Sarcouncil Journal of Engineering and Computer Sciences

ISSN(Online): 2945-3585

Volume- 01| Issue- 07| 2022

Research Article | Received: 01-09-2022 | Accepted: 20-09-2022 | Published: 29-09-2022

Assessment of Wind Power Potential at Kano State Nigeria for Efficient Energy Utilization

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Abstract: Kano state in Nigeria suffers from conventional energy shortage which attributed to the geographical nature of the region. Therefore, exploring the other alternative sources of energy such as wind energy with a view to evaluating their potentials for efficient energy utilization could help alleviate the power problems the region is facing. A new concept of energy efficiency index (*EEI*) is introduced to help and guide policy makers in making decision on both the energy and climate change issues. The wind is highly variable both geographically and temporally in Kano, North-Western Region of Nigeria. The study analyses the wind speeds data obtained from Nigerian Meteorological Agency (NIMET) Abuja for 20years (2000-2020) using Weibull distribution function.

Keywords: Energy utilization, Mean wind speeds, Wind power, Renewable energy.

INTRODUCTION

Renewable energy resources and technologies provides a platforms in which sustainable economic development and environmental protection goals are achieved. Increasing interest in renewable energy resources arises due to growing of energy demand and energy prices. Fossil fuel energy resources' impact on environment due to CO_2 emission has also triggered this interest as renewable energy resources which are inexhaustible, and most importantly environmentally friendly. Global cumulative installed wind capacity has increased from 6,100 *MW* in 1996 to 282,430 *MW* in 2012 [Shehu, G.S. *et al*., 2017; Dursun, B. *et al*., 2012]. In addition, wind power's share in worldwide renewable electric capacity has increased from 2% to approximately 20% in the last decade [Okeniyi, J.O. *et al*., 2013; US Department of Energy, 2012].

Nigeria has vast conventional and renewable energy resources sufficient enough to meet the entire country's electricity need, but electricity consumption rate per capita is one of the lowest in Africa because of underutilization of the resources and low generation capacity [Shaaban, M. *et al*., 2013]. The first installed electricity capacity in Nigeria was designed from 30 *MW* generation capacity in the year 1956 to 4000 *MW* in 2015. They are thermal and hydro power generation stations. Currently the estimated demand stands at 20,000 *MW* including losses in the entire network which is estimated to be at 38% [Unachukwu, G.O, 2010; Akuru, U.B. *et al*., 2010]. Kano, one of the most populous states in the country and a commercial hub, is located in the northern region of the country, based on the 2006 census results, had a population totalling 9,383,682 and by 2011 the population was estimated to reach 11,058,300. Approximately 30% of the total population live within Kano Metropolis and 70% live in the rural areas. With population growth and technological development, alternative energy sources must be exploited, because the fossil fuels which serve as primary sources are rapidly running out [Kose, F. *et al*., 2014]. It is no doubt the state is one of the important industrial and commercial canters in Nigeria [Ibrahim, A.K, 2003], electricity supply problems in the state, due to low generation capacity and high demand, has led to shutting down of a large companies. For instance, the textile industry in Kano state, the number of fully operational textile companies has fallen from thirty-one to three in the last two decades due to energy shortage. There are several reasons for the continuous decline of the textile industries one of the notable ones is lack of raw materials to support the local textile companies, but more than half of the problems are due to inadequate power supply [CRD, 2012]. Hence energy is a major challenge for other industries in Kano as well.

In May 2015, the estimated electricity consumption of Kano as stated by Kano Electricity Distribution Company (KEDCO), the distribution system operators, in order to ensure 8 hours per day of electricity power supply of between 270 *MW* to 300 *MW* is needed daily, however, the state received only between 10 *MW* to 40 *MW* from the generation company (GENCO). GENCO is part of a private generation company after the

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DOI- https://doi.org/ 10.5281/zenodo.7294904

privatization of power sector in the country, it generates about 2 *MW* of power which in no way will meet the needs of critical loads. In this present state of inadequate energy, the search for alternative energy sources becomes imperative in order to compensate for the short falls of energy demand. There a lot of abandoned wind energy project across the country as reported in [Amoo, O.M, 2012; Ohunakin, O.S. *et al*., 2011], but there is has never been one in Kano. Therefore this could be one of the potential solutions to energy needs. There is need for extensive and comprehensive analyses that will lay the foundation for the establishment of wind energy project in Kano. The state has no wind power project currently due to lack of research that could reveal its potentials and benefits. There is ongoing 10 *MW* and 25 *MW* hydro power electricity plant projects in Tiga and Challawa respectively to boost electricity capacity.

