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Economic Utilization Of Wind Energy As An Alternative Power For Yola

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--***ABSTRACT***--
This paper is aimed at assessing the economic use of wind energy in Adamawa State, Nigeria. The Total average wind speed per year, per study areareveals that Yinagu (74.1km/h), Wuro ledde (73.9km/h), Jabilamba (67.3km/h), Malabu (68.4km/h), Ngurore (66.2km/h), and Lamurde (88.5km/h). Study shows that for these 10 year periods, Jabilamba has the minimum average wind speed observed in the average moths of January 48.3km/h; while Lamurde has the maximum of 121km/h. The 10 Years Total Mean Speed Per Month for the six Study Areas from January to December (65.3, 76.2,86.3, 85.3, 86.6, 85.7, 79.0, 72.3, 62.6, 57.6, 58.2, and 57.9 respectively). Factors used in harnessing wind energy based on the equations and existing standards are contained.

Key words: *Wind, wind speed, wind energy, wind turbine.*

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I. INTRODUCTION

Wind is the air moving across the earth surface with different velocities at different times. Wind has much impact on nature, it can create ocean waves that can damage ships, wind can cause erosion, it can blow up structures and can as well be used as a source of energy.

Winds are mainly caused by the unevenly level of solar radiation that falls on different regions of the earth. Differential air pressure causes convection current by which the cool air in the poles is drawn towards the equator to replace the warm air which rises and moves towards the poles. These major flows are affected by rotation of the earth, (Tizhe 2013)

Windis described as the air motion over the ground which has direction and speed. Wind direction is measured with familiar wind vane while the wind speed is measured with an anemometer. A common measure of the wind speed is the knot (kt), and one knot is equal to the speed of one nautical mile per hour. There are sixty nautical miles in one degree of latitude. One knot = 1.15 standard miles or 1kt = 1.85km/h (Encyclopedia Americana, vol.29).

Wind energy being one of the renewable energy resources is infinite and cost free, it occurs naturally in everyenvironment. It is easier to utilize than the fossil fuels for water pumping purposes in the rural areas. This is because the cost fossil fuels are always on the rise or increase as the population and demand increases and every individual looks forward to a better way of living.

Though one of the oldest, and widely used sources of energy utilized in water transport system, the abundance of fossil fuels has greatly limited its dominance and full utilization in the energy sector. Withmodern technology on a large scale on wind power projects, its pursuance as a free renewable energy source cannot be apprehended (Eugene, et'al, 1997).

Wind energy has been applied for wind powered water pump. This application had been used in China as far back as 2000 BC. The principle is still under development as new technological researchers are being carried on. (Encyclopaedia,1992/93)

Severalforces that influence and create wind mightinclude: -

- Weight- this is the force that always act downward the center of the earth and produce downward acceleration due to gravity of 32feet or 9.8m/s.
- Pressure gradient: isthe force at atmospheric pressure between any two locations divided by the distance between them. The vertical part of the pressure gradient force (pressure decreases upward) tends to balance the downward acceleration of gravity. this is called hydrostatic balance. In intense thunder storm, however, air may accelerate to up and downward speeds of tens of meters per second. The strong up drafts and down drafts in the storm can be very dangerous to aircrafts when encountered. Thus, the greater the difference between locations, the greater the wind speed.

- **Coriolis forces:** wind described as the effect produced on a moving body by the earth's rotation; acts to deflect winds to the right of the path of motion in the northern hemisphere and to the left in the southern hemisphere. Coriolis forces varies in magnitude from zero at the equator to a maximum at the poles.
- **Frictional forces:** results when individual air molecules rub against each other or the ground, hence slows the motion of the wind.

Wind energy is now a significant consideration in the planning and developing of the modern electric system. In the united states, wind energy output grew as a sector ten times faster than the combination of all other forms of electric system, experiencing wind industry installation of more wind turbines in the recent years (Kimball, 2010).

The wind energy can be easily being converted into useful work directly depending on the following parameters:

- Wind velocity, v(m/s)
- Area of the wind falling with the span of the wind mill rotor A, (m^2)
- Proportion of available power extracted by the blade, P(kw)
- Overall efficiency.

Mathematically expressed as, $P = \frac{1}{2}\rho A v^2$, where ρ = density of air, A = area, V = velocity, P = power. (Twidell, 1986).

The application of wind energy has advanced during the recent years.

