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Research Article

Assessment of Wind Speed in San Jose, Mindoro, Philippines

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Abstract

The present research work was focused on the assessment of the wind speed in San Jose, Mindoro, Philippines to determine the primary relationship of its location on feasibility of constructing a wind power station. The demands of electric power generation are rapidly increasing as the population increases; thus, the need to build a power station in locality is necessary to meet the demands. Normally, wind power stations are in remote areas to prevent hazard and noise pollution for residential areas and commercial establishments. Further, wind speed is stronger to non-obstacle areas, as it reaches its peak values on clear and plain fields. Moreover, it will provide additional knowledge for scientific observations and study in the area to help in the different aspects of science related to wind studies. Wind speed parameters are discussed and analysed in this paper to investigate the viability of the location. The results show that the average wind speed in San Jose, Mindoro, Philippines varies from 2.35 to 2.43 kph between the years of 2015–2018. Although, it is possible to harvest wind energy during the first quarter of the year, it is not, however, ideal to construct a wind power farm for energy consumption, as it may only produce a minimal capacity of the wind power station because 60% of the data recorded in each year is only at its minimum wind speed.

Keywords: Assessment; Renewable Energy; Wind Speed; Wind Power Station.

Introduction

After forming the ASEAN community, there are ideas in various aspects such as politics, society, economy, which includes energy for collaboration. Circulation energy is promoted by all nation members due to being green and friendly to environment making therefore a better quality of life for mankind aside from having a stable energy [1-3]. As the demand for electricity increases, scientists and engineers were seeking energy that are not reliable with coals and fossil fuels [4,5]. There are, however, some differences that exists between traditional energy source and renewable energy source [6-8]. As compared to other sustainable energy, wind power is gaining momentum, reliable, and cheaper. Wind farms worldwide are growing as the realm of sustainable energy and a major source of electric power, In China alone, the total installed wind reached around 44.73GW in the last quarter of 2010 [9]. Various designs of wind turbines affect electrical power generation.

The direction of wind speed is important for wind turbines to generate electrical energy. Although, the greater the wind speed, the greater the power generated; however, in general, wind turbines have maximal wind speed to avoid the destruction of turbine blades. Normally, a wind speed is recorded by a device located at the top of the pole. The fluctuation of wind speed has an impact on electricity generation and operating characteristics. In general, the wind speed classification can be as follows [10-11], (a) 8kph (2 m/s) minimum, required to start rotating most small wind turbines (b) 12.6kph (3.5m/s) typical cut-in speed, a small turbine starts generating power (c) 36–54kph (10–15m/s), produces optimal generation power and (d) 90kph (25m/s), turbine is stops or brake (cut-off speed).

For wind farms investments, the capital raise may exceed thousands up to millions. Hence, analysis of data for wind speed is crucial for decision makings. It is essential to evaluate the location of wind farms through data

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acquisitions and analysis, turbine selections, economics and environmental concerns before investing to a wind farm. The archives of data are important to save biological footprints of the location where a station can possibly be located [12]. Weather stations are used as a reference by scientists, experts, and researchers involving renewable and sustainable energy coming from different nations. The estimation of available wind energy in a potential site is necessary by all investors and manufacturers of wind turbines. Acquiring wind data is necessary to decide for feasibility in setting up wind farm. Wind maps can also provide estimation of areas, in which wind energy resources are available. These maps therefore allow researchers, experts, and investors to determine a place for a good source of wind energy.

The present work will give an idea on the viability of the location to construct wind power station in San Jose, Mindoro, Philippines and a possible amount of energy that can be harvested with available wind speeds. The collected data of wind speed and its analysis can also be used for further study in forecasting of wind speed and wind power.

Research methodology

Figure 1 shows the flowchart in conducting the data for analysis of wind speed in San Jose, Mindoro, Philippines. The authors have used the available online weather station [13] to gather wind speed data between the years 2015 up to 2018 in a 3-hr interval. These data were represented graphically to analyze the pattern of wind speed for each year. Using Excel for the data analysis, the authors have determined the mean, standard deviation, variance, among others. In the end, assessment results were interpreted by the authors.

