THE 10 MW JOS WIND FARM, PLATEAU STATE, NIGERIA

OUTLINE Page Number

Abstract

Wind energy could be harnessed in Nigeria to improve her energy portfolio for a stable power supply to the residents. Following the analysis of meteorological and engineering data, we proposed the establishment of a 10 MW wind farm at Jos in Plateau State of the country. The 10 MW capacity will be achieved using 37 individuals 275 kW HAWT turbines with project financing provided via a joint venture between the government, private investors and international agencies.

The performances of wind turbines are important factors in the bid to optimize their usage as renewable energy sources. WT_PERF developed by Buhl in 1998 utilize the blade element momentum (BEM) theory to evaluate the turbine's efficiency as power generator.

The design parameters for this turbine are rotor radius = 17.1 m, tip speed ratio = 11, height = 2R = 34.2 m, angle of attack = 8.1 and wind speed at hub, V = 11.32 m/s, varied pitch angle from 3 to 5 degrees, Cp = 0.4, and number of blades = 3. A wt-perf analysis shows that it could produce about 892 kW power for a wind speed close to 25 m/s at 5 degree pitch angle. The performance of this turbine is comparable with those of commercially available ones that are currently on the market.

The economic assessment of the 275 kW turbine to be installed at Jos Farm was perform using the HOMER software. HOMER identified a configuration of systems with their architecture that has the optimized result using the metrics like COE, annual energy production, power curves and efficiency. The architecture consisting of Wind turbine Fuhrländer 100, Battery 48 Surrette 4KS25P, Inverter, 40 kW, Rectifier 40 kW was found to produce the best optimized results of Total net present cost of $ 322,704, Levelized cost of energy of $ 0.315/kWh and operation/maintenance cost of $15,373/yr. The LCOE agrees with values determine by other researchers and industrial experts. The value could be reduced by using large turbine with rated power of 1.5 MW or larger, expansion into grid off-shore wind farms where the wind speed is higher than on the land, and the adoption of policies that will motivate a large percent of the people to consider the implementation renewable energy projects.

The initial environmental assessment carried out by our team reveals that the project is in full compliance with policies and public interest demands regarding avian, noise and other environmental issues.

Introduction/Site description/Energy Need Overview

Nigeria, a country in Western sub-region of sub-Saharan Africa has a latitude and longitude of 8.0000° N, and 10.0000° E respectively. The industrial development and the provision of energy that is enough to meet the residential needs of its over one ninety million people remain daunting tasks nearly 60 years after independence from British rule. The country consists of thirty-six states and a federal capital territory with a capital city of Abuja and also an economic capital city of Lagos. Figure 1 is a map of Nigeria showing the thirty six states of the country.

Figure 1: A map of Nigeria (1)

Jos city, the site of this wind farm is in Plateau state, the middle-belt of the country. The city and its surroundings with approximate population of 3.5 million, estimated GDP per capital of $1,587, an altitude of 1217 m above sea level has less than 50% access to electricity despite its viability for benefiting from wind energy. The people depend largely on biomass such as wood and diesel generator for meeting their residential energy. The health and environmental price for these sources of energy is enormous and are well documented in various research publications. Majority of the people lives around the urban area and will require about 3-4 GW of electricity.

The potentials of solar and wind have proven reserve and could make significant impact on the energy situation if given serious consideration. Solar radiation has 3.5 to 7 $kWh/m^2/day$ and the wind has a speed of about 2.4 to 4 m/s or sometimes higher (9.5

m/s) at an height of 10 m in the northern part of the country, especially in Jos, Plateau state. Figure 2 is the wind speed map of Nigeria. The suitable available land area for wind farm is about 87 x 10^3 km^2 in this area (1-5).