- Wind electric generating plants (small and large scales) have been operated for several years with rated power capacities of about 3MW to 4MW. This can be used to produce electricity over twenty-year life time. It is used for fertilizer production.
- It is used to produce heat through friction using the system of turbulent fluid system.
- Windmill (Dutch mill) is used for commercial milling in direct mechanical system i.e. in grinding or grain milling.
- The mechanical energy in the wind is used for sea transport to sail ships and also some propeller of air planes is driven by wind energy
- Domestic needs for cooking, lighting, water pumping. Water heating, refrigeration.
- Community needs for hospitals, clinics, school, barracks etc.
- Industrial/commercial use for small scale to medium industries, shops, banks, restaurant, etc (Sambo, 2005).

Therefore, the evaluation of wind energy as an alternative source of power generation and utilization, using the six locations as study area in Adamawa state becames necessary. The study areas are: Yinagu (Madagali Local govn't.) ; Wuro Ledde (Maiha Local government); Jabilamba (Girei local Government); Malabu (Fufore local government); Ngurore (Mayo belwa Local government); and Savanna (Lamurde local Government) respectively.

Table 1: Global location of Study Areas in Adamawa State.

S/NO.	SAMPLES	CO'ORDINATE
1	YINAGU	10^0 53' N; 13^0 38'E
2	WURO - LEDDE	10^0 16' N; 12^0 16'E
3	JABILAMBA	9^0 21'N; 12^0 32'E
4	MALABU	9^0 32'N; 12^0 26'E
5	NGURORE	9^0 28'N; 13^0 05'E
6	LAMURDE	9^0 28'N; 12^0 03'E

II. METHODOLOGY

The mean wind speed for twelve calendar monthsover a period of ten years, and its total average wind speed in the six primary locations were obtained. The wind turbine, and general wind power algorithms and applications were examined as deemed necessary.

Table 2.: - Mean wind speed (Km/h) of 12 months, for period of 10 years and its total average for the six study areas from Adamawa State, Nigeria. (weather station of Modibo Adama federal university of technology yola)

Mean wind speed (Km/h) of 12 months, for period of 10 years from 2007 to 2016												
Study Area	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Yinagu	**67.9**	**74.3**	**88.0**	**84.5**	**89.4**	**85.0**	**79.6**	**71.9**	**64.0**	**58.8**	**56.9**	**68.3**
Wuro ledde	**69.1**	**74.3**	**83.2**	**97.1**	**87.4**	**85.2**	**79.6**	**69.1**	**64.5**	**59.3**	**57.1**	**60.6**
Jabilamba	**48.3**	**61.0**	**98.0**	**96.8**	**89.9**	**82.4**	**69.7**	**66.5**	**50.5**	**48.5**	**47.9**	**47.5**
Malabu	**58.0**	**79.6**	**76.5**	**86.5**	**96.0**	**79.5**	**61.5**	**62.5**	**67.5**	**51.5**	**51.5**	**50.0**
Ngurore	**52.0**	**56.0**	**71.0**	**81.0**	**78.8**	**82.8**	**84.0**	**66.0**	**58.0**	**69.0**	**51.8**	**43.7**
Lamurde	**96.2**	**112.**	**121**	**66.0**	**78.0**	**100**	**99.7**	**98.1**	**71.1**	**58.2**	**84.1**	**77.2**

Harnessing of Wind Energy.

The methods used in harnessing wind energy includes the use of multi-bladed wind mills; the use of Darrieus wind mills; the use of Dutch mills; the use of the Savonius rotor; the use of cup anemometers; the use of single or two bladed mills; All these methods are based on the same principles but differ in their applications. The wind turns the blades and it turns the shaft which produces mechanical energy to drive the device coupled to extract the wind power which may be used as electrical or mechanical energy. (Tizhe, 1013).

Wind Power and Its Conversion

Wind power for home uses are small scale power system suitable for providing electricity or mechanical power. Small scale systems generally include a propeller and DC generator rated in the range from 50 to 600wtts, a tail vane keeps the propeller rotation plane perpendicular to the wind direction, a steel tower 10 to 100feet, (3 – 30m) high, a set of 20 or more lead-acid storage wind batteries charged by the generator to produce electric power when there is little or no wind, and an inverter that converts dc to ac currents. This is practical where the wind speed is at an average of 8miles (13km) per hour. (Encyclopedia Americana, vol.29).

Wind Turbines.

