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Evaluating Wind Characteristics and their Potential for Producing Electricity in Dodoma Region of Tanzania

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Abstract: Tanzania relies heavily on hydropower for its electricity despite the frequent shortages occurring during dry seasons. This study evaluated the characteristics of wind and its wind energy production potential in Dodoma, central Tanzania. Three-hourly wind speed data observed at a height of 10m were obtained from the Dodoma Meteorological Station for the period from 2014 to 2025 and were evaluated for their potential for wind power generation. Both monthly and annual mean wind speeds and wind speed frequency distributions were extrapolated to a hub height of 50 m using the Power Law. The analysis showed a mean annual wind speed of 5.6 m/s with an average wind power density of 285.8 W/m² at 50 m above ground level. Based on these wind characteristics, the region has an annual electrical energy generation potential of approximately 23,343.21 kWh. Moreover, the estimated annual power output of 580 kW puts the region within Wind Power generation Class 4, which is moderately suitable for wind turbine development projects. The dry season, which is also windy, occurs between March and November, coinciding with the months when hydropower production constrained offering added advantage for wind energy production. In this case, the development of wind energy could be recommended as a means of supplementing electricity supply during limited water resources, to allow allocation of water to other economic activities like irrigation and agriculture.

Keywords: *Wind Characteristics, Electricity Generation, Wind Power Density, Wind Power Potential.*

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I. INTRODUCTION

Many emerging and underdeveloped nations are finding it more and more difficult to generate electricity (Ponce-Jara et al., 2017). As these nations' economies expand, it is frequently discovered that there is no clear correlation between power supply investment and economic growth (Chen et al., 2023). Because there is insufficient electricity to support the expanding economy, these economies typically experience severe power outages or shortages. In many economies, this problem has grown commonplace, and its consequences severely impair economic sector output and impede the advancement of growth. It's also true that our nations, like Tanzania, have extremely small economies, making sufficient investments to address the power crisis a daunting commitment that they might not be able to maintain.

Products and technologies related to renewable energy, particularly solar and wind power, are in high demand worldwide. Recent wind power projects have demonstrated that wind energy is not only economically viable but also provides other advantages for the environment and economy (Adeyeye et al., 2020). Global interest in wind energy development has led to consistent advancements in wind power plant performance and technology. However, using the wind's power requires a consistent supply of reasonably strong wind (Wen et al., 2009). A thorough grasp of wind resources is essential to the development of wind energy. The wind kinetic energy can be converted to electrical or mechanical energy. In more recent times, it has been extensively employed for specific uses, such producing power using wind turbines.

The Tanzania Electric Supply Company Limited (TANESCO), Tanzania's only manufacturer, produces the majority of the country's electricity through hydro power generation, with a small amount coming from more contemporary natural gas power facilities. Hydro accounts a largest share of TANESCO's total power generation, making it the greatest contributor (Poncian & Pedersen, 2023). When most hydrological sources are exhausted, productivity is negatively impacted by severe droughts and extended dry seasons (Msoka & Pauline, 2025). Tanzania experiences a lack of electricity during these period, necessitating the rationing of electricity. The nation must look for alternate sources of energy in order to stabilize the energy situation and lessen its excessive reliance on the hydrological cycle and fossil fuel sources as a result of the electric energy crisis.

Although wind energy appears to be abundant in the nation, its magnitudes have not yet been quantified and examined to an encouraging degree. According to Kainkwa, (2006) analysis, Tanzania possesses a fair amount of wind power, although it hasn't been utilized in a long time. Before deciding to develop wind energy facilities and plan related projects, a site's wind power potential must be evaluated. The present study assesses the potential for wind power in Central Tanzania's Dodoma Region.

II. MATERIALS AND METHODS

- *Study Site*

Dodoma region lies between approximately 6°10′S and 35°44′31″E occupying a strategic location of central plateau of Tanzania. It is bordered by Singida region to the west, Manyara to the north, Iringa to the south, Rukwa to the southwest and Morogoro to the east. In contrast to the majority of Tanzania, Dodoma has a semi-arid climate. All year round, the area has comparatively warm weather. Average lows fall to 13 °C in July, although average highs remain rather constant throughout the year. The majority of Dodoma's 570 mm annual average rainfall falls during its unimodal wet season, which runs from November to April. The region's dry season lasts the rest of the year (John, 2022).

Fig 1 Location of Dodoma Region

- *Wind Extrapolation to Higher Heights*

Usually, the speed of the wind increases with height; phenomena is called vertical wind shear. The degree of wind shear is primarily determined by two factors: the roughness of the topography and the mixing in the atmosphere. Solar heating usually drives a daily cycle of atmospheric mixing. This cycle frequently results in wind speeds rising during the day and falling at night at a wind turbine's hub height. However, as hub height grows, the range of change between day and night usually decreases. It becomes weaker or sometimes goes away at a height of about 50 meters (Chaudhry, 2008).

