Performance Evaluation of some selected Mediums Wind Energy Conversion system for Wind Power Generation at Anyigba, Nigeria

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Abstract
Energy is a crucial component to every nation's economic and social growth. Mitigation of global energy demands and climate change are essential factors for renewable energy supplies in recent times. This paper presents the Performance Evaluation of some selected Mediums Wind Energy Conversion System for Wind Power Generation at Anyigba, Nigeria. Wind speed data for this work was collected at 4m height from the Campbell Scientific Automated Weather Station under the Tropospheric Data Acquisition Network (TRODAN). The data is at an interval of five (5) minutes update cycle for sixty months. The wind speed data height was then interpolated to 20m using a power-law relationship. Three selected Wind Energy Conversation System (WECS), were used for the wind power evaluation. The result indicated the Wind Energy Conversion System-30 (WES-30) as suitable for Anyigba. 4.961m/s was the highest wind speed obtained in February 2016 while 1.135m/s was the lowest wind speed in November 2015. This might be linked to the dry season and the rainy season for the high and low wind speeds. Using the Weibull model, the average scale parameter and shape parameter value are 0.88 in November and 6.31 m/s in January of the entire months

Keywords
Wind Energy, TRODAN, Renewable Energy

1. Introduction
With the rapid growth of the economy and modern civilization, energy demand has risen exponentially across the globe(Verma et al., 2016)(Salim et al., 2019). Factors that threaten global climate change as a result of environmental problems related to over-reliance on the generation of energy from traditional fossil fuels (Benaaouinate et al., 2020),(Ighravwe et al., 2018),(Saleh, et al). For such reasons, several scientists are being motivated to search for alternative clean, renewable energy sources with energy efficiency and economic advantages. Wind power is highly preferred as an alternative to conventional energy sources as a remedy of long-term environmental degradation. (Benaaouinate et al., 2020),(Pachauri & Chauhan, 2012). Wind energy has been used in boats, maize grinding, agriculture as well as many other sectors as an eco - friendly energy resource. In addition, wind technology is being used to balance energy needs, which will be a key concern for the future. (Mahersi et al., 2013). Global installed wind capacity rose from 100GW in 2008 to 542GW in 2018. It is also estimated that this figure will hit 1787GW by 2030.(Aldaoudeyeh et al., 2020).

wind power investigation by (Wang et al., 2018) the employing data on wind speed for the development and application of wind power. The results suggest that the evaluation of the output of wind turbine generators is important for applications like wind farm location. (Ishaq., et al), Shows that the probability density function of the wind power is the Weibull function pulse at both ends when the wind speed approaches the two-parameter Weibull distribution and the characteristic of the wind turbine matches the cubic function. (Islam., et al), Shows that the voltage profile of the wind farm is improved after analysing the wind speed data using Weibull distribution at Oromia, Ethiopia. The wind data used was collected for the month of January 2017.

Researcher such as (Yahaya et al., 2020) Evaluated five years of wind speed in Kebbi State University of Science and Technology Aliero, Nigeria. The findings indicate the lowest and highest average wind speed in October as 1.20 m/s and 2.81 m /s in January. They also concluded that the maximum power density was in January and December as 0.8295 W/m^2 and 8635 W/m^2 respectively. (Adaramola & Oyewola, 2011), Wind power has three key reasons as an attractive potential to produce electricity from renewable energy sources: first, growing public awareness of carbon dioxide emissions, climate change and other environmental concerns related to other competing energy sources. Second, knowledge of the decline of oil and gas reserves and the anticipated global peak in oil production. Third, the fast expansion of wind power is the growth of wind turbine technology that has contributed to cheaper prices. Their argument is also consistent with reference (Ahmed, 2011),(E. K. Akpinar & Akpinar, 2004).

This paper presents the Performance Evaluation of some selected Small to Medium Wind Energy Conversion System for Wind Power Generation in Anyigba, Nigeria using a Weibull distribution function.

2 Material and Method

This paper discusses the Performance Evaluation of some selected Small to Medium Wind Energy Conversion System for Wind Power Generation in Anyigba, Kogi State, Nigeria. The data used in this study was obtained from an automatic weather station situated at Prince Audu Abubakar University campus, Anyigba, Kogi State, on (latitude 7.48583ºN and longitude 4.497.183622ºE). The data is for sixty months from January 2015 to December 2019. Wind speed is the parameter used to conduct the evaluation. The monthly and annual mean values for the parameter were determined using the statistical model.

