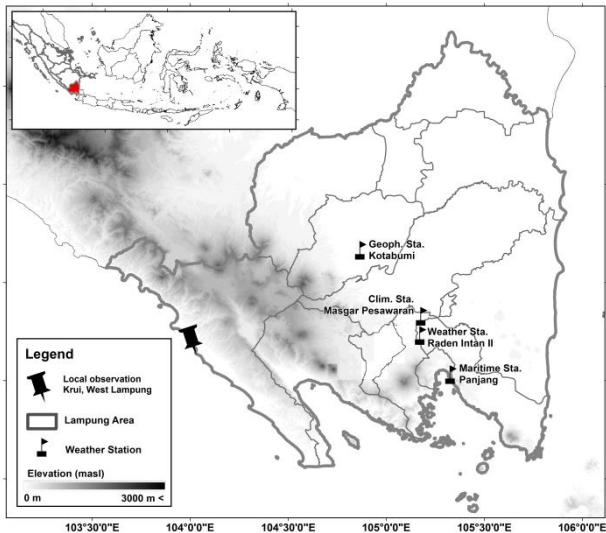


Figure 4. The geographic location of Krui, West Lampung, Sumatera

Here, we find the unique characteristics in this area due to wind barrier (on Mt. Bukit barisan) over east area. Furthermore, the barrier from Mt. Bukit Barisan will be protecting wind speed to move in another area. The local distortion and circular movement of wind speed due to barrier from Mt. Bukit Barisan called Katabatic Wind (KW) area. Here, the characteristics of KW area have special characteristic due to unpredictable wind flow pattern over Mt. Bukit Barisan (see Figure 5).



Figure 5. The illustration characteristic wind speed over Katabatic Wind (KW) area in Mt. Bukit Barisan, Sumatera (https://www.weather.gov/source/zhu/ZHU_Training_Page/winds)

As can be seen in the figure 5, the unpredictable wind flow pattern over Mt. Bukit Barisan in illustration is caused by KW area. The KW area is a wind condition on Valley and Mountain breeze due to airflow turbulent. Thus, the special design of wind turbine in KW area due to airflow turbulent has performed in this study. However, the technical and detail of wind turbine has been studied in near future. Figure 6 shows the special design of vertical wind turbine over KW area due to airflow turbulent.

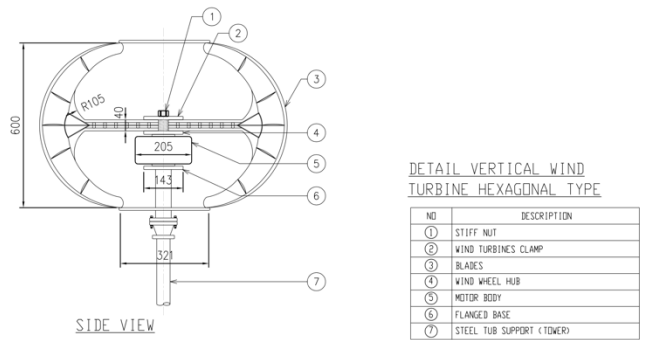


Figure 6. Special design of vertical wind turbine over KW area due to airflow turbulent

As can be seen in the figure 6, the special design of vertical wind turbine over KW area was studied to anticipate airflow turbulent from Valley and Mountain breeze. Here, the vertical wind turbine was designed due to characteristic and topology Krui, West Lampung area. The vertical wind turbine over KW area will be generated more than 100 kW per-days from POWER, NASA application for one device at Krui, West Lampung area. In order to calculate wind energy potential in this area, the calculation based MTSAT and lognormal distribution model were calculated and validated by local observation. The positive correlation with R-sq 0.71 and 0.77 from output target and input parameter (predictor) has performed in this study. The

strong correlation with R-sq 0.71 from MTSAT and local observation while the correlation value with R-sq 0.77 from lognormal distribution model and local observation, respectively. Based on correlation result, we obtain strong correlation from both parameters to analyse wind speed characteristics over Krui, West Lampung, Sumatera. Table 1 shows the comparison between MTSAT measurement, lognormal distribution model, and local observation with statistical calculation to obtain accuracy and quality of wind speed data over Krui, West Lampung area.

Table 1. Comparison result using statistical calculation

| Parameter | MTSAT Observation | Lognormal distribution Model | Local Observation |
|-----------------|-------------------|------------------------------|-------------------|
| RMSE (%) | 1.934 | 2.032 | - |
| VAF (%) | 92.452 | 93.883 | - |
| PE (%) | 7.548 | 6.117 | - |
| Min wind speed | 3.86 m/s | 4.01 m/s | 3.09 m/s |
| Max wind speed | 6.91 m/s | 7.09 m/s | 7.01 m/s |
| Wind speed Avg. | 5.89 m/s | 6.081 m/s | 5.98 m/s |

As can be seen in Table 1, the minus symbols (-) means not calculated due to the comparison of MTSAT observation and lognormal distribution model was validated using local observation. Thus, we not calculated the three statistical parameters such as RMSE, VAF, and PE. However, we also calculated the max, min, and average wind speed calculation to investigate the wind speed potential over Krui, West Lampung area. During investigation, we obtain the MTSAT observation and lognormal distribution model have smallest error on statistical calculation. Here, we obtain max, min, and average wind speed parameter from investigation result showed all parameter is closed between MTSAT, lognormal distribution model, and local observation. Thus, based on the result the wind speed potential over Krui, West Lampung, Sumatera have wind potential energy based on characteristics geographic location and wind speed during investigation.

4. Conclusion

The investigation of Wind Speed Characterization Over West Lampung Area for Wind Power Potential Application has been successful in this study. The correlation analysis shows wind speed and wind potential energy have positive correlation with R-sq value 0.71 and 0.77 from MTSAT, lognormal distribution model, and local observation. The statistical calculation showed the parameter RMSE, VAF, and PE was calculated to obtain accuracy of wind speed data. The calculation of wind speed max, min, and average was obtained to collect wind speed potential. However, we also found the Katabatic wind (KW) over characteristics wind over Krui, West Lampung, Sumatera. Thus, the vertical wind turbine was proposed due to unpredictable

airflow over KW area. Finally, we successful to study the characteristics of wind speed over Krui, West Lampung, Sumatera.

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