Results and discussion

In this section, the area of concern is situated in San Jose, Mindoro, Philippines. Figures 2 to 5 shows the graphical representation of wind speed data obtained with 3-hr interval from the years 2015 to 2018. The data obtained were evaluated and interpreted in a yearly basis, then performed the statistical analysis and treatment to verify the consistency and variance of data.

Figure 2 shows the wind speed for the year 2015 ranging from 0–11 kph and has an average wind speed of 2.352 kph with a variance of 3.30. The wind speed of 1 kph represents the highest frequency equivalent to 42.27%.

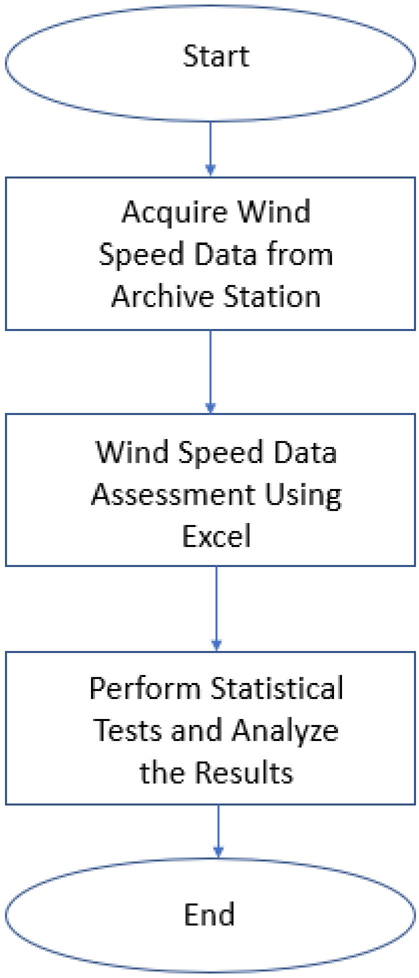

Figure 1. Flowchart in conducting the assessment of wind speed in San Jose, Mindoro

The maximal wind speed of 11 kph occurred during the month of February of 2015. These data were recorded at the interval of 3-hr for a year. Figure 3 presents the wind speed for the year 2016 ranging from 0–11 kph and has an average wind speed of 2.348 kph with variance of 2.904. The wind speed of 1 kph represents the highest frequency equivalent to 37.98%. The maximum wind speed of 10 kph occurred during the last week of January. These data were recorded at the interval of 3-hr for a year. Figure 4 shows the wind speed for the year 2017 ranging from 0–20 kph and has an average wind speed of 2.395 kph with a variance of 2.717. The wind speed of 1 kph represents the highest frequency equivalent to 37.41%. The maximum wind speed of 20 kph occurred during the last week of January. These data were recorded at the interval of 3-hr for a year. Figure 5 illustrates the wind speed for the year 2018 ranging from 0–20 kph and has an average wind speed of 2.426 kph with variance of 2.738. The wind speed of 1 kph represents the highest frequency equivalent to 36.52%. The maximum wind speed of 20 kph occurred during the last week of January. These data were recorded at the interval of 3-hr for a year.