The weather station used for this research is a fully solar-powered automated configured station. The facility consists of a highly durable enclosure containing a high precision Campbell scientific data logger, a 12 V battery Source, a charge controller and a barometric pressure sensor. This station is equipped with a standardized set of sensors that record: air temperature, relative humidity, solar irradiance, wind speed and direction, soil temperature and humidity, etc.

Table 1 present the selected small to a medium wind turbine with their characteristics for this study. From the table, E-3210 has a rated power of 55 KW, the hub height of 12 m, a rotor diameter of 19.2 m, a cut-in wind speed of 3.5 m/s, and a rated wind speed of 11 m/s while the cut-out wind speed is 25 m/s. NARDTANK has a rated power of 150 KW, the hub height of 14.5 m, a rotor diameter of 10 m, a cut-in wind speed of 4 m/s, and a rated wind speed of 12 m/s and the cut out wind speed is 25 m/s. WES30 has a rated power of 250 KW, the hub height of 36 m, a rotor diameter of 30 m, a cut-in wind speed of 2.7 m/s, and a rated wind speed of 12.5 m/s with same the cut-out wind speed as the previous one. These fall within the wind potential of Anyigba.

Table 1: Characteristics of the Selected Wind Turbine

Turbines	**E-3120**	**NARDTANK**	**WES30**
Rated power (kW)	55	150	250
Hub height (m)	12.5	14.5	36
Rotor diameter (m)	19.2	10	30
Cut-in wind speed (m/s)	3.5	4	2.7
Rated wind speed (m/s)	11	12	12.5
Cut-out wind speed (m/s)	25	25	25

2.1 Data Collection

This analysis is based on data source observed at a height of 4 m and then interpolated to 20 m using the power law relationship shown in the equation. (1) (Ishaq & Dincer, 2020),(Kodicherla, 2018). Data has been collected between 2015 and 2019 using the areophane anemometer of the TRODAN Meteorological Station of the Center for Atmospheric Research Anyigba. For applications that involve wind turbines, the wind speed at the height of the hub is of importance and, as a result, the wind speed is tuned to the height of the hub of the wind turbine using the following power law interpretation.

$$\frac{u}{u_o} = \left(\frac{H}{H_O}\right)^{\alpha} \qquad (1)$$

Where, u is the wind speed at the targeted maximum height H, $u_o$is wind speed at the initial height H_O and α is the surface roughness coefficient and is to be 0.143 (1/7) in this research.

2.2 Weibull Distribution Parameter

The understanding of the distribution of wind speed is a very important factor in determining the potential for wind speed in a given region. In the analysis of wind speed, a number of main parameters are required to explain the behaviour and pattern of a wide range of wind speed data. The best and most powerful method of analysis is to use the Weibull Distribution that is a two-parameter distribution as seen in the equations. (2) and (3) (Das & Akella, 2018),(Zhou et al., 2006),(Islam et al., 2014).

$$f_w(v) = \left(\frac{k}{c}\right)\left(\frac{v}{C}\right)^{k-1} \exp\left[-\left(\frac{v}{c}\right)\right]^k \qquad (2)$$

$$F_W(v) = 1 - \exp\left[-\left(\frac{v}{c}\right)^k\right] \qquad (3)$$

Where, $f_w(v) =$ is the probability density function of the Weibull
k is shape factor, c is scale factor, andv is the mean wind speed
For the estimation of the Weibull parameters (c and k), equation (4) and (5) can be used;

$$k = \left[\frac{\sigma}{v_m}\right]^{-1.08} \qquad (4)$$

$$\frac{c}{v} = (0.568 + 0.433/k)^{1/k} \qquad (5)$$

Where, σ = standard diviation

An easy way to comply with the requirements stated in the Author Guide (Adaramola, & Oyewola, 2011) is to use this document as a template and simply type your text into it. PDF files are also accepted, so long as they follow the same style.