Several researches on potentials of wind power in Nigeria and Kano were conducted by many researchers with different objectives and approaches, such as wind potential, wind speed capacity and techno economic aspect, but none of the researchers included energy efficiency index (*EEI*) formulation. Olaleye studied wind power prospective of two south western sites in Nigeria, Abeokuta and Ijebu-Ode [Amoo, O.M, 2012]. The study inspected data of twenty years (1990–2010) of monthly mean wind data at 10 m height subjected to two-parameter Weibull analysis. The paper ranks Ijebu-Ode to have more wind energy prospect than Abeokuta. Ohunakin in 2011, used wind energy conversion system (WECS) to equate wind energy availability of seven different sites in North-Western region of Nigeria including Kano [Ohunakin, O.S. *et al*., 2011]. The authors applied statistical examination of 36 years (1971-2007) of wind speed data captured at 10 *m* height. The analysis was conducted using 2-parameter Weibull analysis. The study concluded that Kano with annual average power density of 368.95 W/m^2 falls under Class 6 according to wind power density class and is considered very appropriate for wind power plant applications**.** The paper fails to evaluate seasonal changes of wind speed and does not provide study of most probable wind speeds (V_{mp}) and wind speeds with the maximum energy (V_{maxE}). In another study, wind energy potential in Nigeria including Kano was analyzed [Felix, A.A. *et al*., 2012]. The paper ranks several regions according to their wind speed capacity based on station, but fails to provide enough statistical analyses of the wind data.

In this case, average monthly wind speeds reading for 20years (2000-2020) obtained from NIMET Abuja is used to characterize wind power and energy potential in Kano. The objectives of the paper is to study and investigate the wind power and energy density capacity available in Kano, group the findings according to month, year and season to have diverse understanding of intermittency of wind energy in Kano so that measures are put in place during investment. This will help the government and private organizations in making renewable energy policies for efficient utilization of investment. The wind speed at the different stations of NIMET in Kano is measured at 10 m height with a cup generator anemometer. The data was observed at two different hours of 9:00 and 15:00 and calculated as average wind speed for each month of each year. Wind energy potential is evaluated at different hub heights to reveal accurate results about Kano's wind energy potential. The study provides wind power potential assessment of Kano-Nigeria for efficient energy utilization. The outcome of this research will be useful for investors, government agencies and other organizations for making decision regarding wind energy investment in Kano.

MATERIALS AND METHODS

Site Description and Data Collection

Investigations have revealed that collecting many years of wind speed data helps in describing an area's wind energy availability and its patterns throughout a year. Thus installing wind turbines at certain sites requires robust analysis and adequate knowledge of the data [Amoo, O.M, 2012. *et al*., 2010; Ohunakin, O.S. *et al*., 2011]. Twenty years (2000-2020) Kano monthly mean wind-speed data was obtained from NIMET Abuja, Nigeria. NIMET has a meteorological station located at latitude 12.05^o N, longitude 08.2^o E, and altitude of 472.5 *m*. The air density recorded at the site is 1.1705 kg/m^3. The wind speed at the respective stations of NIMET are measured at 10 m height with a cup generator anemometer and calculated as average wind speed for each month of each year. The site was chosen because of high wind speeds in the area and abundance of land for wind power plant installation.

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Figure 1: Map of Kano region with transmission line interconnection.

Wind Data Analysis/Probability Density Function

Wind speed frequency distribution information is an important parameter in calculating the wind energy probability of potential candidates. If the wind speed distribution is known it is easier to assess wind energy potential and the economic feasibility of any potential area, thus, it is essential to know some of the important factors that are used to describe the behaviour of diverse wind speed information in the analysis. Probability distribution function is the easiest and one of the most used methods to do the related analysis, even though others used artificial neural network as in [Özgür, M.A, 2014]. Wind speed frequency curve can be defined with numerous probability density functions. The two parameter Weibull distribution probability density function (PDF) was chosen to characterize the wind energy potential of the area as it has proven to be the most accurate of several statistical distribution functions [Ayodele, T.R. *et al.*, 2012-Rehman, S. *et al.*, 2012]. In [Dhunny, A.Z. *et al.*, 2016], the authors include the economic aspect of wind viability of the location using Weibull PDF. The two parameter Weibull distribution is given by Eq. (1).