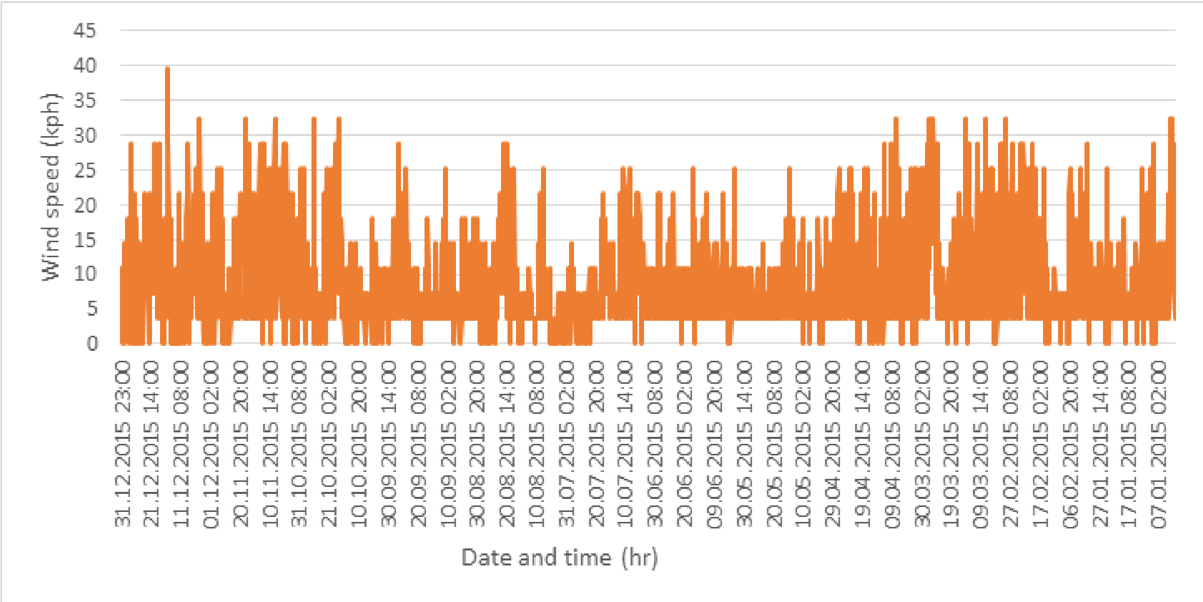

Figure 2. Sampled wind speed for 2015

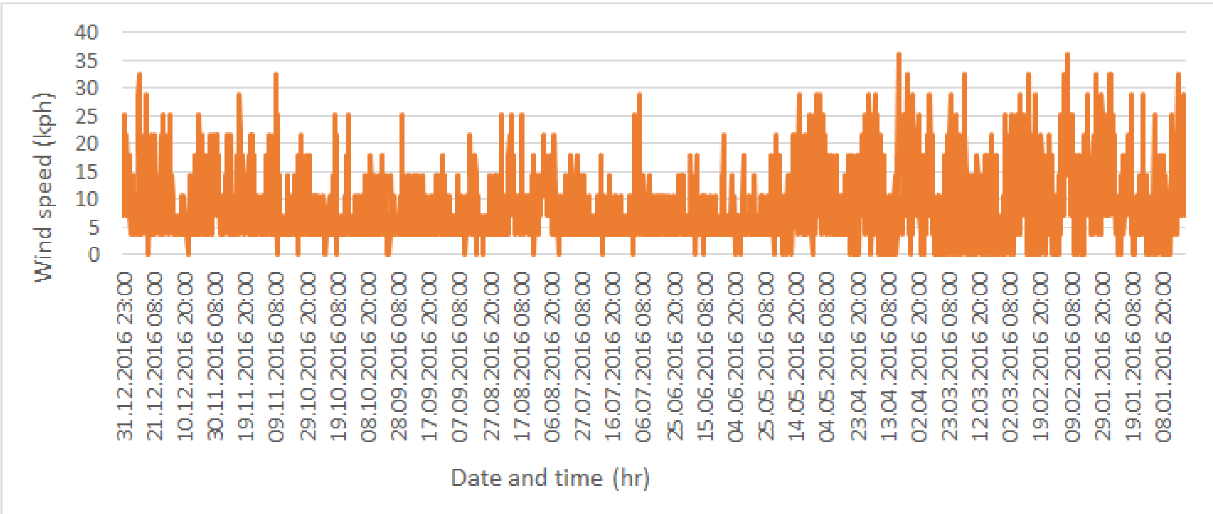

Figure 3. Sampled wind speed for 2016

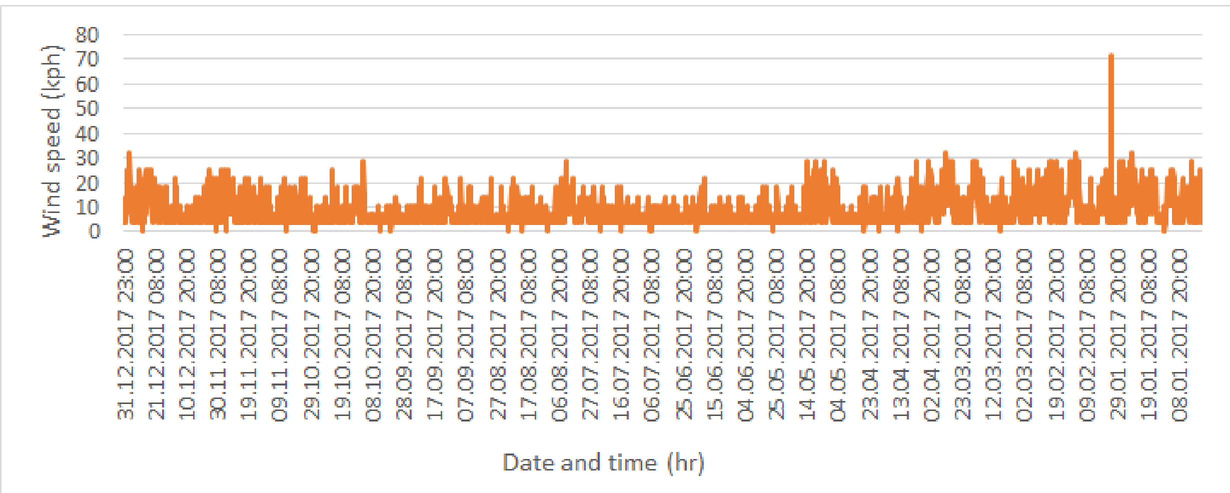

Figure 4. Sampled wind speed for 2017

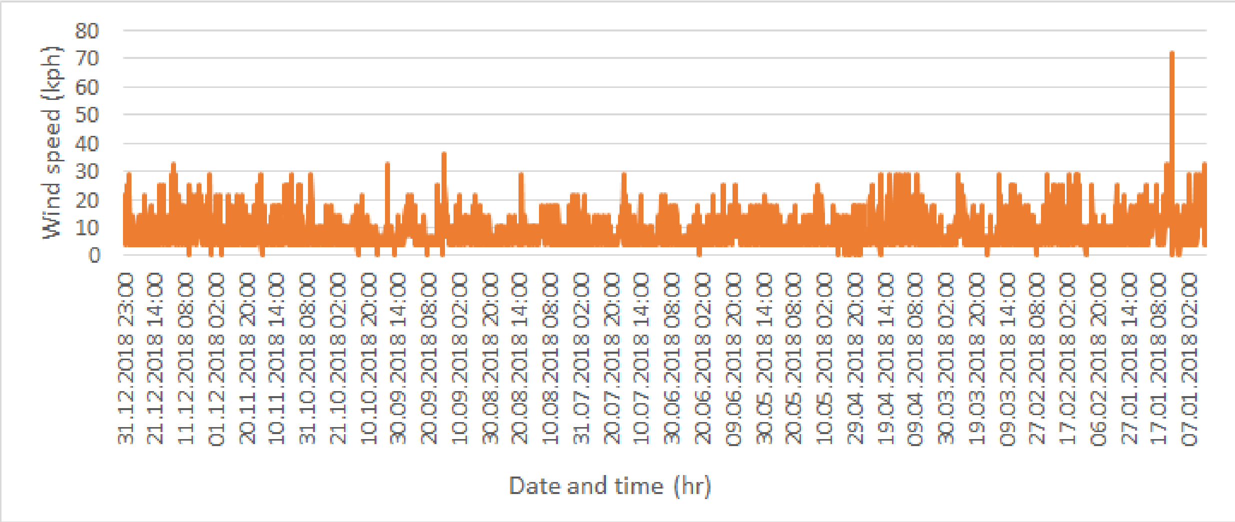

Figure 5. Sampled wind speed for 2018

Table 1 presents the summary of statistical data of wind speed in San Jose, Mindoro, Philippines. The average wind speed from 2015–2018 was ranged from 2.34 kph to 2.43 kph. The minimum wind speed of 0 kph occurred, is when either the device is not recording or under maintenance. The maximum wind speed ranges from 10 kph to 20 kph which occurred during the month of January to February in the 2015–2017 and late December of 2017 under normal weather condition. In the graphical representations of Figures 2–5, the graphs clearly show the rise and fall of readings at which the speed reaches as high as 20 m/s. Changes in the reading of wind speed usually occurred at the first quarter of the year.

Table 2 shows the statistical treatment, which is analysis of variance of wind speed data from 2015–2018.

