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DETERMINATION OF ENERGY PRODUCTION POTENTIAL OF WIND RESOURCES IN LAUTECH OGBOMOSO, NIGERIA

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ABSTRACT
This work presents a study of wind resources in Ladoke Akintola University of Technology, Ogbomoso Area. The experimental measurement of wind speed and wind direction data were collected from Nigeria Meteorological Agency (NIMET) Oshodi, Lagos for a period of four years, 2006, 2007, 2008 and 2009. The annual mean wind speed of LAUTECH, Ogbomoso located on (Latitude 8^o 5' S and Longitude 4^o 12' W), was estimated to be 37.99m/s through the monthly wind speed and wind direction data collected. The annual energy capture potential of 1081.79MJ is obtained for a single wind power system applying the power law equation with MS visual basic programming Language. The obtained equivalent power potential of 123.99kW is a considerable amount when compared with power consumption of 1200kW utilized in Lautech Ogbomoso. It is then realized that the energy capture potential for a single wind turbine is 10.33% of the power consumption in Lautech through conventional energy source. Thus, we suggest that power potential from wind resources can be used to supplement the power potential of conventional energy in Lautech.
Keywords: Energy potential, power potential, Wind speed, Power law equation, wind turbine

INTRODUCTION
Wind energy is a form of converted solar energy. It simply means air in motion, which is caused by the uneven heating of the earth's surface by the Sun. The Sun's radiation heats several parts of the earth at different rates; different surfaces such as land, water, desert and forest areas absorb or reflect sun at different rates and most notably during the day and night. During the day, the air above the land heats up faster than the air over water. The warm air over the land, which is less dense, expands and rises, than the heavier, cooler air over the water which are more dense moves in to take its place, creating a conventional current known as winds. At night the motion of air is reversed because the air cools more rapidly over land than over water. Then, the large atmospheric air that enclose the earth are created because the land near the earth's equator is heated more by the sun than the land near North and South poles. The air has more energy when it is in motion [1]. It possesses the energy of their motion (kinetic energy). Some portions of that energy can be converted to other forms of energy. The energy that the windmills produce can be used in many ways, traditionally for grinding grain or spices, pumping water, sawing wood, hammering seeds, sailing and flying a kite [2]. Nowadays, wind energy is mainly used to generate electricity. Wind energy is one of the renewable energy sources, because the wind will blow as long as the sun shines. The good sites for wind plants are the tops of smooth rounded hills, open plain or shore lines and mountain gaps that produce wind tunneling due to their low friction

coefficients [3]. The wind turbine works in the opposite of an electric fan [4]. Instead of using electricity to generate wind, like a fan, wind turbines use wind to generate electricity. The wind turns the rotor, which spins a shaft and connects to a generator that produces electricity. The wind power plant operation is not as simple as just building a windmill in a windy place. It is important to consider how fast, how much of the wind blow and how much energy can be generated which form basis of this research. The various wind generator projects in Nigeria were neglected in the last decade due to increasing popularity and low price of crude oil. In recent times the high price of Petroleum products lead to attempt at restructuring these windmills [5] [6]. However, difficulties in obtaining spare parts for models which were no longer being manufactured hindered the restoration. Also, some other factors that led to the failure of past wind generators are the assessment of wind energy potentials, feasibility studies on wind energy utilization, inadequate wind data base used as the bases for designing and building different prototypes that need be considered in reducing locally manufactured windmills. This shows that total inherent energy of the wind is also determined by the following equation [7]:

$$P_{Total} = \frac{1}{2}\rho A u^3 \quad 1.1$$

where

P_{Total}: Total power (watts)

ρ: air density (kg/m^3)

A: Rotor Swept Area (m^2)

u: wind speed (m/s)

We assume density of air to be 1.225kg/m^3.

We use equation 2 for altitude varying wind speed and that relates the speed to the height assuming a low surface roughness. It provides an easy method for calculating the mean wind speed at a certain height and power law equation is given as

$$u = u_i \left[\frac{z}{z_i}\right]^{\frac{1}{7}} \quad 1.2$$

u = modified wind speed

u_i = wind speed data

z = height of turbine above ground level

z_i = normalize height.

There is increase in wind speed with increase in the height above the ground, due to the frictional drag of the ground, vegetation and buildings. It is important to put into consideration all these variables in order to harness the wind energy.

The use of wind power for the supply of electricity broadens the energy base and reduces environmental pollution. It is particularly practical if it can be made economically competitive with conventional energy sources [8].

The weibull probability distribution function with two parameters is given as

$$g(u) = \left(\frac{k}{c}\right)\left(\frac{u}{c}\right)^{k-1} \times e^{-\left(\frac{u}{c}\right)^k} \quad 1.3$$

where k is the shape parameter, c is the scale parameter employed to calculate the probability of mean wind speed.

This paper reveals that wind is viable renewable energy source for Lautech, Ogbomoso to supplement power potential from convectional energy.