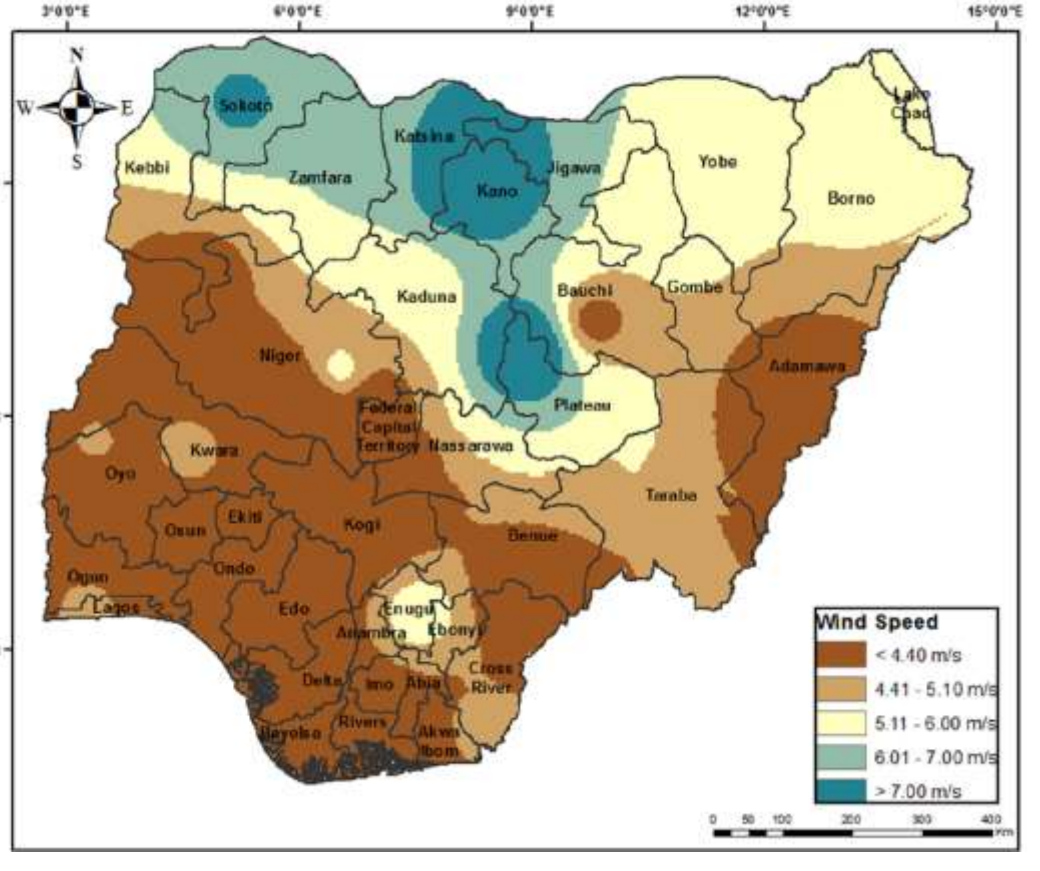

Figure 2 : Wind speed map of Nigeria . (17)

Additionally, the problems of aging infrastructures for distribution must be tackled to improve the standard of living of the people and promote economic development through job creation.

Wind Farm and Turbine Rotor Design

The rotor of the turbine is an important piece of this equipment needed to convert wind energy into electricity. We designed the rotor of the 275 kW HAWT by selecting “some starting values of parameters like the number of blades, blade radius, power coefficient, blade RPM, tower height and pitch angle. Next, we select airfoils to generate the chord and twist for the various blade element positions. The design parameters will then be used in WT_PERF to analyze the design by predicting its performance. The number of blades, pitch angle and RPM were then varied for optimization checks”.

The design parameters for this rotor are shown in table 1 below.

Rated Power (kW)	275
Rotor Radius (m)	17.1
Hub Height (m)	34.2
Wind speed @ hub, V (m/s)	11.3
Anemometer height (m)	10.0
Tip speed ration, λ	11.0
Ω (rpm)	69.0
Ω (rad/s)	7.23
Power coefficient C_p	0.40
Pitch angle (degrees)	3 - 5

Table 1: Rotor design parameters.

With reference to Tangler, et al’s recommendations on the selection of airfoils for HAWTs, the S809 airfoils was selected for application from root to tip for this rotor design. Figure 2 shows the diagram of this airfoil.

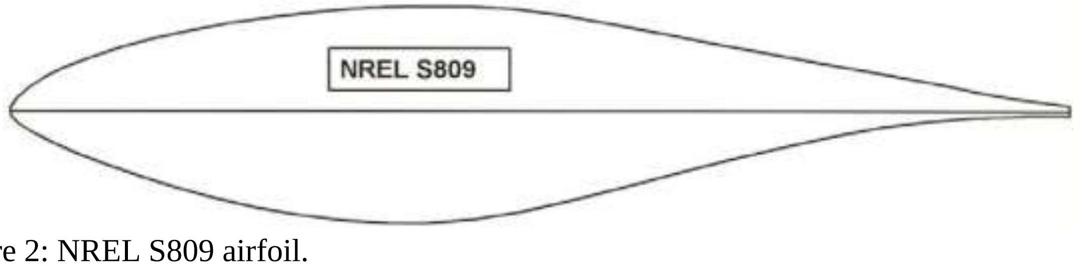

Figure 2: NREL S809 airfoil.

The aerodynamic data for S809 airfoils yield angle of attack (α) of 8.1 degrees with a lift force coefficient C_l of 0.9 at the best combination of C_l/C_d. Figure 3 is a plot of Cl and Cd as a function of the angle of attack for S809 airfoils. The table for this calculation is attached as appendix.

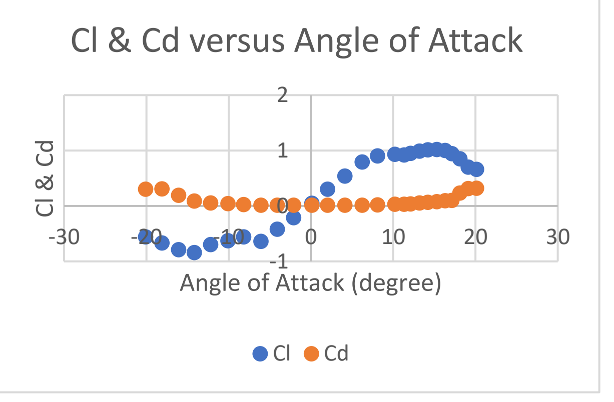

Figure 3: Cl/Cd versus angle of attack for S809 airfoils.

