

Wind Electric Power System in Edo State (Ekpoma)

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Abstract: The issue of electric power supply in the country has been a great concern because of incessant Electric power in the country. This study shows how wind electric power system can be achieved in Ekpoma. Wind electric turbine was designed to capture the kinetic energy in wind. The average wind speed in each day was recorded. The highest wind speed recorded was 120 mph and the lowest wind speed recorded was 90 mph. The gross total for each month was also recorded. The highest total wind speed was 3,262 mph and it was recorded for the month of January. The output of the generator, voltage = 220 V, current = 13.9 A, frequency = 50 Hz, power 8 kW. This research will be of benefit to independent electric power producers and investors who would want to invest in wind electric power generation (wind farm).

Key words: Rotor blades, wind electric power, wind flow, shaft, tower, power output

INTRODUCTION

The electric power supply in Nigeria has been a great national interest due to unstable electric power supply in the Country. The Federal Government of Nigeria has invested huge sum of money on the Power Holding Company of Nigeria (PHCN) with the desire to resolve this problem. This investment has not yielded a satisfying result, hence, the need for an alternative source of power supply.

The wind electric power supply, which is an alternative means of electric power supply, will help to alleviate the problem.

Energy has been a source of hope to man and every living thing. Based on our initial knowledge about science, energy cannot be created nor destroyed but rather change form one form to another. We need to harness the available natural energy around us to suit man's comfort on earth.

A stable and reliable electric power supply system is an inevitable pre-requisite for any developing nation, especially a developing place like Ekpoma.

It's hard sometime to imagine air as a fluid. It's just seems so invisible. But air is a fluid like any other except that its particles are in gaseous form instead of liquid. When air moves at a fast rate in the form of wind, those particles are also in motion. Motion means kinetic energy, which can be captured, just like the turbine in a hydroelectric dam can capture the energy in moving water. In the case of a wind-electric turbine, the turbine

blades are designed to capture the kinetic energy in wind. The rest is nearly identical to a hydroelectric setup. When the turbine blades capture wind energy and start moving, they spin a shaft that leads from the hub of the rotor to the generator. The generator turns that rotational energy into electricity. Generally, generating electricity from the wind is all about transferring energy from one medium to another.

Wind power starts with the effect of the sun. When the sun heats up a certain area of land, the air around that land mass absorbs some of the heat. At a certain temperature, that hotter air begins to rise very quickly because a given volume of hot air is lighter than an equal volume of cooler air. Faster-moving (hotter) air particles exert more pressure than slower-moving particles. When that lighter hot air suddenly rises, cooler air flows quickly to fill the gap the hot air leaves behind. That air rushing to fill the gap is wind (Howstuffworks, 2008).

If you place an object like a rotor blade in the path of that wind, the wind pushes on it, transferring some of its own energy of motion to the blade. This is how a wind turbine captures energy from the wind. The same thing happens with a sail boat. When moving air pushes on the barrier of the sail, it causes the boat to move. The wind has transferred its own energy of motion to the sail boat. Wind electric turbine was designed to capture the kinetic energy in wind. On a global scale, wind turbines are currently generating about as much electricity as 8 large nuclear power plants in the world (Howstuffworks, 2008).