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

In this equation, *f (v)* is the probability of wind speed, v in *m/s*. c (*m/s*), is the Weibull scale parameter and k is the dimensionless shape parameter. Weibull cumulative density function (CDF) is calculated by taking the integral of Weibull PDF and it is given in Eq. (2).

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

Numerous methods are used to estimate the Weibull k and c parameters. In this analysis, the wind speed standard deviation is chosen because its representation of the Weibull distribution when there is zero wind-speed data for calm days does not lead to disjointedness of the function by [Sohoni, V. *et al.*, 2016; Rehman, S. *et al.*, 2012]. The *k* Parameter for Weibull is obtained using Eq. (3)

$$k = \left(\frac{\sigma}{v_m}\right)^{-1.086} \qquad (3)$$

In this equation, σ and $v_m$represent the average wind speed (*m/s*) and the standard deviation respectively. Similarly, the Weibull c parameters are estimated from.

$$c = \frac{v_m}{\Gamma\left(1+\frac{1}{k}\right)} \qquad (4)$$

Where *Γ(k)* is the gamma function of k dimensionless shape parameter. Here, the Weibull standard deviation σ and the Weibull mean wind speed v_m of the known data can be found using (5) and (6) respectively.

$$\sigma = \sqrt{c^2\left\{\Gamma\left(1+\frac{2}{k}\right) - \left[\Gamma\left(1+\frac{1}{k}\right)\right]^2\right\}} \qquad (5)$$

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$$v_m = c\,\Gamma\left(1+\frac{1}{k}\right) \qquad (6)$$

The most important parameters for wind resources estimation are the most probable wind speed *(V_{mp})* and the wind speed of maximum energy *(V_{maxE})* carrying capacity [Islam, M.R. *et al*., 2011]. The most probable wind speed can be defined as the peak of the probability density function. On the other hand, the wind speed carrying maximum energy can be used for estimating the rated wind speed of wind turbine selection. The most probable wind speed is calculated from Eq. (7), which is expressed in [Ajayi, O.O. *et al*., 2011] as.

$$V_{mp} = c\left(\frac{k-1}{k}\right)^{\frac{1}{k}} \qquad (7)$$

The wind speed that is carrying maximum wind energy is found by using Eq. (8) as described in [Jamil, M . *et al*., 1995].

$$V_{maxE} = c\left(\frac{k+2}{k}\right)^{\frac{1}{k}} \qquad (8)$$

Wind Speed Extrapolation at Different Hub Heights

In most cases, the available wind data is measured at heights different from wind turbine hub height. However, it is essential to obtain the wind speed at the hub height for wind power installations. The available wind speeds are corrected to the wind turbine hub height with the power law expression in Eq. (9) as given in [Jamil, M. *et al*., 1995; Ngala, G.M. *et al*., 2007].

$$\frac{V}{V_o} = \left(\frac{h}{h_o}\right)^{\alpha} \qquad (9)$$

Where V and V_o give the wind speed at the required height (h) and the original height (h_o) respectively. Wind shear coefficient (α) is an empirically derived coefficient that varies depending on the stability of the atmosphere and it is obtained from the log arithmetic law. For neutral stable conditions, α is selected to be approximately equal to 0.143, because Kano has hard ground surface which is relatively smooth. In most wind resource assessments, α is assumed to be constant as the differences between the two levels are not usually big enough to cause significant errors in the estimation [Sohoni, V. *et al*., 2016; Ajayi, O.O. *et al*., 2011].

Wind Power and Energy Density Estimation

We can assess the wind source of an area from the wind power density. Wind power density indicates the amount of available energy at a given site [Ajayi, O.O. *et al*., 2011- Dahmouni, A.W. *et al*., 2011]. The wind power per unit area, *P/A* or wind power density (W/m^2) based on Weibull probability density function distribution is given as follows:

$$\frac{P}{A} = \frac{1}{2}\rho c^3\Gamma\left(\frac{k+3}{k}\right) \cong \frac{1}{2}\rho V^3 \qquad (10)$$

Where *P* is the power in Watts, ρ is the density of the air in kg/m^3, and 1.1705 kg/m^3 is selected at average atmospheric pressure at sea level, *A* is the area perpendicular to the wind speed vector in m^2, or sweep area of the rotor blade in m^2 and *V* represent the wind speed in *m/s*. In the case of a height that is less than available hub height of the selected turbine, the power density of wind can be extrapolated by [Kose, F. *et al*., 2014; Adem, A, 2013].