The performance of the turbine as evaluated using WT_PERF for power output and power coefficient variation compare favorably with those of pre-manufactured turbines by Vergnet and ENERCON. Figure 4 is a plot of output power versus wind speed for this turbine.

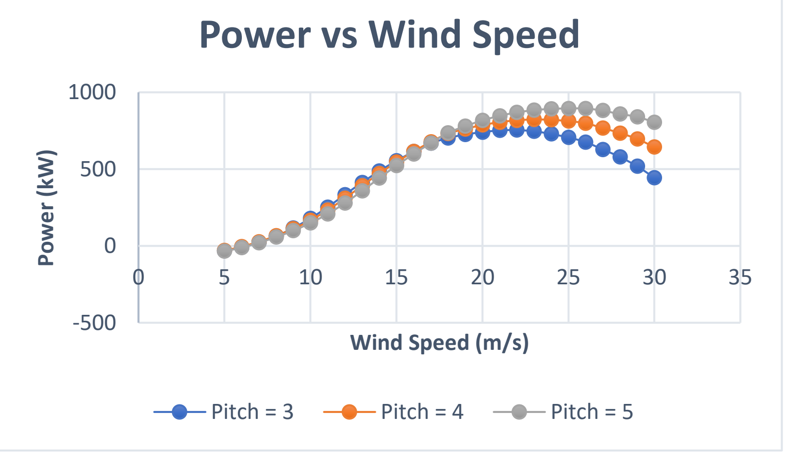

Figure 4: Turbine power output versus wind speed at various pitch angle.

The turbine is capable of producing an output power of about 892 kW at about 22.5 m/s wind speed before beginning to show signs of stalling (3).

Economic Assessment of Wind Turbine

An economic assessment of the wind farm project was carried out using the HOMER software along with efficiency and probability distribution functions. The site of the farm is in a remote area that is far remove from existing grid. The farm will be operated as stand-alone and off-grid. The average wind speed is well over 5 m/s in Jos and the sites in the northern region of Nigeria should be able to support the generation of 97 MWh per year hence a potential viable contributor to the energy needs of the area (8-9). The LWST baseline (2002) turbine calculations – class 4 and the HOMER system model are attached as appendix 1 and 2. We analyzed the turbine using metrics such as the annual energy production modelling, wind turbine construction, operations and maintenance costs, and cost of energy (COE). The turbine could capture 1340.38 MWh of energy per year with a capacity factor of 55.65% and energy capture ratio of 29%. HOMER suggested a hybrid system for optimized results that consists of Wind turbine Fuhrländer 100, Battery 48 Surrette 4KS25P, Inverter (40 kW), and Rectifier (40 kW). The cost summary of this system is shown in table 2.

Cost summary

Total net present cost	$ 322,704
Levelized cost of energy	$ 0.315/kWh
Operating cost	$ 15,373/yr

Table 2: Cost Summary of Wind turbine Energy Generation.

Other possible system involves the widely used diesel generator and wind turbine. We model an average household size of 4 people with an average monthly consumption rate of energy per person put at 28 kWh. Thus, our proposed load of 275 kWh per day could meet the residential energy need of 10 homes, and the 10 MW farm when operating at full capacity should serve between 370 – 2000 homes. The actual residential needs of the communities in Jos is very low based on the survey of energy needs. Several factors than range from high start up cost, long length of time for recouping investment, and lack of available local technology make the use of solar PV as a possible energy source in our model.

The LCOE of $0.315/kWh compares well with $0.30/kWh for wind turbine and $0.33/kWh for diesel generator as determined by other researchers. The values suggested by IEA ranges between $0.15 to $0.35/kWh for small wind turbine. The LCOE would trend downward as the as the country embraces favorable energy policies such as green energy credit, energy buy-back schemes and low interest loans for developers of renewable energy ventures like wind farms. The use of large off-shore turbines could produce energy that could be transmitted and distribute on the land. The wind speed at seas are generally higher than land and hence the LCOE will be lower to values like $0.162/kWh. Large on-shore turbines with power rating of 1.5 MW or greater would serve a larger population and thus bring down the cost of the energy. In developing the farm, the operators should make a great deal of effort and will to use locally available materials and manpower as may be available to bring down the overall cost.

The efficiency of the turbine rose from 54% to 90 % when used to generate power in the range of 13.75 kW to 123.8 kW (4).

Environmental and Other Issues

There are several benefits to using wind as an alternative source of energy. These advantages include no air pollution, greenhouse gasses, mercury polluted water, and no need for water for turbine operations. The community will also have access to diverse energy portfolio, economic development via farm construction, installation, operation and maintenance, and also energy cost stability over time. Nevertheless, the selection of wind farm sites requires not just the availability of adequate wind speed and turbine but also permit approval, large land area and friendly public and government support (American wind association). In the light of these factors, wind projects may include public notices for hearing before the securing the permits and licenses that will allow for initial start of actual physical constructions. Several issues ranging from avian, noise, power quality and general environmental/economic/ social topics may be covered during such public hearing. In the Nigeria setting, local elders, government officials, private citizens and community leaders may need to be on-board with project before it can start. Thus meetings will be scheduled in village squares and town centers to document public participation and acceptance of the project.