2.3 Wind power Density

Determination of the wind power density is of primary importance in evaluating the wind power of the area A at wind speed v through the blade sweep area as the cube of its velocity increases, which is expressed in the equation. (6) (A. Akpinar, 2013).

$$P_v = \frac{1}{2}\rho AV^3 \qquad (6)$$

Where, Γ is the gamma function and c is the Weibull scale parameter. Where, ρ (kg/m^2) is the mean air density. 1.293kg/m^2 is used for this work.
The monthly or annual wind density per unit area of the site, based on the Weibull probability density function, could well be defined as (Ohunakin et al., 2011).

$$P_v = \frac{1}{2}\rho c^3\Gamma[1 + 3/k] \qquad (7)$$

2.4 Instrumentation

Campbell Automatic Weather Station installed at Prince Audu Abubakar University Campus, Anyigba at the 7.48583N, 7.18362E coordinate, was used to collect the wind speed parameter. The collected data was for the period of sixty-month (2015-2019). The weather station shown in Fig. 1 is from the network of automated weather stations in Nigeria.

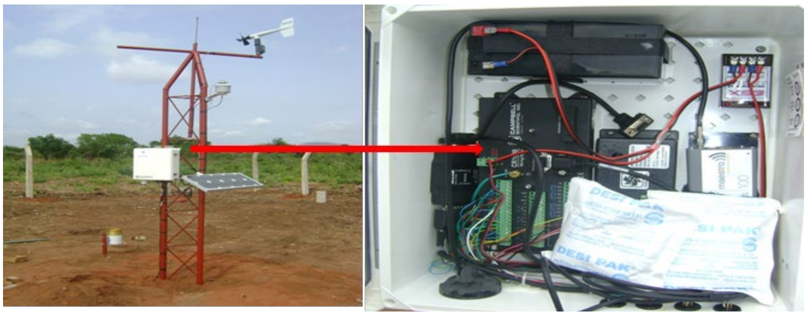

Figure 1. Campbell Scientific Automatic Weather Station situated at Prince Audu Abubakar University Anyigba

Meteorological wind speed parameters are measured in-situ. The data has been collected since (January 2015-December 2019). Records cover up to five minutes of cycle for 24 hours a day. Wind speed is measured in m/s. This is done by averaging the five-minute interval data in hourly values, even in daily values and finally in monthly values for each year. Small to medium-sized commercial wind turbine were used for the power density evaluation

2.5 Medium Commercial Wind Turbine (WES)

Wind Energy System converts wind kinetic energy into electrical or mechanical energy that can be harnessed for practical use to transforms the economy of rural areas (Kashiwaya et al., 2020). Medium-sized wind turbines can be used for a variety of purposes, such as telecommunications towers, rural schools, on-and off-grid home, offshore platforms, farms and hospitals, remote control and other purposes requiring electricity in which there is no electrical grid or where the grid is unreliable. Small wind turbines may be as low as a 50 W generator.(Systems, 2005)

3. Results and Discussions

The results of this analysis are summarised in the Fig. 2, 3, 4, 5, 6, 7, and table 1. From the Fig. 2 the minimum wind speed was around 1.135 m/s in November 2015, whereas the maximum wind speed was around 4.961 m/s in January 2016. In 2015, the average wind speed ranges between 1,135 m/s and 4,830 m/s. The wind speed in the year 2016 lies between 1.192m/s and 4.961m/s. The maximum wind speed occurs in January, 2016 under the years observed. The wind speed varies between 1.241m/s to 4.820m/s in 2017 while year 2018 lies between 1.238m/s and 4.683m/s. The result shows that the maximum average wind speed is reached during the dry season. This may be due to the fact that the dry season is windier than the rainy(Yahaya et al., 2020) while The unexpected drop in wind speed may be due to a reduction in driving power as well as a rise in drag force (Wu et al., 2018).

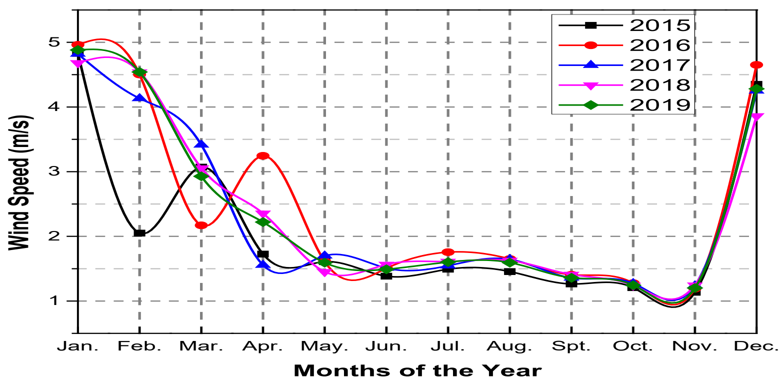

Figure 2. Variation of the Monthly Wind Speed (2015-2019)

Fig. 3 shows the overall monthly average wind speed variation in all the years considered which indicates the lowest wind speed was in November (1.135m/s) while the highest was in January (4.961m/s) respectively.