$$\frac{P_h}{P_{10}} = \left(\frac{h}{h_{10}}\right)^{\alpha} \qquad (11)$$

Where P_{10} is the adjusted power selected at specific height, P_h is wind at a height of 10 *m* and $\boldsymbol{\alpha}$ is the roughness factor of the site wind conditions. The annual energy is expressed by the relation given in Eq. (12) and (13) [Amoo, O.M, 2012; Ohunakin, O.S. *et al*., 2011].

$$E_{jm} = 24 * 10^{-3} dp (kWh/m^2) \qquad (12)$$

$$E_a = \sum_{j=1}^{12} E_{jm} (kW.h/m^2/year) \qquad (13)$$

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Where, E_{jm} is the mean monthly energy extractible given by 24x10^{-3} ***dp***, ***p*** is the mean wind power density (W/m^2) while ***d*** is the number of days in the month considered.

Energy Efficiency Index (*eei*)

Calculating energy efficiency index helps policy makers to make decision on both the energy and climate change issues. To calculate *EEI* for a given condition, we break down the case into a number of sub-conditions i.e. monthly or yearly data. In this study, monthly data is considered for *EEI* calculations, for which both final energy forecast and power output data are available

$$EEI = \frac{E}{P} = \left\{(48 * 10^{-3}dp) / \left(A\rho c^3 \Gamma\left(\frac{k+3}{k}\right)\right)\right\} \quad (14)$$

Where *E* is the extractible mean monthly energy given in equation (12) and *P* is the monthly extractive power from the power density in equation (10) including the defined parameters. A unit *EEI* value is calculated for each month for the period under analysis [Cahill, C.J. *et al*., 2010]. The *EEI* value is indexed such that its value for any year is given relative to a base year value. Index *EEI* value is an indication of how efficient the proposed location will be for wind turbine installation.

RESULTS

Figure 2. shows the average monthly wind speeds of Kano for the period of 15 years: 2000 to 2014. Similar wind speeds trends are observed for all the months except for November which appeared to have little divergence from year 2009 to 2014. The month of November is the beginning of dry season and this may have effect on the wind direction, even though, the phenominom is exactly the case of intermittency of wind speeds. Computed average monthly wind speeds variation is shown in Figure 3., which represents a wind speed plot of the entire 15 years (2000-2014), with month June and November having the highest and lowest wind speed respectively. These values are good enough to help in studying wind energy potentials of the region. Also Figure 4. shows annual evolution of wind speeds for the years 2000 to 2014 ranges, with year 2005 having the lowest wind-speed of 7.8 *m/s*, and the years 2008 and 2014 are having the highest wind speeds of 10.7 *m/s*. These are values the analyis is based on

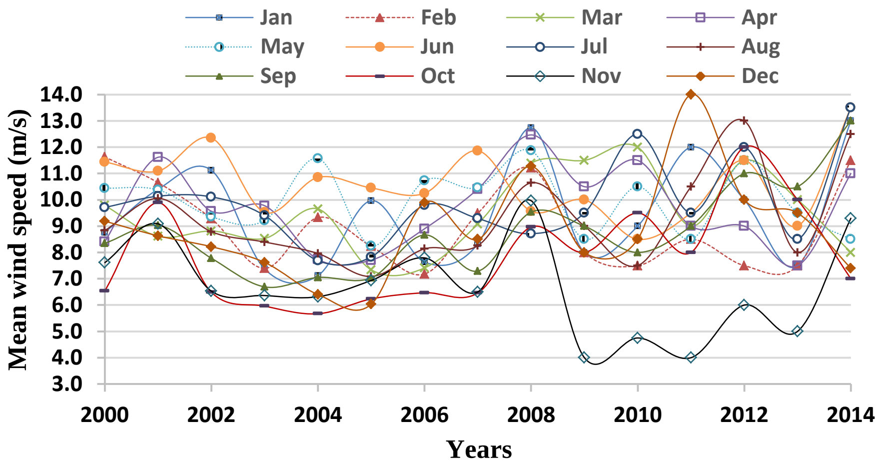

Figure 2: Mean monthly wind speeds in Kano (2000-2014)

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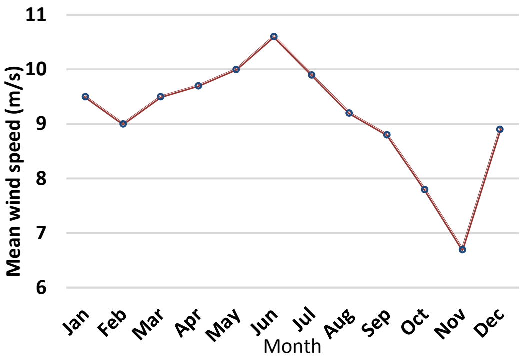

Figure 3: Wind speeds mean seasonal variation for the entire period.