In this section, we will discuss these issues in general and how it relates to the Jos environs in particular.

Avian issues

In siting a wind farm, the effect of the project on various bird species need to be considered seriously. The species include both the local and the migrant birds. It is believed that birds could be endangered by facilities like overhead power lines, poles, masts, building windows, cars in traffic, hunting, shooting, poisoning and trapping during the annual migrations.

126 bird species identified as “Afrotropical-palearctic migrants” travel from Eurasia to Africa seeking nicer weather and food. Also, some species are known to move from west Africa to south Africa for reasons similar to those of the afrotropical-palearctic migrant bird species. Appendix 5 shows the tables of the identified bird species. On the tables, the birds are classified as PW (Palearctic winter), IA (Intra-African), BV (Breeding Visitor), VU (Vulnerable), and NT (Near Threatened). Their population trends are indicated as Least Concern/population trend increasing (↑), Least Concern/population trend decreasing (↓), Least Concern/population trend stable (-), Least Concern/population trend unknown (*), and Unassessed (**) (5-7).

Several worldwide studies suggest that the chance of bird collision with wind turbines are low since the birds will adjust travel path as they approach the location of the turbine within 100 – 200 m. Nevertheless, birds could nest on turbine or still collide as seen at Altamont Pass, California, we will endeavor to use the right turbine design that will reduce the probability of this danger for the birds. The location of the Jos wind farm is also far from the Hadejia-Nguru Wetlands (HNWs) consisting of four protected sites namely , Adiani Forest Reserve, Baturiya Game Reserve, Chad Basin National Park, and

Nguru Lake and Marma Channel. These sites provide wintering ground for migratory birds.

In Nigeria, the government along with conservation organization monitor the compliance with various policies and laws that have been promulgated to protect birds against some of this dangers. Some of these laws include the National Park Service Act (1999/2006), Endangered Species Act (2000), Environmental Protection Law (1988/1989), Forestry Law (1938) and Wild Animal Law (1963) to protect wildlife including birds.

In the recent years, the activities of insurgency groups like Boko Haram a subsidiary of the Iraq/Syria Islamic State group is a danger to endangered and migrating bird species who are hunted for food in their territories and the security posed by the group prevents conservation efforts in that part of the country that are closer to the wetlands than our farm site.

Figure 5 shows the map of Hadejia-Nguru Wetlands (HNWs) within Nigeria and the continent of Africa. It covers two states, Jigawa and Yobe , which are located in the north-eastern part of the country. Jos is in the plateau state along the middle belt region.

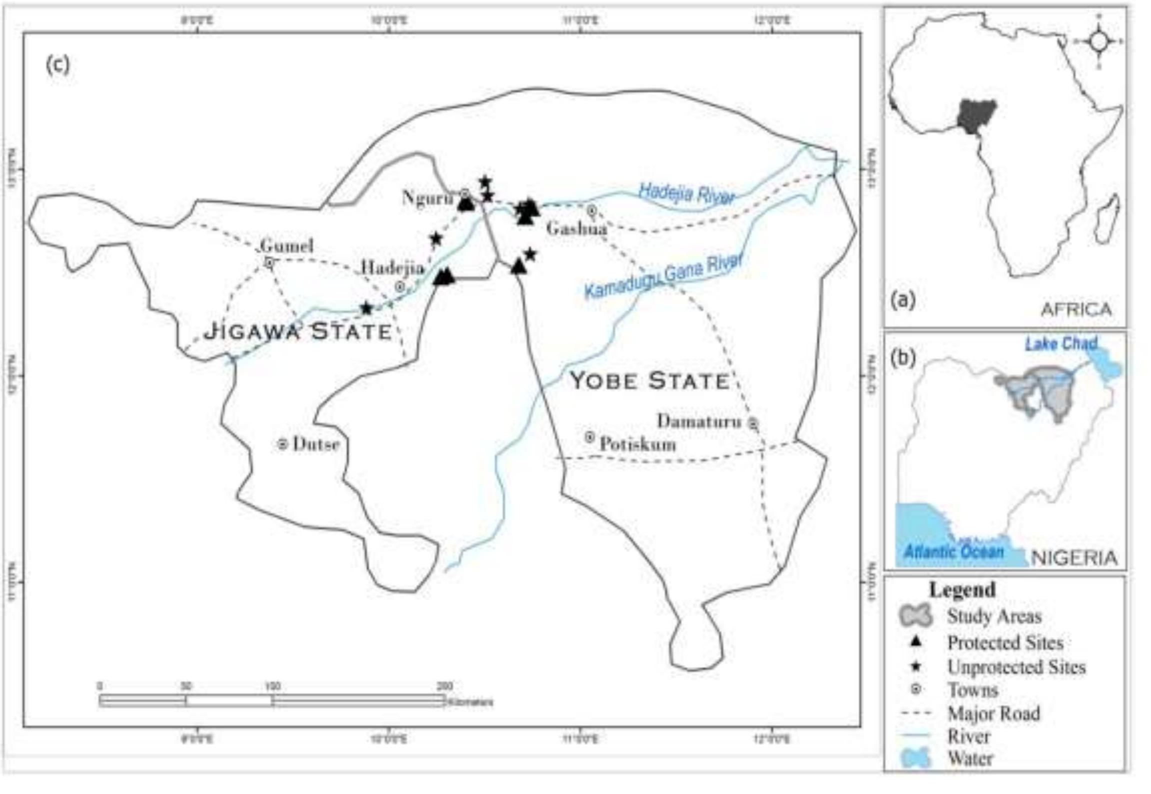

Figure 5: Map of Hadejia-Nguru Wetlands (HNWs) (5).