The earth's surface roughness influences wind speed because the atmospheric boundary layer extends to the first few hundred meters above the ground. Uneven surfaces, like buildings and woods, provide greater resistance than smooth ones, like water. The power law, which is shown as follows, is an expression that accounts for this impact on wind speed.

$$U_Z = U_{10} X \left(\frac{Z}{10} \right)^{\alpha} \quad (1)$$

In this equation, U_z represents the average speed of wind at height Z, U_{10} represents the average speed of wind at 10m, Z represents the height at which the wind speed is to be estimated, and α is an empirically derived friction coefficient that changes based on atmospheric stability. At neutral stability conditions on open lands, α is around 1/7, or 0.143. This relationship was used to predict wind speeds from 10 to 50 meters (Jung & Schindler, 2021).

- *Wind Characteristics Determination*

The distribution of the direction of wind, mean wind speed, and diurnal, seasonal, and yearly trends were among the site wind characteristics relevant to wind turbines. The wind speed frequency distribution was obtained by plotting the different wind speeds against their frequencies or relative frequencies. Additionally, the average wind speed at a specific time of day and month was plotted to create the diurnal and monthly wind profiles

- *Estimation of Wind Power Density (WPD).*

The WPD, measured in watts per square meter, is the power available from wind per unit area (perpendicular to the wind direction), averaged over a year at a certain location. When examining a region's wind power potential, the average wind speed numbers do not accurately reflect this potential since the process of averaging wind speed suppresses a lot of information about the wind speed the frequency distribution. In this sense, the average power output per m² of wind-swept area A at a particular location may be shown using the turbine's power density, which is a useful comparative measure. It is expressed as:

$$\textit{Power Density (P)}, P = \frac{1}{2} A\rho\, U^3 \quad (2)$$

Where ρ is the air density (kg/m3), and U is the average speed (m/s). The area A varies with the size of the rotor. As a result, it is evident that power density is mostly determined by wind velocity and increases as the cube of it (Burton et al., 2001).

- *Determination of Wind Power Class*

The yearly average WPD, which takes into account variations in wind speed and, consequently, power produced at each instant, is a useful predictor of a site's capacity for wind energy generation, even if equation 2 shows the instant power collected from the wind. The monthly average wind speed was compared to the wind power class in order to estimate wind potential as a resource. Assigning regions to one of seven wind classes—each of which represents a range of wind power density at a unique height above the ground—makes characterizing the wind power potential easier. Table 1 displays the basic international wind power categories. By comparing the Wind Speed Scale at heights of 10 meters or when calculated to 50 meters, it will be possible to determine the wind power density for various wind speeds (Wei et al., 2018).

Table 1 Wind Power Class

Wind Power class	**10m**		**50m**	
	Speed (m/s)	Wind power density (W/m^2)	Speed (m/s)	Wind power density (W/m^2)
1	4.4	100	5.6	200
2	5.1	150	6.4	300
3	5.6	200	7.0	400
4	6.0	250	7.5	500
5	6.4	300	8.0	600
6	7.0	400	8.8	800
7	9.4	1000	11.9	2000

Large wind turbines are currently being created in places that are generally classified as class 5 or higher. As wind turbines are used to operate more efficiently at lower wind speeds, Class 4 sites are also being explored for future development. Although a smaller wind turbine might be more cost-effective in locations where the value of the energy produced is higher, class 1 and class 2 places are not seen to be appropriate for large machines (available at http://www.awea.org/faq/basicwr.html "American Wind Energy Association").

- *Wind Speed to Power Output Converting*

Wind speed and turbine size are significantly correlated, despite the fact that a number of factors influence the power production of wind turbines. Each wind turbine's rated capacity is the highest power, measured in watts that it can produce during good wind conditions. The power is usually measured in megawatts (MW) and kilowatts (kW). The energy produced by a wind turbine is calculated by multiplying power output by time (Chaudhry, 2008).

Wind turbines work within a certain range of wind speeds, and the wind's speed determines how much electricity they can produce. The relationship between wind speed and power output for a 2000kW Gamesa G90 wind turbine is displayed in Table 2 and Figure 2. When the wind reaches the cut-in speed of 3 m/s and the cut-out speed of 25 m/s, the turbine produces power.

The power output of a wind turbine varies in response to variations in wind speed, ranging from 3 m/s to around 14 m/s. Regardless of variations in wind speed, the power production of wind turbines has achieved a maximum and is nearly constant between 14 and 25 m/s (figure 2). Some of the properties of Gamesa G90-2.0 MW IIA model are as follows:

Diameter = 90m,

Swept area A= 6,362 m^2,

Rated power= 2.0 MW,

Power factor = 0.95

The computation of Wind power = Average (Power Density) * Swept area

Wind energy = [[Wind Power * (Count of days * 24)]/1000] * Plant Load Factor (3)

(Faghani et al., 2018).