Table 1. Statistical analysis of wind speed between 2015–2018

	2015	2016	2017	2018
Mean	8.4616	8.4493	8.6133	8.7243
Standard Error	0.1210	0.1135	0.1098	0.1103
Median	7.2	7.2	7.2	7.2
Mode	3.6	3.6	3.6	3.6
Standard Deviation	6.5414	6.1368	5.9369	5.9602
Variance	42.7905	37.6507	35.2472	35.5251
Kurtosis	1.4380	1.5085	5.5821	5.6073
Skewness	1.3170	1.2607	1.6624	1.6528
Range	39.6	36	72	72
Minimum	0	0	0	0
Maximum	39.6	36	72	72
Sum	24699.6	24663.6	25142.4	25466.4
Count	2919	2919	2919	2919
Largest Value	39.6	36	72	72
Smallest Value	0	0	0	0
Confidence Level (95%)	0.2374	0.2227	0.2154	0.2163

Table 2. Wind speed (ANOVA) between 2015–2018

Variation	SS	DF	MS	F-value	p-value
Between Group	151.0845	3	50.3615	1.3321	0.2619
Within Group	441270.4536	11672	37.8058		
Total	441421.5382	11675			

Data were grouped according to the year collected and fed for analysis using Excel. The null hypothesis of the study assumes that all means are equal, and the alternative indicates that at least one of the groups is different. The F-value of the variance is 1.33 with a p-value of 0.26, therefore, the null hypothesis is rejected and the alternative hypothesis is accepted, which means that, there is at least one set of data, that is distinguished from the other sets of data.

Table 3 shows the histogram of the wind speed between the years 2015–2018. It shows the cumulative frequency illustrating the most frequent wind speed in a particular year. Likewise, 60% of the total reading indicates a wind speed of 7.2 kph. In Figure 6, 65.47% of the whole data for the year 2015 is contributed by 0–10 kph, which is only the minimum wind speed rating to operate a wind power station. The ideal wind speed reading of 30–45 kph was only about 0.51% of the total accumulated data for the year 2015. Figure 7 indicates a 65.81%, which is contributed by 0–10 kph of the whole data for the year 2016, which is a minimum wind speed rating to operate a wind power station. Whereas, the ideal wind speed reading of 30–45 kph was observed only around 0.41% of the total accumulated data for the year 2016.

Further, this was also the only year, in this study, that has no reading of a wind speed above 36 kph. Figure 8 indicates a 65.26% of the whole data for the year 2017 is contributed to around 0–10 kph. The ideal wind speed reading of 30–45 kph was only around 0.21% of the total accumulated data for the year 2017. Figure 9 provides a 63.48% of the data for the year 2018, which is contributed by 0–10 kph. The wind speed readings of 30–45 kph was only about 0.24% of the total data for the year 2018.

Table 3. Wind speed (histogram) between 2015–2018

Bin	2015		2016		2017		2018	
	Freq.	% Cumulative	Freq.	% Cumulative	Freq.	% Cumulative	Freq.	% Cumulative
0	162	5.55	155	5.31	25	0.86	26	0.89
5	1073	42.31	955	38.03	1069	37.48	1042	36.59
10	676	65.47	811	65.81	811	65.26	785	63.48
15	629	87.02	643	87.84	674	88.35	727	88.39
20	145	91.98	164	93.46	166	94.04	168	94.14
25	109	95.72	107	97.12	88	97.05	87	97.12
30	110	99.49	72	99.59	80	99.79	77	99.76
35	14	99.97	10	99.93	5	99.97	5	99.93
40	1	100	2	100	0	99.97	1	99.97
45	0	100	0	100	0	99.97	0	99.97
50	0	100	0	100	0	99.97	0	99.97
More	0	100	0	100	1	100	1	100