Avian issues will also be addressed by formulating appropriate protection plans after the reports of site assessment survey and pre-construction assessment by the ministry of environment. Annual assessment of dead birds will be carried out to obtain bird fatality data around the farm site as we join efforts to ensure compliance with the various acts of the government. Some part of the budget for this project will also include expenses related to creating public awareness of bird conservation in particular and wildlife in general so as to discourage the practice of hunting of wildlife as "bushmeat" for local delicacies popular within many Nigerian communities (8-13). Figure 6 shows other important bird areas within the country and we will join effort to protect these sanctuary locations closest to the Jos Farm.

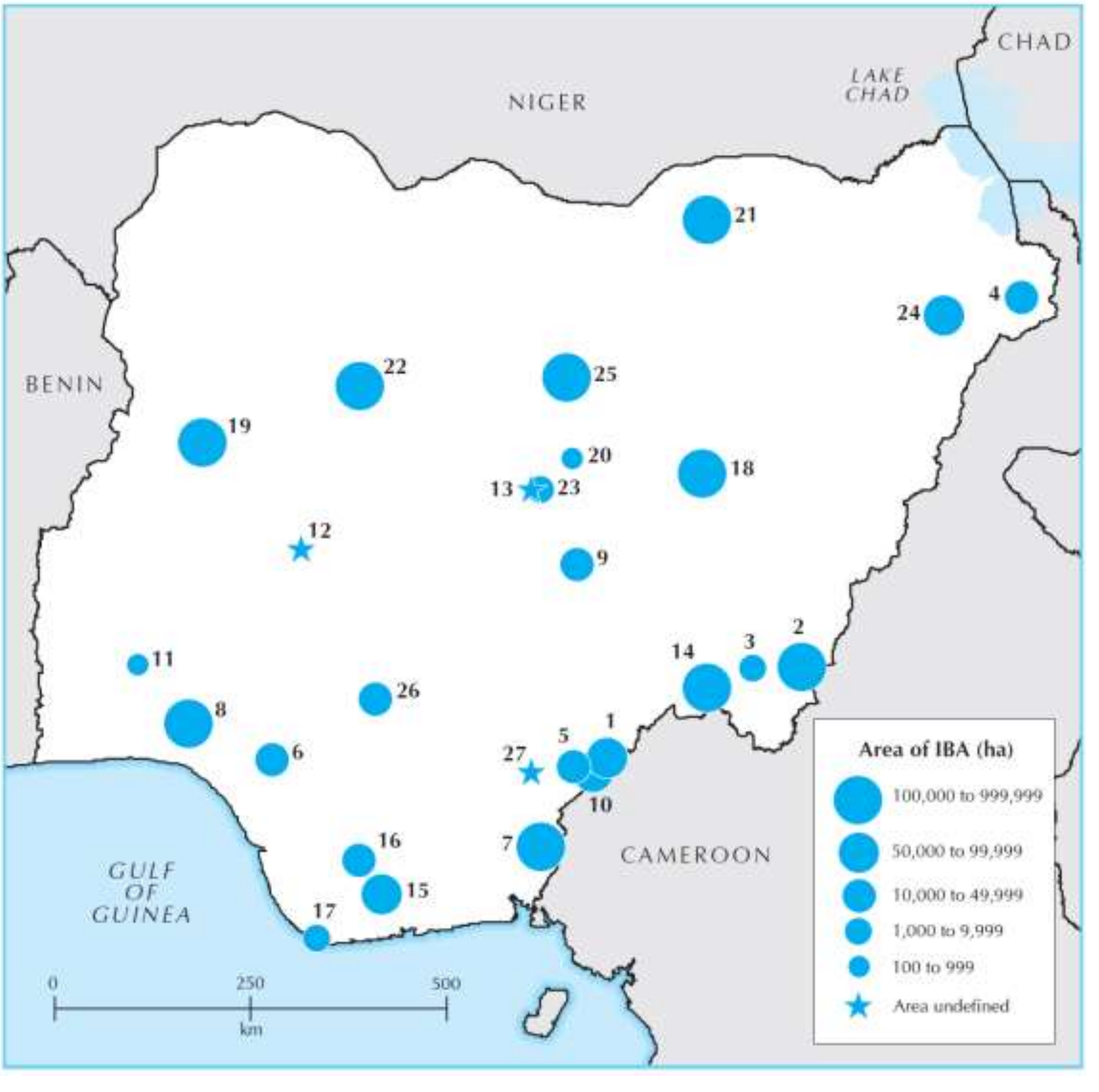

Figure 6: Map of Important Bird Areas in Nigeria (21).