Wind turbines are the essential ingredient in the wind energy conversion system; it was traditionally called the wind mill. We have the predominant configurations of the horizontal axis and the vertical axis wind turbines, (HAWT and VAWT) respectively. (Eugene.A,1997)

Vertical Axis Machines:

The vertical axis types rotate with its axis parallel to the shaft. They are omnidirectional and need not be guided into the wind. They can accept wind from any direction. These types can have their pump or turbine coupled directly at the ground level.

The major disadvantages are – they usually suffer fatigue failures which arises from natural resonances in the structure; unwanted power fluctuation appear with the output due to periodic variation of torque within the cycle. Some examples of verticalaxis machines are: Cup Anemometer, Savonius Rotor, and Darrieus Rotor.

Horizontal axis machine

The horizontal axis type rotates with its axis perpendicular to the shaft or to the ground. They need to be guided into the wind i.e. to maintain orientation. They need a tail such as side facing fan tail rotors. The blades on the rotors are either in front (upwind) or behind (downwind) of the tower.

Downwind rotors may be quite seriously affected by the towers which produce wind shadow and turbulence in the blade path. Perturbation of this kind causes cyclic stress on the structure, noise and output fluctuations. Wind may be expected to veer frequency in a horizontal plane and the rotor must turn to follow the wind without oscillation. These type of devices are either single bladed or more. (Twidel l & weir 1986).

III. THE GENERAL ALGORITHM OF WIND POWER

The general principle of wind powered devices can be established by the fundamental relationship illustrating the availability and transfer of power from the wind to the shaft power. The wind passing through the wind mill is altered from an upstream velocity V, to a wind speed v_1 (which is the speed of the wind actually passing through the rotor) and finally to a far distance downstream wind speed v_2(which is the speed at a far distance downstream from the rotor). The mass of air passing through the rotor in unit time is m, this expressed as

$m = \rho AV$……………………………………………………………………(5)

Where $\rho = \text{dencity of air at } 21^0$

A = sectional area of wind device

The rate of change of momentum is given by

Mu = m $(v_1 - v_2)$ ……………………………………………………..(6) (Which is equal to the thrust).

The power absorbed is therefore given as:

$P = m\,(v_1 - v_2)\,V$

$= \rho AV\,(v_1 - v_2)$ ………………………………………………..….(7)

Rate of change of kinetic energy is:

$\frac{1}{2}m(v_1^2 - v_2^2)$ ….………. (8)

By equating equations (3) & (4), we get

$V = \left(\frac{V_1 - V_2}{2}\right)$………………………………………………………….(9)

Therefore, substituting for V in (3), we have power,

$P = \frac{\rho A(V_1 - V_2)^2(V_1 - V_2)}{2}$…………………………………………………. (10)

$= \frac{\rho A V_1^3}{4}[(1+\propto)(1-\propto)]$ ……………………………………… …… (11

Where $\propto = \frac{V_2}{V_1}$.. (12)

= ⅓ for maximum power

∴Maximum power $Pm = \frac{8}{27}\rho AV_1^3$ ……………………………………………(13)

When compared with original power in the wind,

$P = ½\,\rho AV_1^3$, a perfect windmill will extract about $\frac{16}{27}$ or approximately 59.3% of the wind power.

The power produced for a given diameter of the device may be increased by concentrating wind from a larger area, and also by having a diffuser coupled downstream of the device. The two can produce higher efficiency than the Betz method. However, the efficiency should be calculated on the bases of swept area of the diffuser or concentrator (Dixon, 1979).

The procedure for comparing the relative performance and relative stability for different types of application is usually done by plotting the efficiency verse quantity known as the tip speed ratio⋌. This is expressed as.

$\lambda = \frac{DN}{2V1}$ ………………………………………………………………… (14)

Where DN = Tip speed

D = Diameter of rotor

N = No. of revolution

The efficiency is normally given as a power coefficient Cp. This is expressed as

$C_p = \frac{p_m}{p\frac{1}{2}\rho AV_1^3}$

T = P/N ………………………………………………………. (12)

P = power

N = Number of revolution

The non-dimensional torque coefficient C_T can be expressed as

$C_T = C_p/\lambda = \frac{T}{\frac{1}{2}\rho V_1^2\pi\left(\frac{D}{2}\right)^3}$

If the torque has a none -zero value at zero revolution per minute, the device is self-starting.

RESULTS.