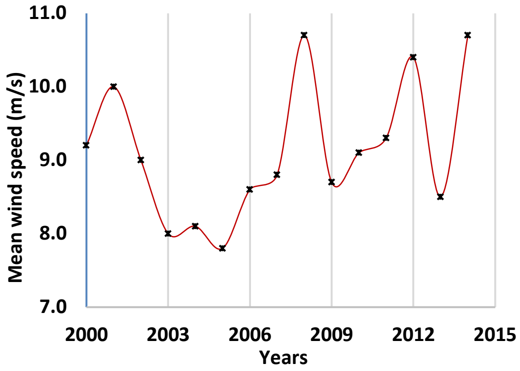

Figure 4: Wind speeds annual evolution for the entire period.

The PDF plot is used to predict the probable times and locations the wind speed is good for wind power plant installation. Figure 5 shows the probability density function all the years and months. It can be seen that it is skewed in the direction of the higher values of the wind-speeds. The plot reveals that highest probability of wind speed in Kano is between April and June for all the years, with 25% probability of wind speed in the range of 9.0 *m/s* and *10m/s*. The CDF in Figure 6 is used to evaluate the time for which the wind speed is within the definite intervals. The peak density of the CDF frequencies tilts toward the higher values and 80% of the wind speeds are in the range of 7.8 *m/s* to 10.7 *m/s*.

