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Technical Loss Reduction Using Wind Turbine In A Distribution Network

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***Abstract*—Nigeria's electric power sector requires substantial reform if the country's economic development and poverty alleviation programme is to be realized. Currently, the country faces serious energy crisis due to declining electricity generation from domestic power plants which are basically dilapidated, obsolete, and in an appalling state of disrepair, reflecting the poor maintenance culture in the country and gross inefficiency of the public utility provider. This paper presents a study of the effect of wind turbine in a Distribution Network in reducing technical losses in Eighty Five (85) bus system.**

Keywords—Global Wind Energy Council (GWEC), Wind Electric Generator (WEG),Wind Turbine, National Aeronautics and Space Administration (NASA), Wind energy conversion systems (WECS).

I. INTRODUCTION

With the renewable sources of energy available today for an era of electrical power, wind energy stands out in the light of the fact that there is no pollution, there is a short gestation period required and fairly low capital expense included. Wind controlled systems have been exhaustively utilized since the tenth century for water pumping, grinding grain and other low-power applications. There were a few attempts to assemble extensive-scale wind powered systems to make power. The Russians assembled a vast windmill of 100 ft (30.5 m) breadth sharpened steel (blade) in 1931. The National Aeronautics and Space Administration (NASA), in conjunction with the Energy Research Development Agency (ERDA), has manufactured and tested a huge number of large wind-powered generators. The first machine was 100 kW unit developed at Sandusky, Ohio, for around a million dollars. Beginning late, ENERCON manufactured a wind turbine of 4.5 MW and rotor width of more than 112.8 meters. [1]

Today wind energy is the speediest creating energy source. Principally wind power meets the power needs of more than 35 million single person. Internationally the wind power industry employs around 70000 individuals and has an estimated value of more than $5 billion. As demonstrated by Global Wind Energy Council (GWEC), Global wind power capacity has stretched from 7600 MW towards the end of 1997 to 47337 MW by Feb 2005. The nations that are mainly producing electricity from wind are Germany, Denmark, Spain, US and India having their installed capacities (MW) 16629, 8263, 6470, 3117, and 3000 respectively by Feb. 2005. Today wind power identifies with for around 0.4% of world's electricity demand. A dissection by European Wind Energy Association (EWEA) displays that there are no asset restriction, technical or economic that keep wind power from creating to around 12% of the world's power supply by 2020, yet with a solid political commitment internationally wind energy industry could install an estimated 1200, 000 MW by 2020 [2].

The electric circulation framework is the most broad piece of the electrical framework, and henceforth, it is the generally responsible for energy losses [3]. Along these lines the utilization of various techniques in the design of this subsystem can prompt significant economic gains, acquiring networks which minimize the immediate costs and further costs (expenses related to energy losses and system maintenance) [4–6]. It is remarkable to know that distribution systems are in constant evolution, subject to load increasing in different places at different times, which leads to the need of successive system developments [7, 8, 9]. Since the last few years, the enthusiasm toward the placement of wind turbine in utility network has extended because of its effective role in reducing the power loss of the distribution networks in order to serve remote loads.

Starting late, the power industry has experienced significant changes on the distribution power system in a far-reaching way in view of the execution of smart-grid technology and the incremental usage of distributed generation. Wind turbine is essentially characterized as the decentralization of a power plant by setting smaller generating units closer to the point of utilization, mostly ten mega-watts or smaller. While wind turbine is not a new concept, it is getting endless investment principally due to increase in customer demand, deregulation, environmental advancements in technology, economics and national security concerns.

The distribution power system generally has been intended for radial power flow, yet with the introduction of wind turbine, the power flow gets bidirectional. In this way, conventional load flow analysis tools and techniques are not ready to legitimately assess the effect of wind turbine on the electrical system. The presence of wind turbine on the distribution system makes an exhibit of potential issues identified with reliability, safety, stability, and security of the electrical system. Wind turbine on a power system influences the voltages, power flow, short circuit currents, losses and other power system analysis results. Whether the impact of the wind turbine is positive or negative on the system will depend on the location and size of the wind turbine. [3]

Wind energy is picking up growing essentially universally. This quick advancement of wind energy technology and of the business has broad implications for different people and associations: for instance, for researchers who examine and show future wind power, and electrical engineers at colleges; for experts at electric utilities who truly need to understand the unpredictability of the constructive and contrary effects that wind energy can have on the power system; for wind turbine producers; and for developers of wind energy projects,furthermore oblige that understanding in order to be able to develop feasible, advance and cost-effective wind energy projects [10].