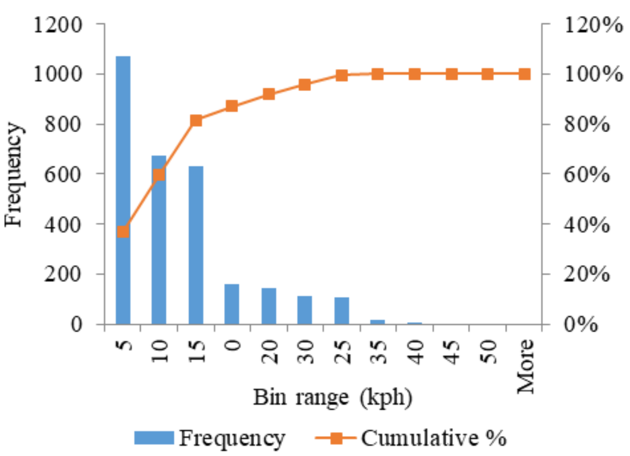

Figure 6. Wind speed histogram for 2015

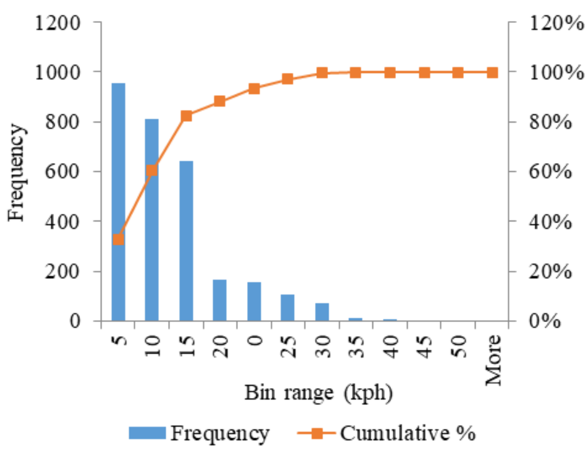

Figure 7. Wind speed histogram for 2016

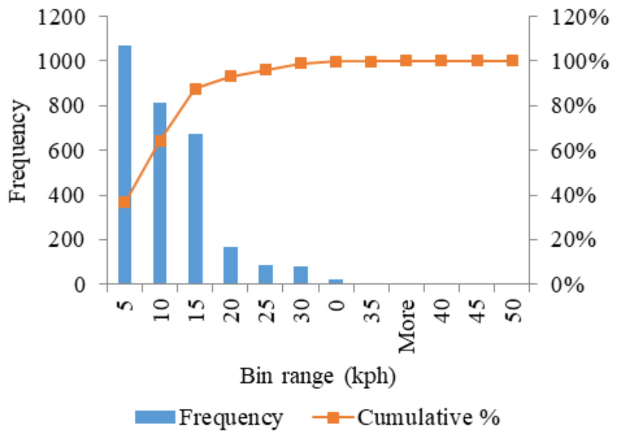

Figure 8. Wind speed histogram for 2017

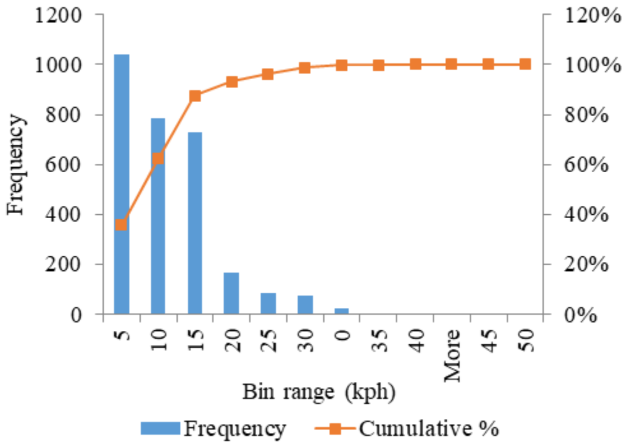

Figure 9. Wind speed histogram for 2018

In line with the results presented, the energy derived from wind can only be utilized at its most efficient record of around 0.21% up to 0.51% for the whole year round. These data were recorded based on a 3-hr everyday interval for the whole year. A very crucial spot for a wind power station is San Jose, Mindoro, Philippines.

This feasibility study of wind power station may possibly face technical and economic crisis. Although at some point, it would be of help, but based on our results, it may contribute only at a small portion of the total electric power generated. Considering the uncertainty of the wind speed and high intermittence in San Jose, Mindoro, Philippines, and based on our assessment results, this may therefore lead to a non-ideal set-up of wind power station due to low wind speed outcomes in the area.

The results in our assessment provides an average wind speed rating of 8–9 kph, and these ratings can start a wind turbine for production of electricity. However, it may not be beneficial for the company, as it may only contribute a small amount of electric power for production. Based on the published literatures [14-16], the most economical wind speed rating for a feasible set-up of a wind farm electric power station should be at least 36 kph. This would provide an effective generation and production of electric power.