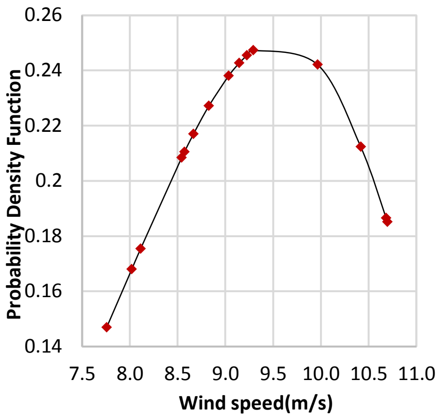

Figure 5: PDF plots whole-year data series

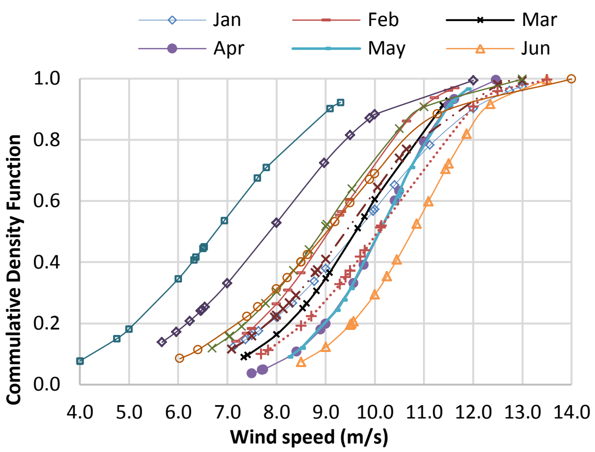

Figure 6: CDF plots of the whole data series

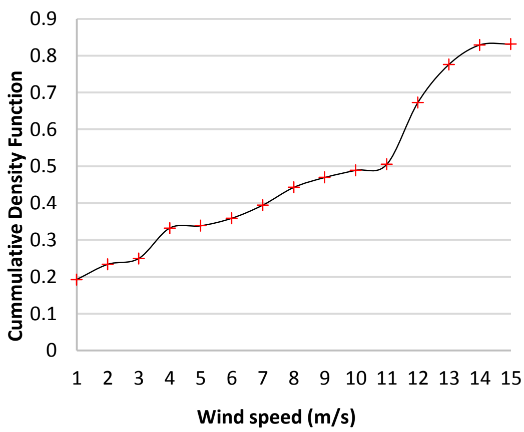

Figure 7: CDF plots of the whole-year data series

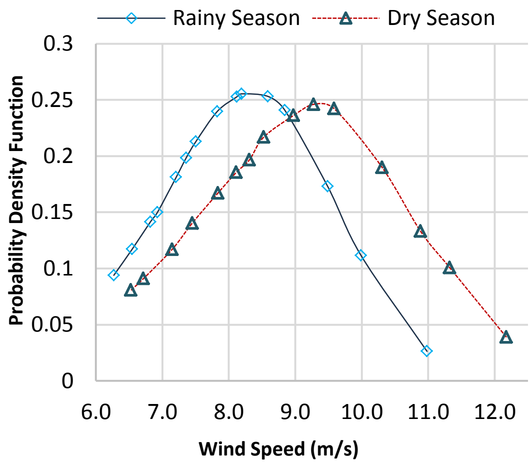

Figure 8: PDF plot of seasons

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The same observation can be made in Figure 7 for the whole-year data series, 40% to 80% probabilities of wind speeds are excellent to drive wind turbine. The 15 years seasonal wind-speeds PDF are shown in Figure 8. It is indicated that, dry season has the highest wind speed in 2008 and the rainy season has the highest wind-speed in 2012. The PDF plot of rainy and dry season with 25% probability of wind speed in the range of high wind speeds. These values show that probability of high wind speeds in the rainy season is more than that of the dry season.

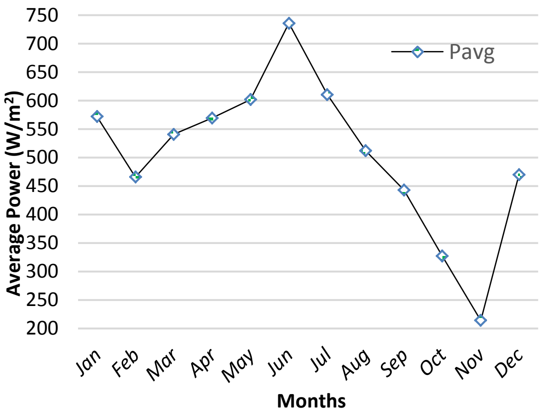

Figure 9: Power Density mean seasonal variation

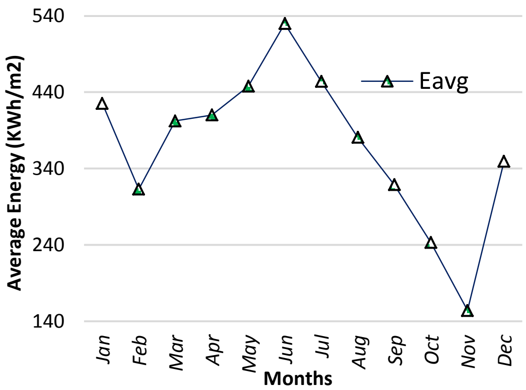

Figure 10: Energy density mean seasonal variation

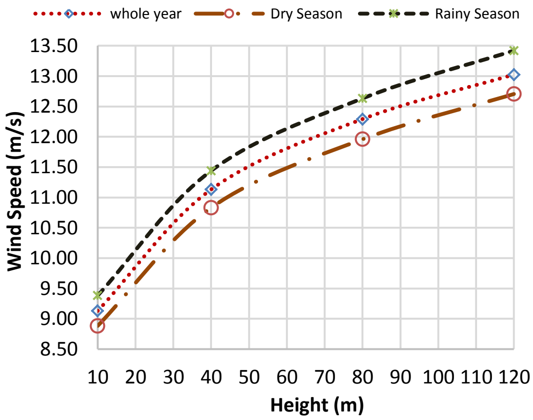

Figure 11: Seasonal and annual extrapolation of wind speed.

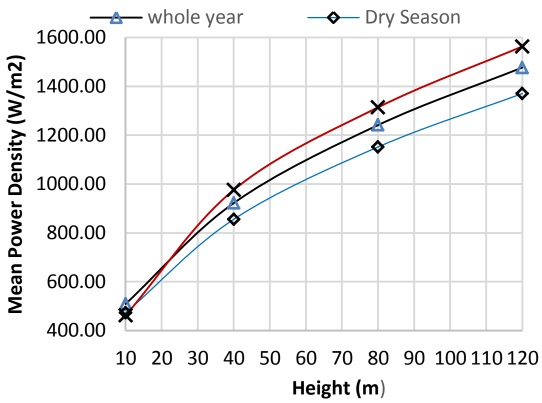

Figure 12: Mean power density Seasonal and annual extrapolation

The plot in Figure 9 demonstrates that average wind power density is estimated to reach maximum value of 735. 925 W/m^2 in June. Likewise, Figure 10 shows that the maximum value of the wind energy density is estimated to be 529.866 kWh/m^2 alos in June and this figures categorise Kano to fall under Class 7 of the wind power density class and thus can be considered for the wind turbine application. The seasonal and whole year extrapolation for wind speed and mean power density is given in Figure 11 and Figure 12. In both cases, rainy season exhibited higher wind speed and mean power density than the dry season at both 10 *m* height and 120 *m* height respectively and the dry season revealed the lowest wind speed and the mean power density.