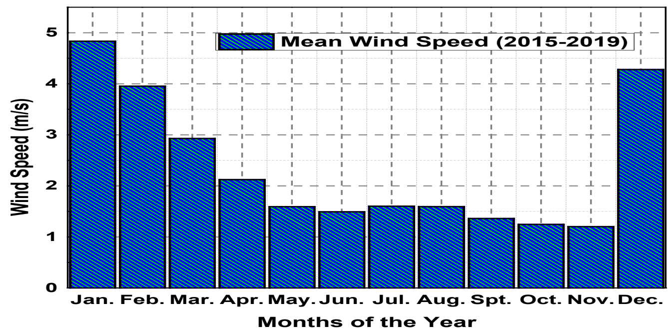

Figure 3. Monthly Average Wind Speed Variation for (2015-2019)

Table 2 presents the monthly and annual variations of Weibull Parameter C (m/s) and K of Anyigba at the predicted height of 20m. As can be seen on the table 1, with minimum monthly value of Weibull shape parameter (K) was observed in November, 2017 (0.88) while the maximum value was computed in January, 2015 (6.68). This indicates that the wind speed has been consistent during dry season of all the year considered while less during the wet season with less wind potentials. The variation of scale parameter (C m/s) is between 0.83 for the month of July, 2015 and 5.66 for the month of January, 2015.

Table 2. Monthly Shape Parameter, K, and Scale Parameter, C, in Anyigba, North Central Nigeria (2015-2019)

Month	**2015**		**2016**		**2017**		**2018**		**2019**	
	K	**C**	**K**	**C**	**K**	**C**	**K**	**C**	**K**	**C**
Jan.	6.68	5.45	6.54	5.32	5.15	5.44	7.87	5.82	6.31	5.37
Feb.	5.05	5.66	6.82	5.00	6.67	4.66	3.82	5.08	4.84	5.10
Mar.	3.76	4.38	1.31	1.22	3.61	4.44	3.77	4.34	3.11	3.60
Apr.	1.66	1.22	3.16	2.94	1.43	1.12	2.74	3.01	2.25	2.07
May.	1.34	1.17	1.27	1.19	1.96	1.42	3.34	4.34	1.98	1.78
Jun.	1.53	0.90	1.52	1.08	1.21	1.00	1.46	1.21	1.43	1.05
Jul.	1.40	0.83	1.46	1.25	1.57	1.14	1.28	1.19	1.43	1.10
Aug.	1.25	1.08	1.49	1.18	1.58	1.21	1.80	1.18	1.53	1.16
Sept.	1.15	0.96	1.22	1.05	1.37	1.21	1.26	1.09	1.25	1.08
Oct.	1.54	0.86	1.38	0.93	1.37	0.99	1.16	0.97	1.36	0.94
Nov.	1.08	0.88	1.84	0.84	1.12	0.87	1.38	0.93	1.36	0.88
Dec.	5.26	4.91	3.99	5.13	4.87	4.80	5.31	4.36	6.12	4.80
Ave.	3.06	2.29	2.67	1.70	2.7	2.4	2.9	2.79	2.63	2.41

Fig. 4: shows the variation of the power density using E-3120 Turbine. In 2015 it was observed that the lowest power density was computed for the month of November (273.63 W/m^2) while the highest was in January (21093.98 W/m^2), in 2016 the lowest was in November (317.15 W/m^2) and the highest was in January (22857.29 W/m^2), in 2017 it maintained the same pattern with the lowest value been obtained in November (354.95 W/m^2) while the highest was in January (20963.23 W/m^2), and in 2018 the lowest and the highest values was computed in October and January as (357.58 W/m^2), (19213.72 W/m^2), in 2019 the highest was recorded in January as (21032 W/m^2)while the lowest in November (327.66 W/m^2) respectively. From the above it can be deduced that it maintain the same trends and pattern of variation