From the research conducted over the period of ten years between 2007 to 2016, and the result showing theaverage wind speed for 12 months over 10-year period.

Table 3: Total average wind speed per year, per study area for period of 10 years from 2007 to 2016.

Mean wind speed (Km/h) of 12 months, for period of 10 years from 2007 to 2016													**Total averagewind speed per 10 year, per study area.**
Study Area	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	
Yinagu	**67.9**	**74.3**	**88.0**	**84.5**	**89.4**	**85.0**	**79.6**	**71.9**	**64.0**	**58.8**	**56.9**	**68.3**	74.1
Wuro ledde	**69.1**	**74.3**	**83.2**	**97.1**	**87.4**	**85.2**	**79.6**	**69.1**	**64.5**	**59.3**	**57.1**	**60.6**	73.9
Jabilamba	**48.3**	**61.0**	**98.0**	**96.8**	**89.9**	**82.4**	**69.7**	**66.5**	**50.5**	**48.5**	**47.9**	**47.5**	67.3
Malabu	**58.0**	**79.6**	**76.5**	**86.5**	**96.0**	**79.5**	**61.5**	**62.5**	**67.5**	**51.5**	**51.5**	**50.0**	68.4
Ngurore	**52.0**	**56.0**	**71.0**	**81.0**	**78.8**	**82.8**	**84.0**	**66.0**	**58.0**	**69.0**	**51.8**	**43.7**	66.2
Lamurde	**96.2**	**112.**	**121**	**66.0**	**78.0**	**100**	**99.7**	**98.1**	**71.1**	**58.2**	**84.1**	**77.2**	88.5

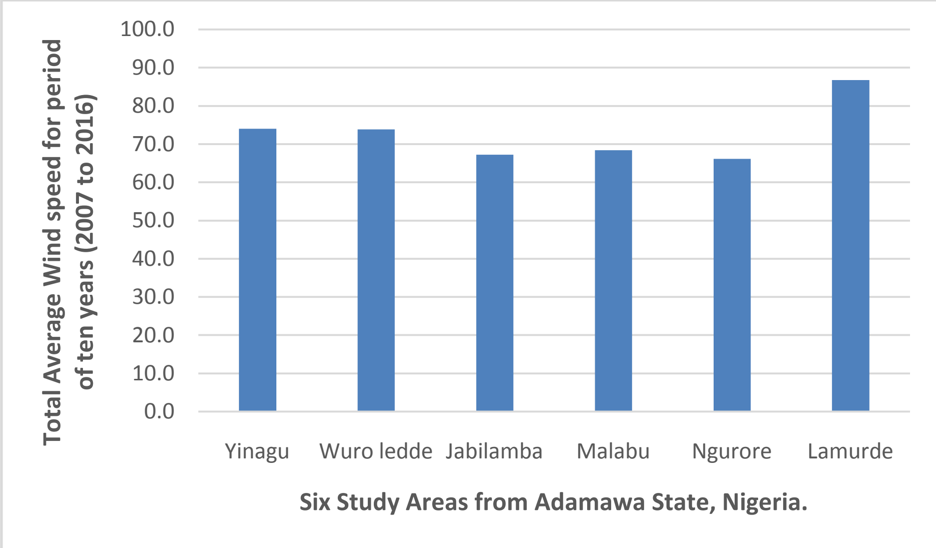

Figure 2: A chart of Total average wind speed per year, per study area for period of 10 years from 2007 to 2016.

Table 4: Total Mean wind speed (Km/h) Per Month per period of 10 years from 2007 to 2016 for the six Study Areas

Mean wind speed (Km/h) of 12 months, for period of 10 years from 2007 to 2016												
Study Area	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Yinagu	**67.9**	**74.3**	**88.0**	**84.5**	**89.4**	**85.0**	**79.6**	**71.9**	**64.0**	**58.8**	**56.9**	**68.3**
Wuro ledde	**69.1**	**74.3**	**83.2**	**97.1**	**87.4**	**85.2**	**79.6**	**69.1**	**64.5**	**59.3**	**57.1**	**60.6**
Jabilamba	**48.3**	**61.0**	**98.0**	**96.8**	**89.9**	**82.4**	**69.7**	**66.5**	**50.5**	**48.5**	**47.9**	**47.5**
Malabu	**58.0**	**79.6**	**76.5**	**86.5**	**96.0**	**79.5**	**61.5**	**62.5**	**67.5**	**51.5**	**51.5**	**50.0**
Ngurore	**52.0**	**56.0**	**71.0**	**81.0**	**78.8**	**82.08**	**84.0**	**66.0**	**58.0**	**69.0**	**51.8**	**43.7**
Lamurde	**96.2**	**112.**	**121**	**66.0**	**78.0**	**100**	**99.7**	**98.01**	**71.1**	**58.2**	**84.1**	**77.2**
10 Years Total Mean Speed Per Month for the six Study Areas	65.3	76.2	89.6	85.3	86.6	85.8	79.0	72.4	62.6	57.6	58.2	57.9