Advantages:

- Wind energy is agreeable to the surrounding environment.
- Wind turbines consume less space than the normal power station.
- Wind turbines are an incredible asset to generate energy in remote areas.

Disadvantages:

- Wind turbine development can be extremely expensive and costly to encompassing wildlife during the build process.
- The noise pollution from commercial wind turbines is now and then like a small jet engine.
- The fundamental drawback in regards to wind power is down to the winds unreliability element. In various regions, the winds quality is so low it would be impossible to support a wind turbine or wind farm.

II. FACTORS AFFECTING WIND POWER

A champion among the most vital instrument in the working with the wind, whether arranging a wind turbine or utilizing one, is the firm understanding of the variables impacting the wind power. Following are the imperative components, which must be considered:

A. POWER IN THE WIND

The total power that is accessible to a wind is given as Total wind power in Watts,

Pw = $(m_w v^2)$ /2= (ρ A v^3)/2 (1)

Where m_w= ρ A V, where ρ is the density of the air in kg/m3, A is the exposed area in m², and V is the speed in m/s. The density is a function of pressure, relative humidity and temperature. It is seen from the mathematical equation (1) that wind power changes as the shape of the wind speed. Sadly, the total wind energy can't be recuperated in a wind turbine in light of the fact that the output wind velocity cannot be reduced to zero; generally there would be no flow through the turbine [11, 12].

B. EFFECT OF HEIGHT

Wind velocity increases with the height inview of friction at earth surface [16, 17]. The rate of addition is given by

$V/V_o = (Z/Z_o)^{1/7}$ (2)

Where V is the expected wind speed at height Z and V_o is the wind speed at heightZ_o. This disentangles into impressive addition power at more prominent heights.

C. LOAD FACTOR

There are no short of what two important prerequisites on wind turbine outline; one is to meet the essential load factor (which is the level of average electrical power to the rated electrical power) requirement of the load. The other is to expand the average power output. Load factor is not of huge concern if the wind electric generator is going about as a fuel saver on the electric system. Anyway if the generator is pumping irrigation water in asynchronous mode, for example, load factor is extremely critical [15].

D. WIND STATISTICS

Wind is exceptionally variable power source and there are few systems for describing this variability. Most basic is the power duration curve [13, 14]. This is a decent thought yet is not effectively used to choose V_c and V_R for a given wind site, which is an essential design necessity. An alternative technique is to utilize a statistical representation, especially Weibull function.

E. VARIATION WITH TIME

For most applications of wind power, it is more fundamental to know about the continuity of supply than the total amount of energy accessible in a year. By and by when the wind blows solidly, e.g. more than 12 m/s, there is no deficiency of power and regularly generated power must be dumped.

Difficulties seem, of course, if there are developed times of light or zero winds. A general rule of thumb for electricity generation is that destinations with average wind speed short of 5 m/s will have unsatisfactorily long periods without generation, and the sites of average 8 m/s or above will be considered amazingly great. In all the cases it will be critical to painstakingly match the machine trademark to the local wind regime to give the sort of supply required.

F. SEASONAL AND DIURNAL VARIATION OF WIND POWER

Intermittent and diurnal variety has basic impact on wind [16, 17]. Load duration data are obliged to judge the suitable impacts. Diurnal variety is less with extended height. Normal power may move from around 80% of the long term annual average power in the early morning hours to about 120% of the long haul average power in the early afternoon hours.