Table 1: Average wind speed for each day and gross total per each month

No. of days	January	February	March	April	May	June	July	August	September	October	November	December
1	95	105	98	98	105	98	95	98	94	94	98	98
2	90	105	98	95	105	98	90	94	95	95	98	98
3	100	105	98	95	105	95	96	94	94	96	98	98
4	100	98	96	95	105	96	98	94	94	96	100	102
5	120	98	98	96	98	96	98	98	94	96	100	102
6	105	95	98	98	98	98	96	96	94	98	100	100
7	105	95	98	98	98	95	96	96	96	98	100	102
8	104	95	98	98	98	95	96	96	96	98	100	102
9	102	98	96	102	98	90	96	95	105	100	102	104
10	105	98	96	102	100	95	98	95	102	103	102	104
11	98	98	96	102	100	95	98	94	103	94	102	104
12	98	105	98	98	100	95	98	94	98	96	104	108
13	98	105	98	101	98	98	90	94	95	97	104	108
14	102	105	98	101	98	96	90	94	96	98	104	108
15	98	98	96	96	105	98	98	98	98	98	105	105
16	98	105	96	96	105	96	110	105	96	100	110	105
17	105	105	96	98	100	96	110	96	96	100	105	98
18	105	105	98	98	100	96	94	96	96	98	110	110
19	105	98	98	96	120	96	90	105	98	98	98	110
20	100	98	98	100	98	98	94	105	105	96	100	110
21	100	98	98	100	98	98	105	96	105	98	100	105
22	105	105	94	100	98	98	100	96	105	98	100	105
23	105	105	94	96	105	98	90	98	98	100	110	100
24	105	98	94	96	105	90	94	98	98	98	105	100
25	100	105	94	98	98	90	96	96	96	98	105	98
26	108	98	96	98	98	96	96	96	94	95	105	105
27	98	98	98	98	98	96	100	96	94	100	98	105
28	98	-	96	98	120	98	98	96	86	98	105	105
29	100	-	96	96	98	98	96	98	96	98	110	110
30	102	-	96	96	110	98	96	98	96	98	110	110
31	108	-	98	-	98	-	96	96	-	98	-	105
Total wind speed in each month	3.262	2.544	3.000	2.939	3.160	2.875	2.998	3.000	3.037	3.027	3.092	3.226

Records of the wind speed in Ekpoma were taken daily. The daily record collected was based on the average of the wind speed per day, which was measured in mph.

Anemometer was used to measure the wind speed in the proposed Ekpoma site for a duration of a year (1st January 2007-31st December 2007). The result is shown in Table 1.

WIND ELECTRIC POWER SYSTEM

Not only utility-scale turbines, but also small turbines generating electricity for individual homes or business.

A typical large wind turbine can generate up to 1.8 mW of electricity or 52 million kwh annually, under ideal conditions that will be enough to power nearly 600 household. Still, nuclear and coal power plants can produce electricity cheaper than wind turbines can. So, why use wind energy? The two major reasons for using wind to generate electricity are the most obvious ones. Wind power is clean and it's renewable. It doesn't release harmful gases like CO₂ (carbon oxide) and nitrogen oxides into the atmosphere the way coal does and we are in no danger of running out of wind anytime soon. There is also

the independence associated with wind energy, as any country can generate it at home with no foreign support. A wind turbine can bring electricity to the remote part of Ekpoma not served by the national electric power grid (Howstuffworks, 2008).

Block diagram of wind electric power system: The wind electric power system is made of three major segments. The blades are basically the sail of the system, in their simplest form; they act as barriers to the wind. When the wind forces the blades to move, it transfers some of its energy to the rotor. The input, which is wind, move against the blades, the blades is attach to the rotor which is centrally mounted on the shaft (Fig. 1).

The rotor blades are of two difference types they are:

- Horizontal axis.
- Vertical axis.

Vertical-Axis Wind Turbines (VAWTs) are pretty rare. The only one currently in commercial production is the Darrieus turbine, which looks like an egg beater. In a VAWT, the shaft is mounted on a vertical axis, perpendicular to the ground. VAWT are always aligned

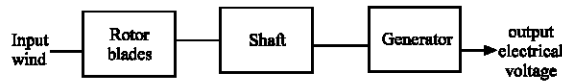


Fig. 1: Block diagram of wind electric power supply

with the wind, unlike their horizontal axis counterparts, so there's no adjustment necessary when the wind direction changes; but a VAWT can't state moving all by itself, it need a boost from it electrical system to get started. Instead of a tower, it typically uses guy wires for support, so the rotor elevation is lower. Lower elevation mean slower wind due to ground interference, so VAWT are generally less efficient than HAWTs (Howstuffworks, 2008).

The wind-turbine shaft is connected to the shaft spins as well. In this way, the rotor transfers its mechanical, rotational energy to the shaft, which enters electrical generator on the other end. The shaft has direct coupling with the generator. The rotor blades, shaft, generator are all mounted on top a tower for optimum elevation for wind speed (and so the blades can clear the ground) and take up very little ground space since almost all of the components are up to 260 feet (80 m) in the air (Wind Power-Wikipedia, 2002; Howstuffworks, 2008).