Table 2 Conversion of Wind Speed to Power Output for a 2000kW Wind Turbine

The speed of Wind (hub height 50m)	Power output	The speed of Wind (hub height 50m)	Power output
1	0	15	2000
2	0	16	2000
3	21	17	2000
4	85	18	2000
5	197	19	2000
6	364	20	2000
7	595	21	2000
10	1649	22	1906
12	1971	23	1681
13	1991	24	1455
14	1998	25	1230

Available at www.awea.org/faq/basicwr.html

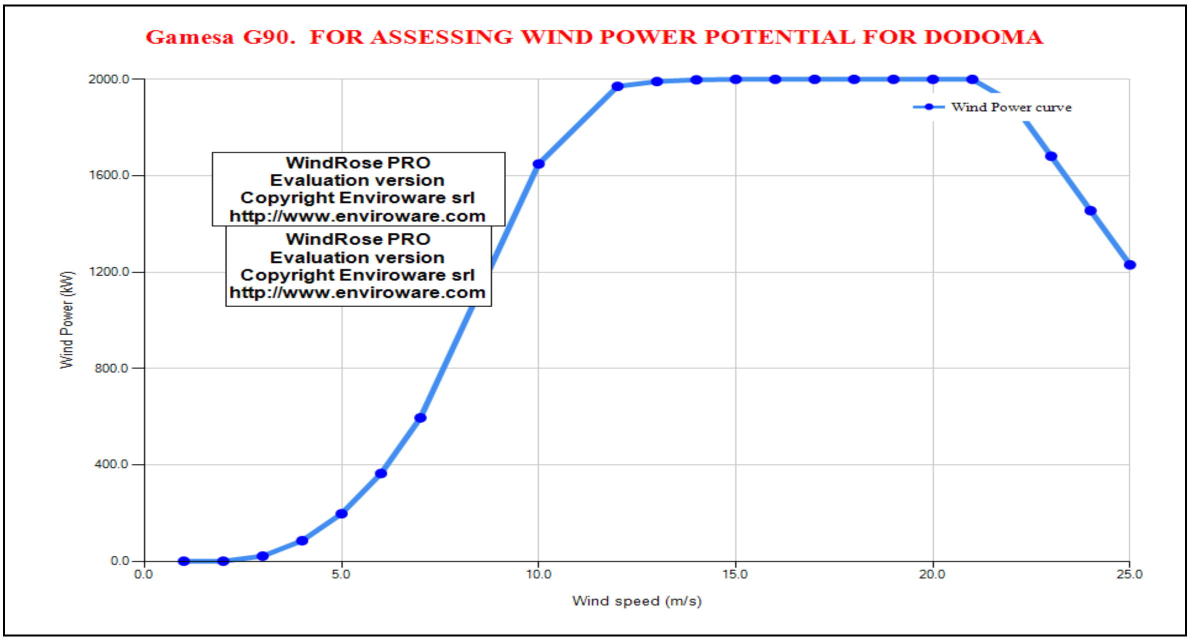

Fig 2 The Wind Speed and Wind Power Potential (www.enviroware.com)

At this step the process of converting wind speed into power output starts. As previously stated, measurements were made at a height of 10 meters, and all of the wind data essentially came from a synoptic meteorological station. Two factors—height above ground and surface "roughness"—were to be taken into account when adjusting the initial wind speed data. This correction is implemented as shown in Equation 1. So, while wind speed logarithmically increases with height, the shape of the profile is determined by the underlying aerodynamic roughness of the surface's length. Because the data comes from an airport station, these statistics are assumed to reflect the average hub height of a flat surface wind turbine at 50 m. Figure 2 illustrates that no power is produced when the at the speed of the wind < 3 m/s or >25 m/s. Thus the quantity of power rises non-linearly between 4 and 14 ms^{-1}, after which the power output continues at its maximum until the cutoff speed of 25 m/s. According to Jowder, (2009) an upper limit of 25 m/s is designed as the power production cuts off in order to prevent the turbine damage during gale force conditions.

III. RESULTS AND DISCUSSION

- *Dodoma Temporal Wind Characteristics*

Dodoma monthly wind speed variation at 50 m (Figure 3a) reveals that average wind speeds are gradually increasing from January, peaking in September and October. It declines till December. During April and May, the months of transition between the wet and dry seasons in the region is when the wind speeds begin to peak, and they appear to be dominated by strong winds.