Table 1. displayed monthly result of a Weibull statistical analysis, estimation parameters and energy efficiency indices. The values are found to be stable for efficient energy utilization. Table 2. shows yearly results of Weibull statistical analysis and approximation parameters. The Weibull dimensionless shape parameter k is lowest in 2011 and highest in 2001 and scale parameter c has the lowest value in 2005 and highest in 2014. Table 3. contains seasonal variations of Weibull statistical analysis and estimation parameters. Two seasons, dry (Nov-April) and rainy (May-Oct) are considered for the analysis as Kano predominantly exhibits these two seasons for the larger part of a year. Table 3 provides the seasonal variations of wind power densities for the dry season and for the rainy season which are similar due to small

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variation in wind speed for the two seasons, like wise wind energy density. Based on the analysis, highest values for V_{mp}, V_{maxE} and P_{avg} are obtained in June 2014, this is practically connected to the fact that during rainy days wind blows with high speed before it rains in kano. Therefore wind speed capture during this time and day exhibit higher values. The analysis of recent data (2000-2020) shows higher wind class compared to previous studies conducted for the region including Kano. This could be mainly due to shifting weather conditions and improved accuracy of the recording and analysis.

Table 1: The monthly result at 10-m height

Month	V*m*	K(-)	C (m/s)	Vmp (m/s)	VmaxE (m/s)	Pavg (W/m^2)	Eavg (KWh/m^2)	EEI (%)
Jan	9.500	5.504	10.322	10.000	10.900	571.923	425.511	74.4
Feb	9.000	6.533	9.649	9.400	10.100	465.640	312.910	67.2
Mar	9.500	7.358	10.138	9.900	10.500	540.876	402.412	74.4
Apr	9.700	7.335	10.315	10.100	10.700	569.604	410.115	72.0
May	10.000	9.826	10.468	10.400	10.700	601.923	447.830	74.4
Jun	10.600	9.343	11.202	11.100	11.400	735.925	529.866	72.0
Jul	9.900	7.016	10.559	10.300	10.900	610.455	454.179	74.4
Aug	9.200	6.073	9.957	9.700	10.400	511.934	380.879	74.4
Sep	8.800	5.928	9.487	9.200	10.000	442.910	318.895	72.0
Oct	7.800	4.717	8.537	8.100	9.200	326.999	243.287	74.4
Nov	6.700	4.059	7.360	6.900	8.100	213.913	154.018	72.0
Dec	8.900	5.131	9.654	9.300	10.300	469.691	349.450	74.4
Average	**9.133**	**6.569**	**9.804**	**9.533**	**10.267**	**505.150**	**369.113**	**73.0**

Table 2: Yearly result at 10-m height.

Year	V_m	K(-)	C (m/s)	V_{mp} (m/s)	V_{maxE} (m/s)	P_{avg} (W/m^2)	Eavg ($KWh/m^2/year$)
2000	9.225	7.257	9.844	9.645	10.180	494.953	4335.787
2001	9.965	12.705	10.378	10.311	10.498	594.796	5210.413
2002	9.034	6.105	9.728	9.448	10.191	477.415	4182.155
2003	8.020	7.169	8.563	8.385	8.862	325.713	2853.245
2004	8.112	4.961	8.839	8.447	9.464	361.356	3165.480
2005	7.758	6.736	8.310	8.114	8.637	297.481	2605.929
2006	8.572	7.412	9.136	8.959	9.436	395.901	3468.090
2007	8.827	6.268	9.492	9.233	9.921	443.341	3883.670
2008	10.695	9.510	11.267	11.136	11.495	749.331	6564.136
2009	8.667	5.349	9.403	9.046	9.978	432.843	3791.702
2010	9.146	4.672	10.000	9.498	10.793	526.139	4608.975
2011	9.292	4.392	10.196	9.614	11.106	561.764	4921.054
2012	10.417	5.865	11.242	10.890	11.819	737.356	6459.239
2013	8.542	6.408	9.174	8.934	9.571	400.200	3505.751
2014	10.683	4.836	11.658	11.113	12.523	830.801	7277.815
Avg.	**9.130**	**6.643**	**9.815**	**9.518**	**10.298**	**508.626**	**4455.563**