Turbine aerodynamics: Sometime, most blades relied mostly on the wind's force to push the blades into motion, modern turbines use more sophisticated aerodynamic principle to capture the wind's energy most effectively. The two primary aerodynamic forces at work in work-turbine rotors are lift, which acts perpendicular to the direction of wind flow and drag, which acts parallel to the direction of wind flow (Fig. 2).

Turbine blades are shaped a lot like airplane wings, they use an airfoil design. In an airfoil, one surface of the blade is somewhat rounded, while the other is relatively flat lift is a pretty complex phenomenon, but in one simplified explanation of lift, when wind travels over the rounded, downwind face of the blade, it has to move faster to reach the end of the blade in time to meet the wind traveling over the flat, upwind face of the blade (facing the direction from which the wind is blowing). Since faster moving air tend to rise in the atmosphere, the downwind, curved surface end up with a low-pressure pocket just above it. The low-pressure area sucks the blade in the downwind direction, an effect known as lift. On the upwind side of the blade, the wind is moving slower and creating an area of higher pressure that pushes on the blade, trying to slow it down. Like in the design of an airplane wing, a high lift-to drag ratio is essential in designing an efficient turbine blade. Turbine

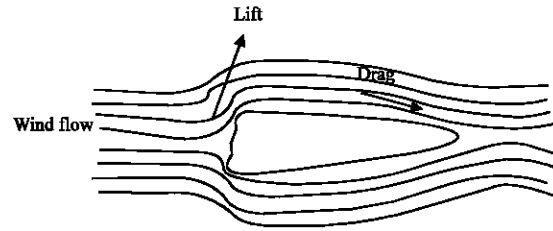


Fig. 2: Airfoil design

blades are twisted so they can always present an angle that takes advantage of the ideal lift-to drag force ratio (Wind Power-Wikipedia, 2002).

Aerodynamics is not the only design consideration at play in creating an effective wind turbine. Size matters, the longer the turbine blades (and therefore, the greater the diameter of the rotor), the more energy a turbine can capture from the wind and the greater the electricity-generating capacity. Generally, speaking, doubling the rotor diameter produces a four-fold increase in energy output. In some cases, however, in a lower-wind-speed area, a smaller-diameter rotor can end up product more energy than a larger rotor because with a smaller setup, it takes less wind power to spin the smaller generator, so the turbine can be running at full capacity almost all the time (Wind Power-Wikipedia, 2002).

Tower height is a major factor in production capacity, as well. The higher the turbine, the more energy it can capture because wind speeds increase with elevation increase from ground friction and ground-level object interrupt the flow of the wind. Scientists estimate a 12% increase in wind speed with each doubling of elevation (Wind Power-Wikipedia, 2002).

DESIGN CONSIDERATION

In the design for this wind electric power requirement, certain factors were put into consideration:

- Efficiency and reliability of the system (wind electric power system).
- The system must enjoy and economical competitive advantages in terms of costing.
- The system must be easy to install and to use.
- Installation site.
 - The minimum wind speed obtain at 80 m 260 feet on site 90 mph.
 - The maximum wind speed obtain 120 mph.
 - Avoid ground interference.

Blades rotor: The blades are basically the sails of the system; in their simplest form they act a barriers to the

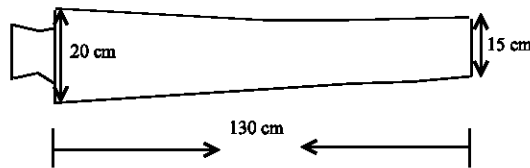


Fig. 3: Fan blade

wind. When the wind forces the blades to move, it captures wind's energy and converts it to rotational energy of shaft. They are made up light material such as aluminium, the diameter of each blades is 5 cm (Fig. 3).

They are 3 in numbers, separated with equal angle each.