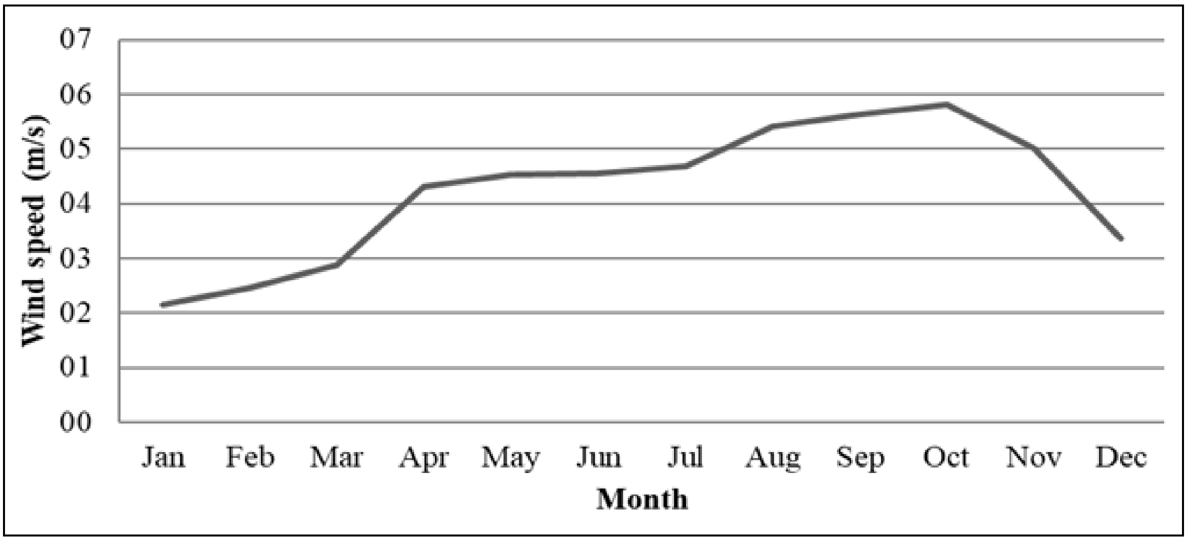

Fig 3 Monthly Variation of Wind Speed Extrapolated at 50m

The small speed winds blow in mid-November, which coincides with the starting of the wet season the region. The low pressure systems prevailing over the region during this time (Borhara et al., 2020). The winds convergence occurs in the region, resulting in calm to low wind speed conditions. The region has a unimodal rainy season that lasts from late November to April (Kebacho et al., 2026). The average wind speed remains low during the rainy season. Every January, wind speeds range from 1.5m/s to 3.5m/s. This wind speed is insufficient for electricity generation (Luickx et al., 2010). This explains the seasonal characteristics of wind speeds mentioned before. Thus, power generation will peak between May and November, then fall from December to the end of March.

The average yearly wind speed from 2014 to 2025 was 5.6 m/s (Fig. 3). Between mid-July and mid-November, the monthly mean wind speed in Dodoma was higher than the yearly average. The period between August and October, the speed of the wind was over 5.6 m/s and was quite consistent with few changes. During June- December period, the wind speed surpassed 5.0 m/s. Wen et al. (2009) reported that, wind speeds of 5.0 m/s are considered feasible for energy harvest. The windy season coincides with a period when most parts of Tanzania are typically dry, making the utilization of wind energy in electricity generation critical. This can help to alleviate the usual lack of electricity from hydropower plants during the dry season.

December through April, wind speeds were significantly lower than the yearly average. This tranquil season coincided with the wet season in most parts of the country, when rivers and dams often have enough water to operate hydroelectric facilities. Except for December through March, wind speeds exceeded 4.0 m/s. Between April and November, the minimum monthly wind speed was slightly more than 5 m/s. This minimum value is sufficient to turn a wind turbine. As a result, if a wind turbine with a hub height of 50 meters is placed at the location in the Region, it will generate power during this time.

Thus, at the wind speed average site, a wind turbine with a cut-in wind speed of no more than 4.0 m/s would provide electricity for most of the year. According to Chandel et al. (2014), wind speeds as low as 3.0 m/s may be relevant to remote decentralized systems, and there are currently small-scale converters made for lower wind speeds. Small turbines may be helpful in certain circumstances, and their expense may be justified, particularly if fuel-dependent diesel generators are the alternative energy source. From 2014 to 2025, the average wind speed was between 6 and 4.9m/s. The wind speed variation over the research period was 1.1m/s, which is quite little in comparison. However, to adequately assess the long-term behavior of annual wind patterns, a longer time period must be evaluated (Chaudhry, 2008). The average wind speed for each year of investigation is sufficient to generate power.