Table 3: Average seasonal variation at 10-m height

Season	V_m	K(-)	C(m/s)	V_{mp} (m/s)	V_{maxE} (m/s)	P_{avg} (W/m^2)	E_{avg} (KWh/m^2)	Monthly Season
Rainy Season	9.400	7.151	10.000	9.800	10.433	461.450	395.823	May-Oct
Dry Season	8.900	5.987	8.200	9.267	10.100	471.941	342.403	Nov-April
wholeYear	9.130	6.643	9.815	9.518	10.298	508.626	4455.563	NA

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Table 4: Monthly extrapolation of wind speed and power density

Month	**Vm** (50m) m/s	**Vm**(100m) m/s	**Pavg**(50m) W/m^2	**Pavg** (100m) W/m^2
Jan	11.958	13.205	1140.763	1535.810
Feb	11.329	12.510	928.771	1250.405
Mar	11.958	13.205	1078.837	1452.438
Apr	12.210	13.483	1136.138	1529.583
May	12.588	13.900	1200.601	1616.370
Jun	13.343	14.733	1467.884	1976.212
Jul	12.462	13.761	1217.620	1639.282
Aug	11.581	12.788	1021.109	1374.720
Sep	11.077	12.232	883.434	1189.367
Oct	9.819	10.842	652.236	878.106
Nov	8.434	9.313	426.674	574.431
Dec	11.203	12.371	936.851	1261.283
Average	**11.497**	**12.695**	**1007.577**	**1356.500**

CONCLUSIONS

This study makes assessments on the wind power potential for the purpose of efficient energy utilization in Kano, Nigeria. The assessments are conducted based on fifteen years of mean monthly wind speed at 10 *m* height obtained from NIMET Abuja. The analysis was carried out using Weibull two-parameter and other statistical computation. Based on the analysis, the following conclusions can be drawn:

Monthly wind speeds have shown similar trends for all the years except November. The overall monthly average wind speed is found to be 9.13 *m/s* with June having the highest wind speed of 10.6 *m/s* and November having the lowest wind speed of 6.7 *m/s*.

Mean wind speeds for each year from 2000 to 2014 are all above 7 *m/s*, with year 2005 having the lowest wind speed of 7.8 *m/s* and year 2008 and 2014 having the highest wind speed of 10.7 *m/s* each.

Maximum monthly value of power density is estimated to be 735.925 W/m^2 with corresponding energy density of 529.866 kWh/m^2 in June. The average monthly values of power density and energy density is computed as 505.150 W/m^2 and 369.113 kWh/m^2 respectively.

Annual power density is in the range of 297.481 W/m^2 to 830.801 W/m^2 and annual energy density is in the range of 2605.929 $kWh/m^2/year$ to 7277.815 $kWh/m^2/year$.

November has exhibited the lowest wind speed, while June has the highest wind speed at 10 *m* and extraplotion. Seasonal and whole year extrapolation for wind speed and mean power density show that rainy season exhibited higher wind speed at 10 *m* height and mean power density at 120 *m* height than dry season. Dry season tends to have the lowest wind speed and mean power density.

Average wind speed and average power density at 50 *m* height is found to be relatevely good for power generation. Likewise average wind speed and average power density at 100 *m* height is found to be excellent for efficient application.

The analysis on recent wind speeds data (2000-2014) shows higher wind speed values compared to previous studies conducted for Kano. This could be mainly due to climatic changes which is a global phenomenon and the use of improved recording equipment.

EEI's for the monthly period are good enough for wind power generation.

Based on the analysis, Kano has sufficient amount of annual wind power density and thus falls under the highest wind power density class, wihch is class 7. It is a very good area for electricity generation using wind farm almost for almost every month of the year.

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Source of support: Nil; **Conflict of interest:** Nil.

Cite this article as:
Muhammad, N.A., Mustapha, M.G., Yahaya, A.S., Tijjani, N., Musa, A.L., Yunusa, A.S. and Shehu, G.S. "Assessment of Wind Power Potential at Kano State Nigeria for Efficient Energy Utilization." *Sarcouncil Journal of Engineering and Computer Sciences* 1.7 (2022): pp 1-11.

Publisher: SARC Publisher