Shaft: The wind- turbine shaft is connected to the centre of the rotor. When the rotor spins, the shaft spins as well. In this way, the rotor transfers its mechanical, rotational energy to the shaft, which enters an electrical generator on the other end. The shaft is made of iron pipe, the shaft length is 2 cm (Fig. 4).

Generator: A.C generator or alternator (as they are usually called) operates on the same fundamental principles of electromagnetic induction as D.C generators. They also consist of an armature winding and a magnetic field. But there is one important difference between the two. Whereas, in D.C generators, the armature rotates and the field system is stationary, the arrangement in alternators is just the reverse of it. In their case, standard construction consists of armature winding mounted on a stationary element called stator and field winding on a rotating element called rotor. The armature winding in alternator are different from those used in d.c. machines. The D.C machine have closed. Circuit wind but alternator winding are open, in the sense that there is no closed path for the armature currents in the winding itself. One end of the winding is joined to the neutral point and the other is brought out. The two types of armature winding most commonly used for 3-phase alternators are (Theraja and Theraja, 2005).

- Single-layer winding.
- Double-layer winding.

Properties of the generator used.

- Type STC-8, No 20052.
- Power 8 kW, $\cos\theta$ 0.8.
- Voltage 220 V.
- Current 13.9A.
- Frequency 50 Hz.
- Speed 1500 r min⁻¹.

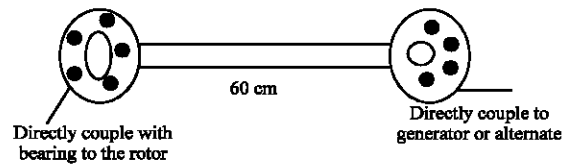


Fig. 4: Shaft (transmission coupler)

- Excitvoltage 100 v.
- Excitcurrent 4 A.
- Connection Y.
- Single phase.

Tower height: The tower is made of iron; having a height of 80 m (200 feet). Also, having a channel of climbing case of asses to the alternator, coupling, fan blade, rotor. They have four base iron which is brazed with iron on different iron base. Output cable wire run from the alternator to the AVR (Automatic Voltage Regulator) then to the voltage double to the distribution AC point (Howstuffworks, 2008).

Calculating power output: The measurement of air in our environment is very important, before carrying out the power output calculation, we need to carry out series of air measurement on different locations and the altitude must be put into consideration.

To install wind electric power supply, it requires minimum wind speeds of 9 mph (3 m sec⁻¹) for small turbines and 13 mph (6 m sec⁻¹) for large turbines. The kinetic energy in wind increases exponentially in proportion to its speed, so a small increase in wind speed is in fact a large increase in power potential. The general rule of thumb is that with a doubling a wind speed comes an eight-fold increase in power potential. So theoretically, a turbine in an area with average wind speed of 26 mph (Howstuffworks, 2008; Ambrose Alli University Research Unit Log Book, 2007; Horowitz and Hill, 2004).

Most of the energy stored in the wind movement can be found at high altitudes where continuous wind speed of significant amount is found (Wind Power-Wikipedia, 2002; Howstuffworks, 2008; Benin Airport Station Log Book, 2007).

The daily record collected was based on the average of wind speed per day, which was measured in mph.

Anemometer was used to measure the wind speed in the proposed Ekpoma site for a duration of a year (1st Jan 2007-31st Dec 2007), the result is shown in Table 1.

Electricity generated from wind power can be highly variable at several different time scale from hour to hour daily and seasonally. Annual variable also exists, but is not as significant. Because instantaneous electrical