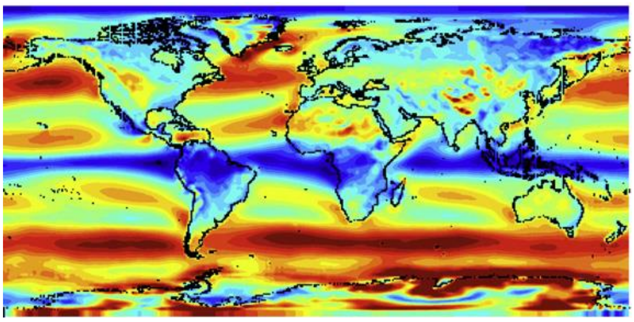

Fig 1.Map of the yearly averaged world wind speed (m/s)at 100m above sea level at 1.5x1.51 resolution, generatedwiththeGATOR-GCMOM3-Dglobalmodel [19].

III CHARACTERIZATIONS OF WIND ENERGY CONVERSION SYSTEMS (WECS)

There are various techniques for the classification of WECs. Emulating are the main types of classifications of WECs:

A. AS INDICATED BY SIZE OF USEFUL ELECTRICAL POWER OUTPUT [10]:

(i) Large Size (100 kW and up): They are utilized to create power for distribution in central power grids.

(ii) Medium Size (2-100 kW): These turbines may be used to supply less than 100 kW rated evaluated limits, to a couple of homes or neighborhood utilization.

(iii) Small size (up to 2kW): These may be utilized for remote applications, or at spots obliging moderately low power.

B. AS INDICATED BY ROTATIONAL SPEED OF AERO TURBINES [11-13]:

(i) Fixed Speed Generators In fixed speed generators wind energy is changed into electrical energy utilizing a direct squirrel-cage induction machine straightforwardly associated with a three phase power grid. The rotor of the wind turbine is coupled to the generator shaft with a altered proportion gearbox. Some induction generators utilization shaft customizable slowing down to engage operation at assorted synchronous speeds. Regardless, at any given working point, the turbine basically needs to work at consistent speed. The development and execution of fixed-speed wind turbines all that much depends on the characteristics of mechanical sub circuits, e.g. pitch control time constants, main breaker maximum switching rate and so on. The reaction time of some of these mechanical circuits may be in the extent of many milliseconds. Hence, each time an impact of wind hits the turbine, fast and strong variety of electrical output power can be watched. These load variations not simply oblige a hardened power grid to enable a stable operation, also oblige a tough mechanical design to absorb high mechanical stresses.

This system prompts to expensive mechanical construction, especially at high rated power.

(ii) *Adjustable Speed Generators*

(ii) Adjustable Speed Generators

Current high-power wind turbines are equipped for movable velocity operation.

Main advantages of adjustable speed generators (ASGs) contrasted with fixed speed generators (FSGs) are:

• They enhance power quality; torque throbs can be reduced on account of the adaptability of the wind turbine system. This takes out electrical power variations, i.e., fewer flickers.

• They upgrade system productivity; turbine velocity is adjusted as a function of wind speed to expand output power. Operation at the best power point can be acknowledged over a wide power range

.• They diminish acoustic noise, in light of the fact that low-speed operation is conceivable at low power conditions.

• They diminish mechanical stresses; impacts of wind can be assimilated, i.e., energy is secured in the mechanical inertia of the turbine, making a "versatility" that lessens torque throbs.

They progressively conform for torque and power pulsations made by back pressure of the tower. This back pressure causes perceptible torque throbs at a rate comparable to the turbine rotor velocity times the quantity of rotor wings.

• They are financially savvy and give immediate pitch control; then controlling velocity of the generator (frequency) permits the pitch control time constants to wind up all the additionally, diminishing pitch control complexity and crest power necessities. At lower wind speed, the pitch angle is usually altered. Pitch angle control is performed just to utmost most maximum output power at high wind speed.

III. PRESENTATION OF NIGERIA POWER NETWORK.

The first electric power plant built in Nigeria was located in Lagos. It was built in 1898 and was managed by Public Works Department (PWD). National Electric Power Authority (NEPA), otherwise known as Power Holding Company of Nigeria (PHCN) which has further being unbundled (Five generation companies (Gencos) and 10 distribution companies (Discos)) came into being in 1972, with a mandate to develop and maintain an efficient, coordinated and reliable power supply in the country. In 1973, only eight (8) of the present 36 States in Nigeria were directly connected to the National Grid. Today all states but one are fed from the National [20] [21].