Noise Issues

There are many sources of noise in a wind turbine system. These sources include cooling fans, generator, power converter, hydraulic pump, yaw motors, bearings and blades. The noise contributes to the avian issues and public acceptance of the project (10)

The range of sound frequencies for birds are 1 to 5 kHz, and 20 to 20000 Hz in humans (20). Wind turbine blades produce low frequency sounds that is almost twice as audible to humans than birds. The wind noise just like that of the turbine are low frequency. The overall noisy environment around a turbine does not change very much even with blade defects. Blade defects produce whistle like sound that has minor impact on the sound pressure signature of the system. An average bird will detect noise signals in the region of 2-3 kHz with intensity ranges of 26-28 dB above the spectrum level , and in human 22 dB above this level will be sufficient.

Noise around a turbine could therefore be a public menace to humans than to birds. Typical values of sound intensity around us are Hearing Threshold: 0 dB, Whisper : 20 dB, Quite Neighborhood: 40 dB, normal Speech: 60 dB, Busy Office: 80 dB Heavy Traffic: 100 dB, and Discotheque 120 dB. Figure 7 shows the diagram of sound intensity levels for various part points in a wind turbine and how they vary with distance. The diagram was originally produced by General Electric.

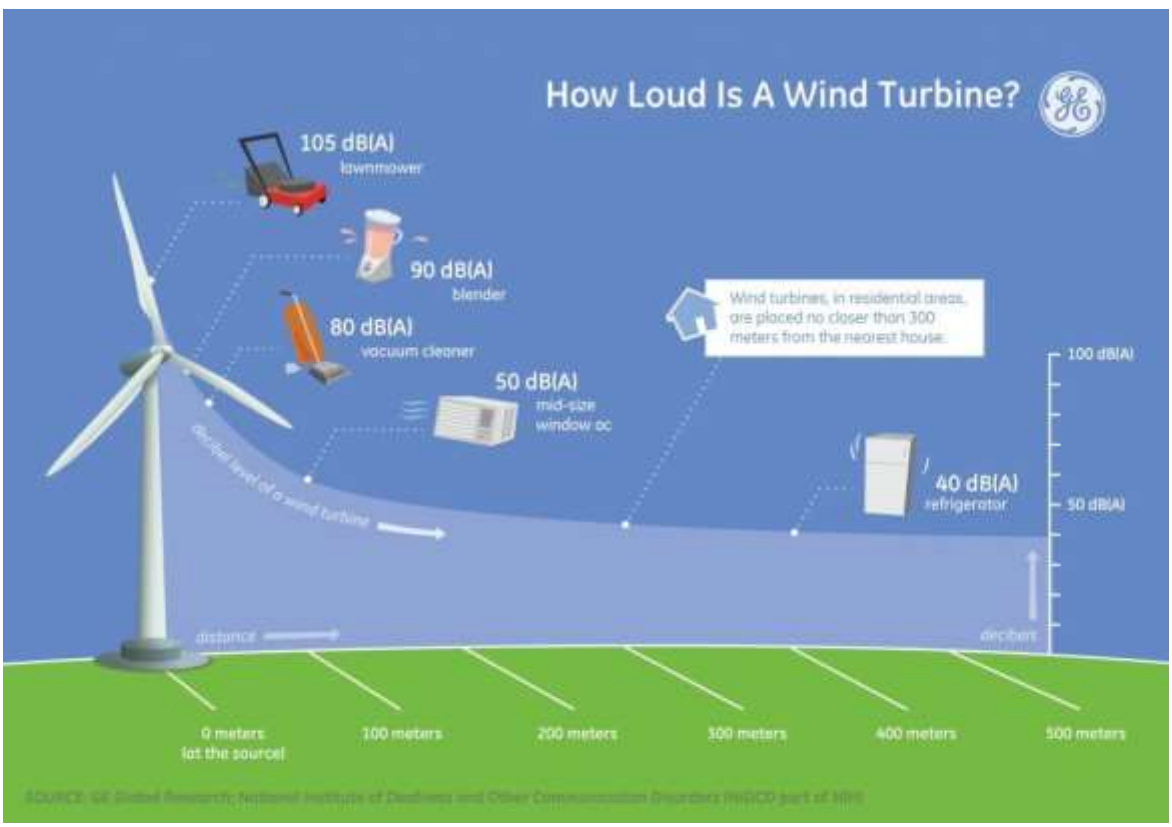

Figure 7: Sound intensity level measurement for various points of a wind turbine (10).

It is as quite as a window AC or refrigerator based on its location to the residential buildings. Occupational Safety and Health Administration (OSHA) has recommendation for Daily Occupational Noise Level Exposure. The OSHA Maximum Allowable Noise Exposure is shown in table 3 below.

	OSHA Maximum Allowable Noise Exposure									
Hours per day (constant noise)	8	7	6	4	3	2	1.5	1	0.5	≤0.25
Sound level dBA	90	91	92	95	97	100	102	105	110	115

Table 3: OSHA Maximum Allowable Noise Exposure (12).