- *Diurnal Wind Speed Distribution*

Wind speeds vary consistently throughout the day when the sun warms the Earth's surface (Mwinuka et al., 2021). Figure 4 shows this effect, which is only limited to eight times each day. This makes determining when it is most windy tricky; however wind speed increases from early morning to afternoon. The windiest time of day was always between 0600Z and 0900Z out of the eight periods for which statistics were available.

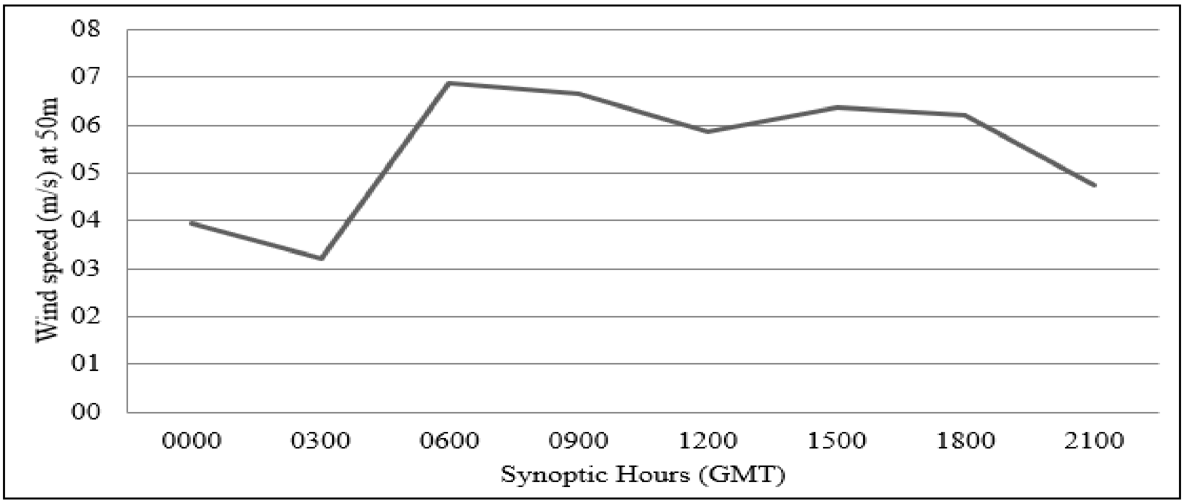

Fig 4 Average Diurnal wind Speed Distribution for 2014-2025

Wind speed varies diurnally as a result of changes in solar radiation input to the atmosphere caused by the earth's rotation. Variations in heat energy (temperature) and pressure during the day determine the amount of wind speed. In the afternoon, when the temperature of the earth's surface and atmosphere is at its maximum, wind speeds are usually at their highest (Dai,, 1999).

The typical daily cycles for three hourly wind speeds are shown in Figure 4, which shows that the highest wind power output happens between 0600Z and 1800Z. This is when the wind peaks. However, Adaramola and Oyewola, (2011) suggested that daily wind power has different monthly patterns, with certain months being more significant than others. Some months have higher wind speeds for longer periods of time than others, and rainy months are typically defined by low wind speeds, whilst dry months are marked by strong winds. Similar trend occurs from May until October. These average daily wind profiles illustrate that wind power levels in the region are often higher throughout the day and early evening than late at night and early dawn. This demonstrates the possibilities for electricity generation during this time.

- *Wind Direction Patterns*

Figure 6 depicts the Wind Rose, which was created using 144 months of data collected at 10 meters in height and direction between January 2014 and December 2025. This Wind Rose shows that the wind primarily blew from east to northeast. The annual average wind speed is 8.44 knots while the wind speed was above 6 knots by approximately 74.5 percent. No month has average calm breezes. This agree with the report by Mwinuka et al. (2021), during summer (wet periods) the climatology of Central Tanzania is featured by low wind speed while during winter (dry periods) the winds are high, with the majority coming from the east and northeast.