MATERIALS AND METHODS

In this work, an average monthly wind speed was obtained from Nigeria Meteorological Agency (NIMET) Oshodi, Lagos for the period of 4 years 2006, 2007, 2008 and 2009.

In 2006, the wind speed ranges between 22.85ms^{-1} and 36.76ms^{-1}. The year 2007 had wind speed between 25.65ms^{-1} and 46.49ms^{-1}. The wind speeds between 27.89ms^{-1} and 52.68ms^{-1} were experienced in 2008, 23.16ms^{-1} and 40.68ms^{-1} in the year 2009.

The power law equation is employed to determine the wind speeds. And visual basic programming language was written to solve power law equation and equivalent digital data logger equation for Weibull Probability distribution function to determining total power and energy capture potential in Lautech Ogbomoso.

RESULTS AND DISCUSSION

We obtained annual average wind speed for the year 2006, 2007, 2008 and 2009 to be 29.79ms^{-1}, 30.29ms^{-1}, 34.36ms^{-1} and 27.93ms^{-1} respectively. Then, the annual average wind speed for the 4 years is calculated to be 30.59ms^{-1}. It is observed from the figure 1 that the wind speed sharply increases from the months of March. The maximum value of 47.71ms^{-1} wind speed is obtained in April 2008 from the wind which blew from south direction. The minimum wind speed of 20.69ms^{-1} in December, 2006 from the wind, which blew south/south west direction. It could be revealed from figure 1 that the months of April produce the highest monthly average wind speed while the lowest monthly average wind speed are obtained in the month of November and December for each year. This is being attributed to the higher uneven heating of the earth surface causing air blowing from ocean through the land during the month of April compared to the months of November and December. These results indicate that the maximum power production of the wind power system can be obtained in the month of April; most especially when the wind blow in south direction and the minimum power production in November and December.

The significance effect can be observed in the months of March and April in Ogbomoso whereby wind blows off many roofs of buildings, breaks up and uproots trees and sometimes causes collapse of buildings and structures. Using power law equation the wind speed to the height assuming a low surface roughness of certain height is obtained. The average modified wind speed is 47.71ms^{-1}. Visual basic programming language was written to solve equivalent digital data logger for Weibull probability distribution function and these were used to determine average wind speed of 47.71ms^{-1} which were consequently used to determine the annual energy capture potential. The annual power production for each year are 105.61kW, 120.34kW, 175.66kW and 92.34kW for 2006, 2007, 2008 and 2009 respectively with the annual energy potential of 925.17MJ, 1054.21MJ, 1538.82MJ and 808.95MJ respectively. Then the average annual power production potential and energy capture potential for the period of four years are 123.99kW and 1,081.79MJ.

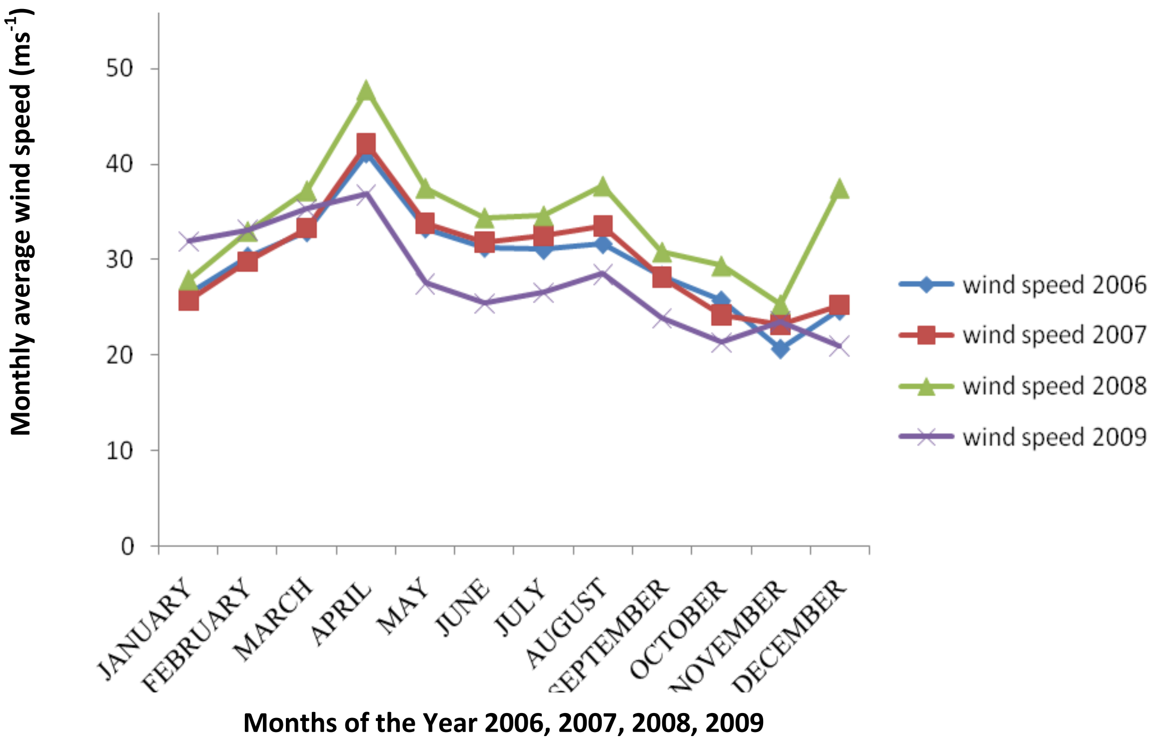
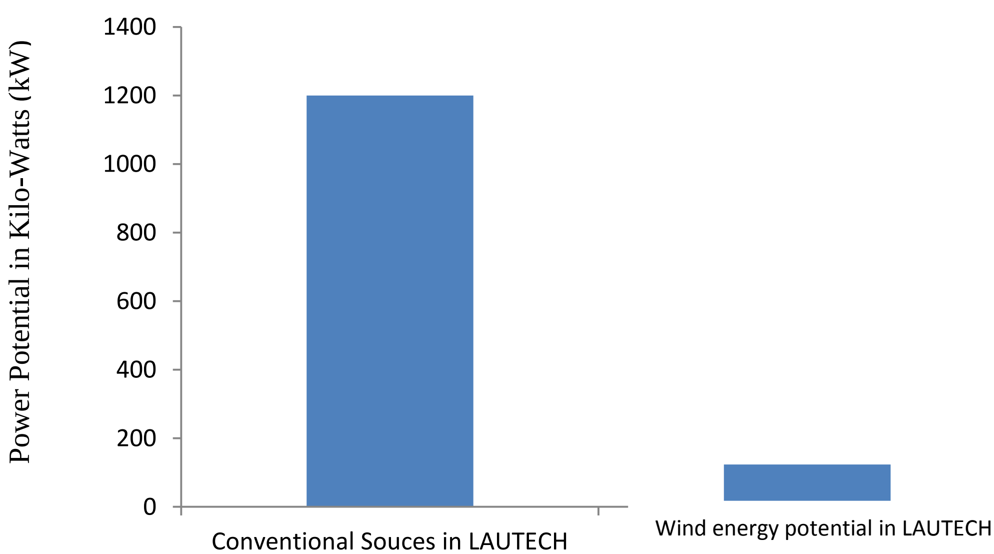