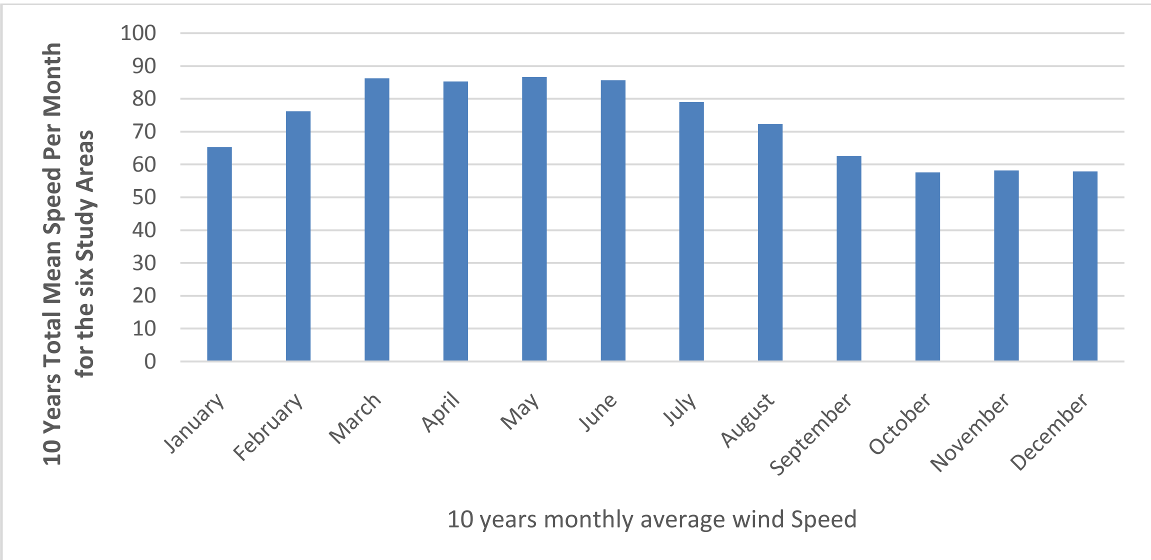

Figure 3: Showing the Total Mean wind speed (Km/h) Per Month per period of 10 years from 2007 to 2016 for the six Study Areas

IV. DISCUSSION OF RESULTS

The result from Table (3) shows that the average minimum wind speed of 48.3km/h in month of January was experienced in Jabilamba; and the maximum of 121km/h in the month of March, in Lamurde. This is his high enough and above the minimum needs for a domestic use.However, the amount of wind speed needed to generate a power 50 to 600watts is 13km/h at the height of 3 to 30meters. Therefore, the research shows that an average 2,229watts (2.23kw) can be produced with one wind turbine, and utilizing ten wind turbines, average of 20kw would be generated.

Figure 2 above revels that total average wind speed per 10 years, per study area; indicating Ngurore with 66.2kw/h as minimum, and Lmurde 88.5 yhe maximum.

Again the total average of wind speed per month, the minimum average speed occurs at the month of September with 62.5km/h, and the highest is at the month of May with an average speed of 86.6km/h as indicated on table (4), and Figure 3.Wind energy being available throughout the two seasons can be harnessed for all domestic small scale entrepreneurship developments and usage within Adamawa state communities. It is cost free and in abundance compared to the fossil fuel which is depreciating in abundance and always on increase in price posing scarcity in most times of need.

V. CONCLUSION AND RECOMMENDATION

- Adamawa state situated in the north east of Nigeria has the abundance of free, non-depleting sufficient wind energy resources should at a state level strongly patronize the application of solar power as alternatively long planning power source for economic purposes.
- The state partnership with reputable international firms/ experts in wind power generation should be a mandate
- National wind power generation plants projects should be a mandate, and monitored for sincere and speedy execution.

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