Conclusions

In the present work, the authors have conducted a wind speed feasibility study in San Jose, Mindoro, Philippines. The results show that the average wind speed varies from 8.44 to 8.72 kph within the year 2015–2018. The maximal wind speed varies from 36 to 72 kph occurs during the first quarter of the year 2015–2017 under normal weather conditions. At some point of time, the wind speed fluctuates at its highest peak. The histogram shows that, at 60% of the whole year, the wind speed is in minimal value to run a wind power station, which would eventually be producing a minimal amount of generated power capacity. Accordingly, it is possible to harvest wind energy during the first quarter of the year. Based on our assessment, it is not advisable to construct a wind power farm for power generation in the area.

Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper. Any findings, recommendations, opinions, or conclusions expressed in this research article are those of the authors only. It does not necessarily reflect the view of the authorities from San Jose, Mindoro, Philippines, third party agencies, among others.

References

[1] Kaewongkol P. Measures of ASEAN on the promotion of circulation energy: A case study of solar energy. Thesis, Mae Fah Lauang University, 2017.

[2] Qiao P, Wang P, Tao T, Shrestha GB. Maximizing profit of a wind genco considering geographical diversity of wind farms. IEEE Transactions on Power Systems 2015;30(5):2207-15.

[3] Kroposki B, Johnson B, Zhang Y, Gevorgian V, Denholm P, Hodge B, Hannegan B. Achieving 100% renewable grid: operating electric power systems with extremely high levels of variable

renewable energy. IEEE Power and Energy Magazine 2017;15(2):62.

[4] Beltran Jr. AA. Standalone Solar PV Maximum Power Point Tracking Using Interval Type–2 Fuzzy Logic. IEEE Eurasia Conference on IOT, Communication and Engineering 2019;534 -537.

[5] Beltran Jr. A, Lontoc Z, Conde B, Serfa Juan R, Dizon JR, World Congress on Engineering and Technology; Innovation and Its Sustainability 2018, Springer, Switzerland; 2019.

[6] Beltran Jr. AA, Tolentino RE, Javier NC, Haihang Z. MCU–based Robotic Elbow Movement Control. International Journal of Scientific Engineering and Technology 2015;4(8):438-42.

[7] Beltran Jr. AA, Caluyo FS. Design and Implementation of Fuzzy Logic Controlled Uninterruptible Power Supply Integrating Renewable Solar Energy. International Journal of Engineering Research 2014; 3(3): 162–166.

[8] Hong YY, Buay PMP, Beltran Jr. AA. Maximum Power Point Tracking of Photovoltaic System Using Taguchi-based Fuzzy Logic Control. IEEE Milan Power Tech Conference 2019; Milan, Italy;1-6.

[9] Slootweg JG, Kling WL. Is the Answer Blowing in the Wind. IEEE Power and Energy Magazine 2003;1(6):26-33.

[10] Zhang Y, Ula S. Wind Data Acquisition and Analysis for a Large Wind Farm in Wyoming. IEEE 39TH North American Power Symposium 2007; Las Cruces, NM, USA.

[11] Das SR. The Answer is Blowing in the Wind. IEEE Spectrum 2005;42(9):20.

[12] Amador MAZ, Lina MAC, Aquino AG, Gutteres FA, Ganggangan AU, Beltran Jr. AA. Design and Implementation of Power Management System Utilizing Supercapacitors for Hybrid Vehicles. International Journal of Scientific Engineering and Technology 2015;3(8):1074-7.

[13] Wind Speed Meteorological Data. [Online]. Available: http://rp5.ru/archive.php

[14] Pappas SS. Adaptive Forecasting Techniques Applied to Short Time Wind Speed Forecasting. IEEE International Conference on Control, Artificial Intelligence, Robotics and Optimization 2019; Athens, Greece; 121-128.

[15] Alhaddad FM, Aly HH, El-Hawary ME. An Overview of Wind-Solar System Output Power. IEEE Canadian Conference of Electrical and Computer Engineering 2019; Edmonton, Canada; 1-6.

[16] Salah MM, Abo-khalil AG, Praveen RP. Wind Speed Characteristics and Energy Potential for Selected Sites in Saudi Arabia. Journal of King Saud University – Engineering Sciences 2019. https://doi.org/10.1016/j.jksues.2019.12.006.

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