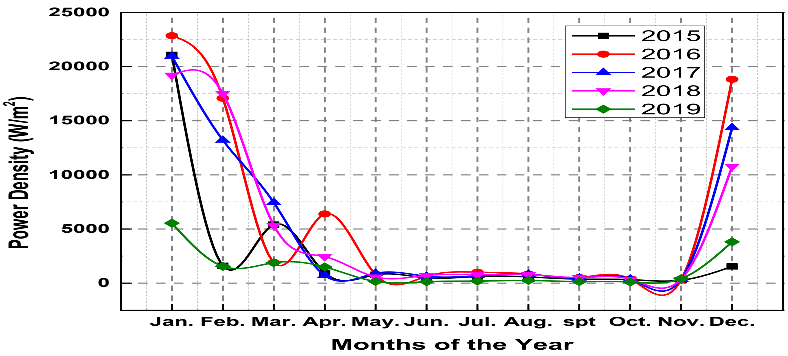

Figure 4. Variations of the Monthly Mean power densities for (2015-2019) Using E-3120 Turbine

Fig. 5: shows the variation of the power density using NORDTANK Turbine, with the lowest power density been computed in 2015 for the month of November and the highest for January as (74.24 W/m^2) and (5722.11 W/m^2) respectively, in 2016 the lowest was in November as (86.03 W/m^2) and (6200.44 W/m^2) in January, in 2017 the results is as (96.03 W/m^2) been the lowest while (5686.64 W/m^2) been the highest and in 2018 the lowest value was in October as (97.00 W/m^2) and (5212.85 W/m^2) as the highest also in 2019 the highest was in January as (57347.79 W/m^2) and the lowest as (88.88 W/m^2), respectively

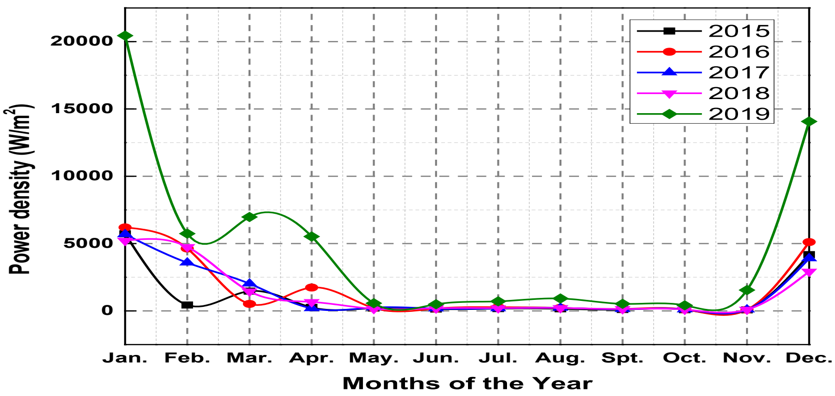

Figure 5. Variations of the Monthly Mean power densities for (2015-2019) Using NORDTANK Turbine

Fig. 6: shows the variation of the power density using WES-30 Turbine. In 2015 the lowest value was computed for the month of November as (668.04 W/m^2) and (51498.80 W/m^2) as the highest, in 2016 the result obtained the lowest value for the month of November as (774.28 W/m^2) and (55803.95 W/m^2) as the highest also in 2017 it was observed as (886.58 W/m^2) been the lowest while (51179.77 W/m^2) been the highest while in 2018 the lowest value was in October as (872.99 W/m^2) and (46908.49 W/m^2) as the highest, in 2019 the highest was (57347.79W/m^2) and the lowest as (799.94 W/m^2), From the discussion above it can be clearly seen that the maximum and minimum wind speeds falls in the dry and wet season respectively

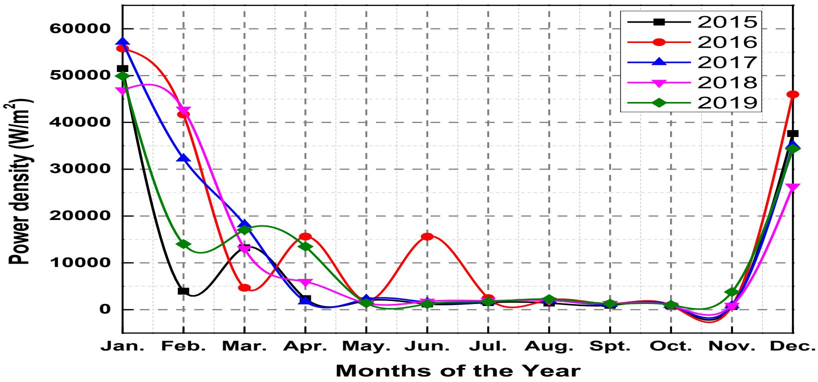

Figure 6. Variations of the Monthly Mean power densities for (2015-2019) Using WES30 Turbine

Fig 7: shows the overall variation of the power density for all the years considered using all the three medium wind Turbine (E-3120, NORDTANK and WES-30) with rated power (T) of 55 kW, 150 kW and 250 kW respectively. It can be observed that the WES-30 conversion system is the best appropriate Turbine for Anyigba with the average power as 55808.95 W/m^2.