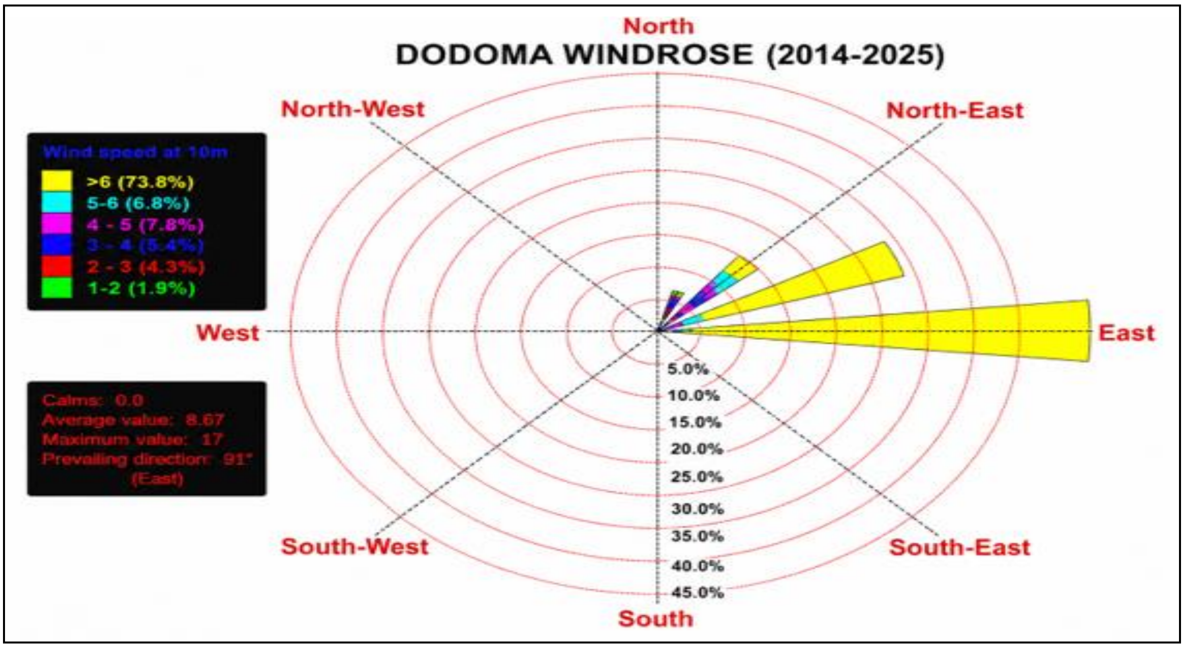

Fig 6 The Wind Rose for Wind Direction Frequency Distribution

The data values for average, maximum and minimum, maximum indicated in figure 6, reveal that the wind speed is higher between 70 and 100 degrees, and the wind is stronger in its prevailing direction.

Figure-7 provides this frequency distribution in percentage form. At a height of 10 meters, it is shown that the wind speed was 4 m/s, 5 m/s, 6 m/s, and 7 m/s which corresponds to 19%, 16.3%, 16.4%, and 14.3% of the time respectively. The location has a moderate potential for production of wind power because 67.4% of the time the wind is strong enough to turn turbines. The accumulated frequencies for wind speed distribution (Figure 7) reveals that the wind speed sufficient to turn a turbine is greater than 55%. This provides a fair level of reliability in the electricity provided by the wind in the region.

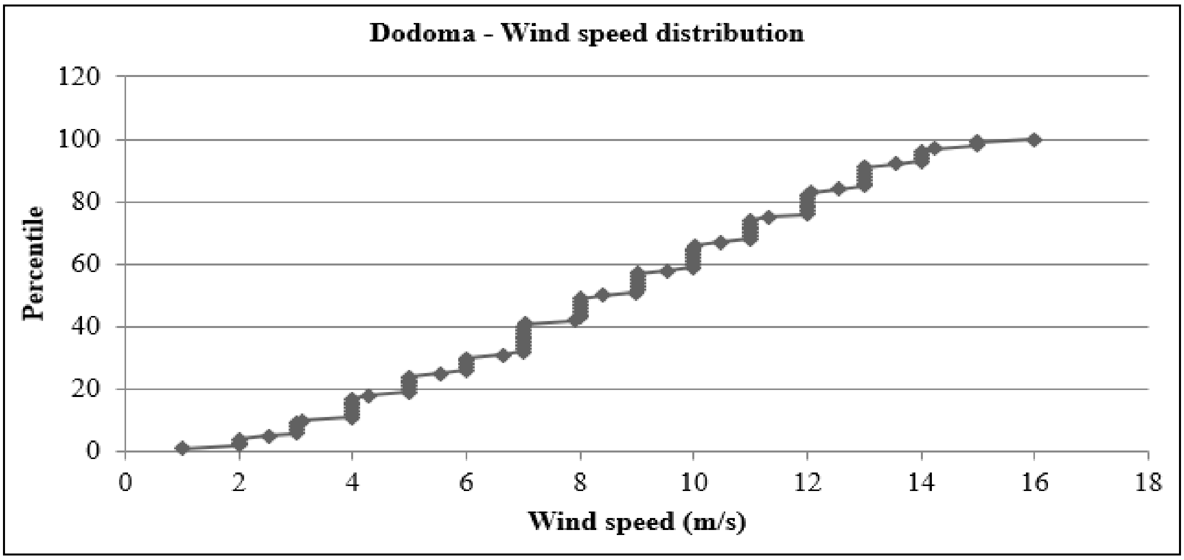

Fig 7 Cumulative Wind Speed Distribution

- *Annual Potential Power Generation from the Winds at Dodoma*

Dodoma's wind speed observations can be converted into wind power output by using the well-known relationship between wind speed and turbine power output. This was done every three hours for the period of study between 2014 and 2025. The wind energy is estimated using the equation (Chou & Corotis, 1981):

$$\text{Energy} = \text{Power} \times \text{Time (hrs)} \qquad (4)$$

The average yearly wind power, estimated from Equation 2 and assuming an average annual wind speed of 5.6 m/s, is 280.5 W/m2. This wind power has the potential to generate 23343.21 kWh of electricity each year.