In a study that "assess the level of noise produced by sound generating machines in Lapai, Northern Nigeria" found that the average noise level was greater than 80 dB and reduced to about 46 dB as the detector location increases beyond 600 cm. The machines investigated were: Lister generators, LLG generators, Block moulding machines, Iron filling machines and grinding machines. These sources are routinely used for economic activities in this area, and fair representative of other locations in the country. However, due to incessant power failure and economic pressure, the people may be exposed for time duration longer than recommended by OSHA. The location of the turbines in Jos Farm will be 300m or more to the nearest building and should not produce noise level in lower than these pre-existing sources in the society. We will obtain verified noise level measurement certificate for this project before operation. The very low level of this noise does not make it health hazard contrary to the claim of many politicians and far-right figures (12 – 20).

Power Quality Issues

As we march forward in the defense of this project for public acceptance and government approvals, it is imperative to discuss the power quality issues of the wind farm and what it will contribute to improving the overall quality of power in the area. We will approach this issue from its engineering and public policy perspectives. Power quality is an indication of the quality of voltage from the electricity source. It is correlated with the loads ability to function correctly. In essence, appliances or electronic devices may perform below optimal level or fail outright when the voltage supplied is not at the correct level. The voltage value could be the average value in the direct current (DC) circuit or the root mean square value in the alternating current (AC) circuit. The complexity of electricity generation, transmission and distribution is infused with circumstances that could compromise the quality of the voltage delivered for consumption.

The examples of power quality problems include voltage surges/spikes, voltage dips, under voltage, high voltage spikes, frequency variation, power sag, electrical line noise, brownouts, blackouts, very short interruptions, long interruptions, voltage swell and harmonic distortions. These problems could result in systems shut down, memory loss in computers, flickering lights, stalling of electric motors, data loss or corruption and fire. The Jos farm management will address this issues at production, transmission and consumer levels using surge suppressors, voltage regulators, uninterruptable power supplies, power conditioners, generators, and battery for energy storage for later usage. The outlined solutions would ensure that the consumers enjoy sooth sinusoidal varying function voltage even with non-linear load.

In Nigeria, backouts, flickering lights, interruptions, surges and dips are common experiences with the consumers. Many of the consumers do wonder at-times if the utility bills are for energy consumptions or blackouts/interruptions. The improvement in power quality is directly tied to the investment and management of the power structure. Newer grids and accessories like transformers, transmission lines should improve quality of customer experience when the farm is in operation. The current state of consumer quality experience in Nigeria could be summed up as a poor services and penetration, According to Adenle and co-workers, in their paper titled "Acritical review of power quality issues in Nigeria", describe the state of electricity service and penetration as "Only 5% of the rural dweller, urban 35% households has access to electricity, and the supply suffers from frequent power cuts and high fluctuations in voltage and frequency, with so-called blackouts and brownouts. The demand-supply gap is currently 7.8% of average load and 13% of peak demand at current prices". With a focus on improving customer experience and fair but smart utility billing and payment, the quality of the electric power consumed in the Jos environs will be first class, and second to nothing as we contribute to closing the energy gap in the area.

The management of this project will also continue to investigate other possible solutions to power qualities issues as we develop the short-term and long-term strategic development plans. These solutions include the use of power conditioning equipment like surge suppressors, noise and harmonic filters, isolation transformers, dynamic voltage restorers,
Static var compensator, thyristor-Based Static Switch, and supercapacitors. The applications of these solutions to ensuring adequate power supply are well documented in standard electrical engineering textbooks and published articles in peer reviewed journals (11, 20 – 28)

Other Environmental Issues

The installation of the turbines will be made with the best possible landscape architectural consideration to preserve economic interests of our hosts and neighbors. A beautiful geometric pattern layout of the turbines will add values to home prices and boost local activities via tourism. Little details such as turbine paint, size , and design will be selected to add value to the community (23).

The use of vortex bladeless wind turbines and other latest innovative designs that could improve on performance and reduce the impact on the environment will be incorporated into the development plan of the farm. Figures 8-13 shows the pictures of the new designs and how they improve landscape (7).

*Vortex bladeless wind turbine.

Figure 8

*NewWind's Tree Vent.

Figure 9

*BAT-Buoyant Airborne Turbine.

Figure 10

*Atsushi Shimzu typhoon turbine.

Figure 11

*Zero Blade Turbine. By Saphon of Tunisia.

Figure 12

*INVELOX wind tunnel tower.

Figure 13

Conclusions and Future Plans/Recommendation

` The development of this wind farm will replace the use of biomass like firewood, and the use of diesel generators whose indoor air pollution has notably been responsible for fatality numbers comparable to those of dreaded diseases like malaria, HIV/AIDs and tuberculosis. It will also improve the power quality enjoy by house holds within its service areas. At this term, these homes are under total prolong blackout due to lack of electricity access or low number of daily hours service via the existing grid or brownouts, flickering and a frequent combination of surges and dips in voltages. The cost of energy of the wind farm is cheaper or in some instances comparable to existing sources like kerosene or diesel and other hydrocarbons. The installation and operation of the farm will improve political and economic activities of the area. The participation in town halls will increase democratic values, and the construction/installation/operation of the farm will bring jobs and a boost to the economic life of the people.