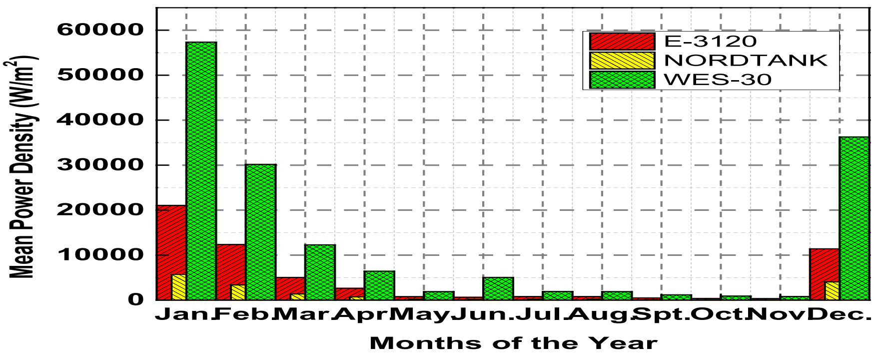

Figure 7. Variations of the Monthly Mean power densities of year (2015-2019) using all the WECS

Power density is a valuable way of determining the available wind resource at a potential site, since it shows how much energy is available at the site for wind turbine conversion i.e. the higher the wind speed, the higher the energy to be produced (Wu et al., 2018).

4. Conclusion

In-situ measurements of wind speed, in Anyigba have been achieved for the purpose of evaluating it for electricity generation and the following conclusions are drawn.

Wind energy is the fastest growing technology and energy resources in the world, and it can be reusable. There have been a rapid development on this technology, this is due to its cleanness and reusability. Wind energy is an alternative renewable source of energy compared to all other sources of energy derived from fossil fuels that pollute the lower parts of the atmosphere. While concerns such as environmental pollution and energy supply requirements are growing, it is important to make use of a pollution-free energy like wind. Also the wind turbines can be used to convert the wind energy to more commonly used electric energy. Wind speed is the most critical parameter of the power that was generated from wind turbines.

The wind Energy potential in Anyigba was evaluated using Weibull statistical model and performance of some selected mediums commercial wind turbine were assessed, it was found out that monthly mean power density of the WES-30 turbine produced the appreciable power output for the chosen location

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6. References

Adaramola, M. S., & Oyewola, O. M. Evaluating the performance of wind turbines in selected locations in Oyo state, Nigeria. *Renewable Energy*, *36*(12), 3297–3304, 2011. https://doi.org/10.1016/j.renene.2011.04.029

Ahmed, A. S. Investigation of wind characteristics and wind energy potential at Ras Ghareb, Egypt. *Renewable and Sustainable Energy Reviews*, *15*(6), 2750–2755 2011. https://doi.org/10.1016/j.rser.2011.04.003

Akpinar, A. Evaluation of wind energy potentiality at coastal locations along the north eastern coasts of Turkey. *Energy*, *50*(1), 395–405, 2013. https://doi.org/10.1016/j.energy.2012.11.019

Akpinar, E. K., & Akpinar, S. (2004). Determination of the wind energy potential for Maden-Elazig, Turkey. *Energy Conversion and Management*, *45*(18–19), 2901–2914. https://doi.org/10.1016/j.enconman.2003.12.016

Aldaoudeyeh, A. I., Alzaareer, K., & Carlo, M. *Evaluating the Accuracy of Wind Turbine Power- Speed Characteristics Fits for the Generator Control Region*. *10*(2), 2020.

Benaaouinate, L., Khafallah, M., Voyer, D., Mesbahi, A., & Bouragba, T. Nonlinear control based on fuzzy logic for a wind energy conversion system connected to the grid. *International Journal of Renewable Energy Research*, *10*(1), 193–204, 2020.

Das, S., & Akella, A. K. Power flow control of PV-wind-battery Hybrid Renewable Energy Systems for stand-alone application. *International Journal of Renewable Energy Research*, *8*(1), 36–43, 2018.