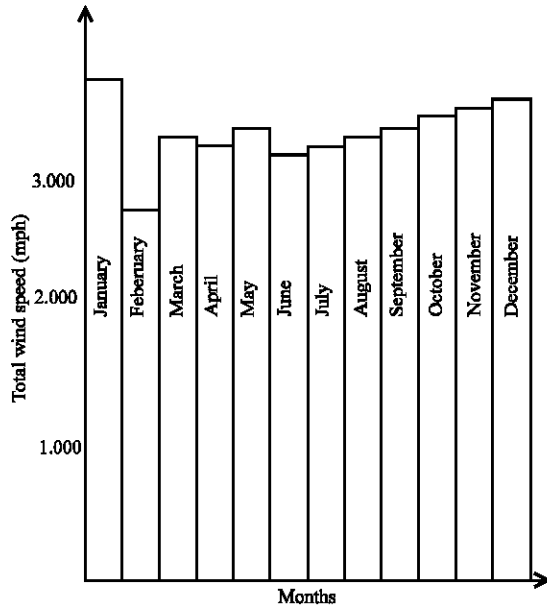


Fig. 5: Bar chart on total wind speed per month

generation and consumption must remain in balance to maintain grid stability, this variability can present substantial challenges to incorporating large amount of wind power into a grid system (Theraja and Theraja, 2005; Wind Power-Wikipedia, 2002; Howstuffworks, 2008). Intermittency and the non-dispatchable nature of wind energy production can raise cost for regulation, incremental operating reserve and (at high penetration levels) could require energy demand management, load shedding and storage technologies must be used to retain the large amount of power generated in the bursts for late use (Wind Power-Wikipedia, 2002). At low levels of wind penetration, fluctuation in load and allowance for failure of large generating unit requires reserve capacity that can also regulate for variable of wind generation. Pumped-storage hydroelectricity or other form of grid energy storage can store energy developed by high-wind period and release it when needed. Peak wind speeds may not coincide with peak demand for electrical power. In the Africa however, rainy season demand is higher than dry season demand and so are wind speeds. Solar power tends to be complementary to wind power (Wind Power-Wikipedia, 2002).

Operation of any utility-scale energy conversion system presents safety hazards. Wind turbines do not consume fuel or produce pollution during normal operation but still have hazards associated with their construction and operation.

There have been at least 40 fatalities due to construction, operation and maintenance of wind turbine, including both workers and members of the public

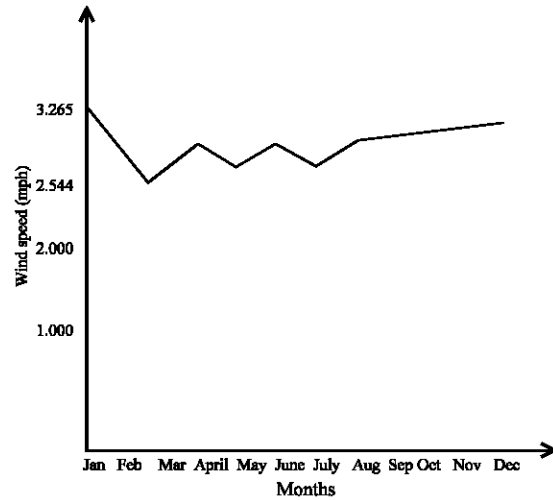


Fig. 6: Plot of wind speed against each month

and other injuries and deaths attributed to the wind power life cycle. Most worker deaths involve falls or becoming caught in machinery while performing maintenance inside turbine housings. Blade failure, a parachutist colliding with a turbine and small aircraft crashing into support structures. Other public fatalities have been blamed on collisions with transport vehicles and motorists distracted by the sight and shadow flicker of wind turbine along highways (Wind Power-Wikipedia, 2002).

Electronic controllers and safety sub-system monitor may different aspects of the turbine, generator, tower and environment to determine if the turbine is operating in a safe manner within prescribed limits. These systems can temporarily shut down the turbine due to high wind, electrical load imbalance, vibration and other problems. Recurring or significant problems cause a system lockout and notify an engineer for inspection and repair. In addition, most system includes multiple passive safety systems that stop operation even if the electronic controller fails (Wind Power-Wikipedia, 2002).

From data and bar chart (Fig. 5), the month of January has the highest wind speed as 3.262 mph, this is base on the wind North-East winds. Since, the wind speed is proportional to the quantity of electricity generated, the electricity generated was highest in January. The month of may was observed to be the third highest, reason was base on the change of season which is rainy-season, South West wind at the period from the Atlantic-ocean. The output of the generator; power 8 kW, voltage 220 V, current 13.9 A, frequency 50 Hz (Fig. 5 and 6).

The wind Electric power is reliable therefore, both the Government and the private sector should invest in (wind farm) power to upgrade the national grid in Nigeria.

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