- *The Patterns of Wind Energy Potential in the Region*

An accurate estimate of wind speeds at the appropriate heights aids in forecasting the likelihood of power generation from a wind farm. Table 3 shows Dodoma's predicted monthly energy output based on an estimated wind speed of 50 m. From March to October, wind speeds gradually increase, increasing the region's energy potential. However, the reduction in potentiality of energy between December and February is sharper across the region. During the windy season, from April to November the wind power that could be available is averaged to 4 13.520W/m^2, with the corresponding energy of 23,003.832 kWh. The low speed months, December to March, had a monthly average power of 64.19 W/m^2, and the energy available is 1785.51 kWh.

Table 3 Average Monthly Wind Power Output (at 50m)

Month	Average wind speed (m/s)	Power output (kW)
Jan	3	21
Feb	3	21
March	4	85
April	6	364
May	6	364
June	6	364
July	6	364
Aug	7	595
Sept	7	595
Oct	8	940
Nov	7	595
Dec	4	85
Annual Average	**6**	**366**

Table 3 present the monthly power output at a hub height of 50 m, which indicates the power output variation, ranging from lowest 21 kW in January to highest 940 kW in October. The lower power output remains below 100 kW during the wet season (December – March), which reflect the relatively low wind energy potential during this period. Nevertheless, the average annual power output of 366 kW places the region into a moderate Wind Power Class 4, for wind power resource. The region possesses sufficient potential for the development of medium-scale wind farms despite of reduced wind energy availability during the four months of the year. However, Chaudhry (2008), reported that large wind turbine projects are mostly established in regions classified as Wind Power Class 5 or higher, but still sites with class 4 are increasingly being considered for development due to improvements in wind turbine technology that can be adopted to run efficiently at lower wind speeds. In contrast, Class 1 and Class 2 areas are generally deemed not suitable for large wind turbines, but can be considered economically viable if the value of electricity generated is relatively high. For these reasons, the amount of electricity that can be harvested from the region is reasonably enough for consideration of installation of wind turbines. The electrical energy produced can be add to other sources of electricity on the national grid line and become supplement of shortages during the dry season.

IV. CONCLUSIONS AND RECOMMENDATION

The wind in Dodoma characterized by recurring periods of high and low wind speeds making a predictable pattern of wind power generation. Despite the variability in wind energy, its intermittent nature can be supplemented by other energy sources during low wind periods. This period with low-wind speed coincides with the rainy season, when hydropower generation is enhanced by adequate water availability in dams and rivers. Conversely, the high wind potential occur between July and November, which correspond to the dry season when hydropower electric generation is usually constrained in the country. Generally, the wind characteristics show a considerable potential for electricity generation. Even at relatively low wind speeds averaging about 3 m/s, the electricity generation can remain feasible when adopting turbines installed at hub heights of 50 m with cut-in speeds of 3 m/s or lower.

As compared to hydropower resources the characteristics of wind suggests that wind energy could occupy significant part in strengthening Tanzania’s energy security. The research recommends the increased utilization of wind energy to allow the use of water to other economic activities like irrigation and agricultural production rather than being used for hydropower generation. In this case, further exploration and development of wind energy projects are recommended as an environmentally sustainable alternative for supporting both energy production and water resource management.

REFERENCES

[1]. Adaramola, M. S., & Oyewola, O. M. (2011). On wind speed pattern and energy potential in Nigeria. Energy Policy, 39(5), 2501–2506. https://doi.org/https://doi.org/10.1016/j.enpol.2011.02.016

[2]. Adeyeye, K., Ijumba, N., & Colton, J. (2020). Exploring the environmental and economic impacts of wind energy: a cost-benefit perspective. International Journal of Sustainable Development & World Ecology, 27(8), 718–731. https://doi.org/10.1080/13504509.2020.1768171

[3]. Borhara, K., Pokharel, B., Bean, B., Deng, L., & Wang, S. S. (2020). and Future Projection. 7–9.