Nigeria Power system consists of twenty three (23) power stations (3 Hydro, 2 steam and 18 gas), both old and new generating ones (National Integrated Power Projects, NIPP and Independent Power Producers, IPP) with a total installed capacity of about 7052.6 Megawatts (MW), but actual generation capacity is 4651 Megawatts (MW). [National Control Centre, Oshogbo. March 3rd, 2014].

The network studied has 85 buses connected to a 15MWA transformer.

The load flow was run with ETAP Software to ascertain the status of the entire Network. Table 1 presents the load flow result during peak period and table 2 presents off peak result.

Table 1. Load flow result for Peak period

Load-MW	9.243
Load-Mvar	6.447
Generation-MW	0
Generation-Mvar	0
Loss-MW	1.045
Loss-Mvar	2.007

Table 2. Load flow result for off peak period

Load-MW	5.101
Load-Mvar	1.93
Generation-MW	0
Generation-Mvar	0
Loss-MW	0.265
Loss-Mvar	0.425

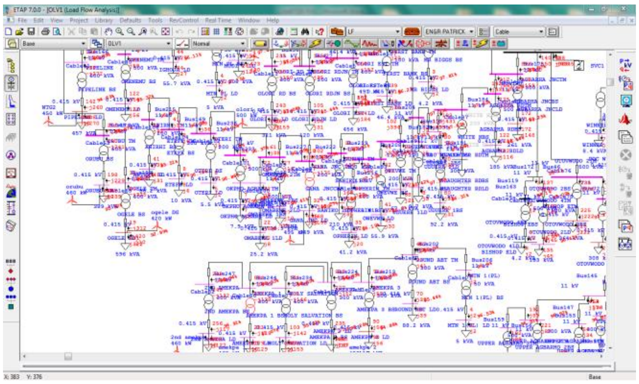

Fig 1. Simulation of the network consisting of the DGs.

ETAP software was also used in placing the wind turbines in the network using Matlab software for the optimization software. The equation involved is given in equation 1.

$$f = \sum_{k=1}^{n}\left(a_k \frac{P_{loss}^{With\ DG}}{P_{loss}^{Without\ DG}} + b_k \left(V_{bus,k}^{With\ DG} - 1\right)^2 + d_k \frac{CG_k}{S_{base}}\right) \quad (1)$$

IV. RESULT

Result of load flow after the wind turbine was placed is presented in Tables 3 and 4.

Table 3. Peak period with Wind Turbine

Load-MW	10.607
Load-Mvar	6.285
Generation-MW	9.413
Generation-Mvar	0.444
Loss-MW	0.432
Loss-Mvar	0.812

Table 4. Off - Peak period with Wind Turbine

Load-MW	5.575
Load-Mvar	2.011
Generation-MW	4.603
Generation-Mvar	0.33
Loss-MW	0.237
Loss-Mvar	0.344

V. DISCUSSION

When the load flow was simulated, the results obtained were as follows: the total load for the entire network was 9.243MW, 6.447Mvar, technical losses 1.045MW, 2.007Mvar during peak period and for off peak period: the total load for the entire network was 5.101MW, 1.93Mvar, technical losses 0.265MW, 0.425Mvar.

When the wind turbine has been introduced the following results were obtained: the total load for the entire network was 10.607MW, 6.285Mvar, technical losses 0.432MW, 0.812Mvar during peak period and off peak; the total load for the entire network was 5.575MW, 2.011Mvar, technical losses 0.237MW, 0.344Mvar.

VI. CONCLUSION

It can be seen from the presentation of tables 1 – 4 that the losses during peak period were 1.045MW, 2.007Mvar and 0.265MW, 0.425Mvar.

When wind turbine was introduced the losses reduced to 0.432MW, 0.812Mvar peak and 0.237MW, 0.344Mvar off peak.

Wind turbine can be introduced to a network to reduce technical losses.

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