Figure 1: Graph of monthly average wind speed against months of the year, 2006-2005



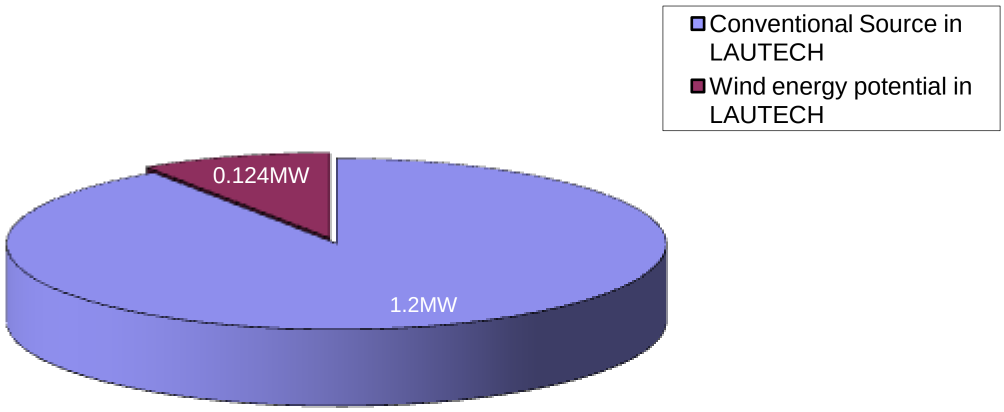


Figure 2: Graph of comparism of power potential between conventional and wind energy

Figure 2 shows the graph that compares the power potential between convectional energy source and wind source in Lautech Ogbomoso. Figure 3 reveals the pie chart representing the percentage of wind power potential to convectional energy source presently in use at Lautech Ogbomoso. The average annual power production of 123.99kW through a single wind turbine is relatively enough in generating electricity for a particular site. Presently, the annual power consumption in Ladoke Akintola University of Technology, Ogbomoso through convectional source of energy is 1.2MW. Our study results into the annual power production of 123.99kW, which is a considerable amount of energy production from a single turbine. We discover that the average annual energy capture potential for wind turbine for the period of 4 years is 10.33% of the power consumption in Lautech through convectional energy source as shown in figure 3. This is made possible as a result of enormous kinetic energy possess by wind, which is then converted into electrical energy through wind turbines. Perhaps, it could be seen from here that combination of many turbines would undoubtedly produce power that can meet up the needed power consumption in Lautech.

CONCLUSION

More often, erratic power supply, low output generation and incessant hike in petroleum prices, among many other factors that are common in our environment in generating electricity, we can then say that wind power system could be used to complement the present source of generating electricity in Lautech and its environs. This would totally improve the generation and distribution of electricity in Ogbomoso most especially when a wind farm is built.

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