Ighravwe, D. E., Babatunde, O. M., Adedoja, O. S., & Okharedia, T. E. Evaluation and selection of hybrid renewable energy systems for healthcare centres in rural areas: A techno-economic approach. *IEEE International Conference on Adaptive Science and Technology, ICAST*, *2018-Augus*, 1–7, 2018. https://doi.org/10.1109/ICASTECH.2018.8506971

Ishaq, H., & Dincer, I. Evaluation of a wind energy based system for co-generation of hydrogen and methanol production. *International Journal of Hydrogen Energy*, *45*(32), 15869–15877, 2020. https://doi.org/10.1016/j.ijhydene.2020.01.037

Islam, A., Islam, M. S., & Islam, M. Z. Monthly and seasonal assessment of wind energy potential in coastal area of Bangladesh. *Proceedings of 2014 3rd International Conference on the Developments in Renewable Energy Technology, ICDRET 2014*, *Fy,* 2014. https://doi.org/10.1109/icdret.2014.6861733

Kashiwaya, K., Kondoh, J., & Funabashi, K. (2020). Total output power variation of several small wind turbines. *Wind Engineering*. https://doi.org/10.1177/0309524X20907987

Kodicherla, S. P. K. Assessing wind energy potential for electricity generation using WECS in eight selected stations of Ethiopia. *International Journal of Ambient Energy*, *39*(5), 477–487, 2018. https://doi.org/10.1080/01430750.2017.1319415

Mahersi, E., Khedher, A., & Mimouni, M. F. The wind energy conversion system using pmsg controlled by vector control and smc strategies. *International Journal of Renewable Energy Research*, *3*(1), 41–50, 2013 https://doi.org/10.20508/ijrer.09625

Ohunakin, O. S., Adaramola, M. S., & Oyewola, O. M. Wind energy evaluation for electricity generation using WECS in seven selected locations in Nigeria. *Applied Energy*, *88*(9), 3197–3206, 2011. https://doi.org/10.1016/j.apenergy.2011.03.022

Pachauri, R. K., & Chauhan, Y. K. Assessment of wind energy technology potential in Indian context. *International Journal of Renewable Energy Research*, *2*(4), 773–780, 2012. https://doi.org/10.20508/ijrer.02684

Saleh, U. A., Haruna, Y. S., Gwaram, U. A. and Abu, U. A. Evaluation of Solar Energy Potentials for Optimized Electricity Generation at Anyigba , North Central Nigeria. *Global Scientific Journals*, *6*(2), 263–270, 2018. https://www.worldenergy.org/wp-content/uploads/2016/10/World-Energy-Resources_SummaryReport_2016.10.03.pdf

Salim, O. M., Dorrah, H. T., & Hassan, M. A. Wind speed estimation based on a novel multivariate Weibull distribution. *IET Renewable Power Generation*, *13*(15), 2762–2773, 2019. https://doi.org/10.1049/iet-

rpg.2019.0313
Systems, E. (2005). *Wes18 Complete Description*.
Verma, V., Kane, A., & Singh, B. Complementary performance enhancement of PV energy system through thermoelectric generation. *Renewable and Sustainable Energy Reviews*, *58*, 1017–1026, 2016. https://doi.org/10.1016/j.rser.2015.12.212
Wang, S., Ji, X., Cheng, Y., Wang, Y., Teng, W., Yu, P., & Sun, S. Evaluation of wind power generation considering wind turbine's characteristic. *IET Conference Publications*, *2018*(CP757), 2–7, 2018 https://doi.org/10.1049/cp.2018.1827
Wu, J., Zha, J., Zhao, D., & Yang, Q. Changes in terrestrial near-surface wind speed and their possible causes: an overview. In *Climate Dynamics* (Vol. 51, Issues 5–6). Springer Berlin Heidelberg. 2018. https://doi.org/10.1007/s00382-017-3997-y
Yahaya, A. A., Bello, I. M., Mudassir, N., Mohammed, I., & Mukhtar, M. I. Evaluation of Wind Potential for the Generation of Electricity in Aliero, Kebbi State. *Asian Journal of Research and Reviews in Physics*, *3*(1), 1–7, 2020. https://doi.org/10.9734/ajr2p/2020/v3i130110
Zhou, W., Yang, H., & Fang, Z. Wind power potential and characteristic analysis of the Pearl River Delta region, China. *Renewable Energy*, *31*(6), 739–753, 2006. https://doi.org/10.1016/j.renene.2005.05.006

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