[4]. Chandel, S. S., Murthy, K. S. R., & Ramasamy, P. (2014). Wind resource assessment for decentralised power generation: Case study of a complex hilly terrain in western Himalayan region. Sustainable Energy Technologies and Assessments, 8, 18–33. https://doi.org/https://doi.org/10.1016/j.seta.2014.06.005

[5]. Chaudhry, Q. Z. (2008). An Investigation on Wind Power Potential of Gharo-Sindh, Pakistan. 6(11), 1–11.

[6]. Chen, H., Jin, L., Wang, M., Guo, L., & Wu, J. (2023). How will power outages affect the national economic growth: Evidence from 152 countries. Energy Economics, 126, 107055. https://doi.org/https://doi.org/10.1016/j.eneco.2023.107055

[7]. Chou, K. C., & Corotis, R. B. (1981). Simulation of hourly wind speed and array wind power. Solar Energy, 26(3), 199–212. https://doi.org/https://doi.org/10.1016/0038-092X(81)90204-8

[8]. Dai, A., and C. D. (1999). Diurnal and semidiurnal variations in global surface wind and divergence fields. Journal of Geophysical Research: Atmospheres, 104(D24), 31109–31125. https://doi.org/https://doi.org/10.1029/1999JD900927

[9]. Faghani, G. H. R., Ashrafi, Z. N., & Sedaghat, A. (2018). Extrapolating wind data at high altitudes with high precision methods for accurate evaluation of wind power density, case study: Center of Iran. Energy Conversion and Management, 157, 317–338. https://doi.org/https://doi.org/10.1016/j.enconman.2017.12.029

[10]. John, O. (2022). Evaluation of Rainfall Extreme Characteristics in Dodoma Urban, A Central Part of Tanzania. International Journal of Environment and Geoinformatics, 9(3), 165–177. https://doi.org/10.30897/ijegeo.1000458

[11]. Jowder, F. A. L. (2009). Wind power analysis and site matching of wind turbine generators in Kingdom of Bahrain. Applied Energy, 86(4), 538–545. https://doi.org/https://doi.org/10.1016/j.apenergy.2008.08.006

[12]. Jung, C., & Schindler, D. (2021). The role of the power law exponent in wind energy assessment: A global analysis. International Journal of Energy

Research, 45(6), 8484–8496. https://doi.org/https://doi.org/10.1002/er.6382

[13]. Kainkwa, R. M. R. (2006). SURVEY OF WIND POWER POTENTIAL FOR WIND-BASED ELECTRICITY AT MAKAMBAKO , IRINGA TANZANIA. December.

[14]. Kebacho, L. L., Nyamtera, J., & Hamadalnel, M. (2026). Climatological rainfall patterns in Tanzania: harmonic analysis approach. Arabian Journal of Geosciences, 19(4), 65. https://doi.org/10.1007/s12517-026-12480-w

[15]. Luickx, P. J., Delarue, E. D., & D'haeseleer, W. D. (2010). Impact of large amounts of wind power on the operation of an electricity generation system: Belgian case study. Renewable and Sustainable Energy Reviews, 14(7), 2019–2028. https://doi.org/https://doi.org/10.1016/j.rser.2010.03.018

[16]. Msoka, W. H., & Pauline, N. M. (2025). The Role of Climate Services in Managing Climate Risks in Hydropower : Insights from Kidatu Hydroelectric Power Plant , Tanzania. 51(2), 310–327.

[17]. Mwinuka, P. J., Uiso, C. B. S., Chang, L. B., & Mwingereza, J. (2021). Atmospheric Instability Conditions during Rainy Seasons over Tanzania. 47(5), 1647–1659.

[18]. Ponce-Jara, M. A., Ruiz, E., Gil, R., Sancristóbal, E., Pérez-Molina, C., & Castro, M. (2017). Smart Grid: Assessment of the past and present in developed and developing countries. Energy Strategy Reviews, 18, 38–52. https://doi.org/https://doi.org/10.1016/j.esr.2017.09.011

[19]. Poncian, J., & Pedersen, R. H. (2023). Resource nationalism and energy transitions in lower-income countries: the case of Tanzania. Review of African Political Economy, 50(177–178), 355–373. https://doi.org/10.1080/03056244.2023.2287878

[20]. Wei, J., Hulio, Z. H., & Rashid, H. (2018). effects on wind turbine components and energy generation Site specific assessment of wind characteristics and determination of wind loads effects on wind turbine components and energy generation. https://doi.org/10.1108/IJESM-10-2017-0007

[21]. Wen, J., Zheng, Y., & Donghan, F. (2009). A review on reliability assessment for wind power. Renewable and Sustainable Energy Reviews, 13(9), 2485–2494. https://doi.org/https://doi.org/10.1016/j.rser.2009.06.006

[22]. G. Eason, B. Noble, and I.N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (*references*)

[23]. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[24]. I.S. Jacobs and C.P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.