As the life of the project increases and we gain gain greater public acceptance, effort should be made to invest in off shore turbine projects at other locations of the country to bring down the energy cost. The careful implementation of the off-shore project so it will have little impact on marine life and safety, tourism, visual seascape, construction and other noise could benefit the Jos area depending on the cost of transmission.

On the overall, the siting of this farm in Jos, Plateau State of Nigeria is an excellent choice for the availability of wind with speed greater than 7 m/s and available suitable land area of eighty-seven thousand square kilometers and reduced cost of energy (1 – 29).

.

References

1. Oladipo, J., 2019, A Wind Farm for Jos, Assignment 1 Submission, AE 6701, Geoargia Institute of Technology.
2. Oladipo, J., 2019, Wind Turbine Performance Analysis Using WT_PERF Software, Assignment 2 Submission, AE 6701, Geoargia Institute of Technology.
3. Oladipo, J., 2019, A 275 kW Wind Turbine Rotor Design Report, Assignment 3 Submission, AE 6701, Geoargia Institute of Technology.
4. Oladipo, J., 2019, Economic Assessment of Jos Turbine, Assignment 4 Submission, AE 6701, Geoargia Institute of Technology.
5. Ringim, A.S., Magige, F.J., and Jasson, R. M., 2017, A Comparative Study of Species Diversity of Migrant Birds Between Protected and Unprotected Areas of the Hadejia-Nguru Wetlands, Nigeria, *Tanz. J. Sci. Vol. 43(1).*
6. Ryan, P. G., Occurrence of two common forest bird species in Amurum Forest Reserve on the Jos Plateau, Nigeria, 2012,Notes Courtes ,45
7. Chucks, Bladeless Wind Turbine, Wind Energy Innovations, 2018, SweetCrude.com
8. Cresswell, W., Boyd, M., & Stevens, M., 2009, Movements of Palearctic and Afrotropical bird species during the dry season (November–February) within Nigeria, *Proceedings of the 12th Pan African Ornithological Congress,* Cape Town, Animal Demography Unit.
9. Shankar, P., Module 7.1,Avian Issues, 2019, Lecture Notes, AE 6701, Georgia Institute Of Technology
10. Shankar, P., Module 7.2, 2019, Noise, Lecture Notes, AE 6701, Georgia Institute Of Technology
11. Shankar, P., Module 7.3, 2019, Power Quality Issues, Lecture Notes, AE 6701, Georgia Institute Of Technology
12. Tersoo, T. M., Dawodu, O. M., and Babakatcha, N., Assessment of the level of noise produced by sound generating machines in Lapai, Northern Nigeria, Advances in Applied Science Research, 2011, 2 (6): 520-531
13. Kaufman, L., Wind Turbines and Health Hazards, 2018, New York Times, Newyorktimes.com
14. Rogers, A., Wind turbine noise, infrasound and noise perception, 2006, NREL, *www.ceere.org/rerl*
15. Adenle, B. J., Adekusibe, K. G., & Ayodeji, A. I., A CRITICAL REVIEW OF POWER QUALITY ISSUES IN NIGERIA , https://www.academia.edu/26056914/A_CRITICAL_REVIEW_OF_POWER_QUALITY_ISSUES_IN_NIGERIA?auto=download
16. Rojin, R. K., 2013, A Review of Power Quality Problems and Solutions in Electrical Power System, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Issue 11
17. Ayodele, T., Ogunjuyigbe, A., Odigie, O., & Jimoh, A. (2018). On the most suitable sites for wind farm development in Nigeria. *Data in Brief,19*, 29-41. doi:10.1016/j.dib.2018.04.144

18. Bird, N., & Dickson, C. (2008). Bushmeat, Forestry and Livelihoods: Exploring the Coverage in Poverty Reduction Strategy Papers. *Bushmeat and Livelihoods: Wildlife Management and Poverty Reduction,*212-226. doi:10.1002/9780470692592.ch13
19. Chapman, S. (2012). The sickening truth about wind farm syndrome. *New Scientist,216*(2885), 26-27. doi:10.1016/s0262-4079(12)62563-9
20. Dooling, R. (2002). Avian Hearing and the Avoidance of Wind Turbines. doi:10.2172/15000693
21. Ezealor, A. U. (1987). New Threats to Nigerias Savanna Woodlands. *Environmental Conservation,14*(03), 262. doi:10.1017/s0376892900016489
22. Green, J., Bowen, A., Fingersh, L. J., & Wan, Y. (2007). Electrical Collection and Transmission Systems for Offshore Wind Power. *Offshore Technology Conference*. doi:10.4043/19090-ms
23. Grieken, M. V., & Dower, B. (2017). Wind Turbines and Landscape. *Wind Energy Engineering,*493-515. doi:10.1016/b978-0-12-809451-8.00023-0
24. Hubbard, H., & Shepherd, K. (n.d.). Wind Turbine Acoustics. *Wind Turbine Technology: Fundamental Concepts in Wind Turbine Engineering, Second Edition,*413-465. doi:10.1115/1.802601.ch7
25. Hunt, W. G., Jackman, R. E., Hunt, T. L., Driscoll, D. E., & Culp, L. (1999). A Population Study of Golden Eagles in the Altamont Pass Wind Resource Area: Population Trend Analysis, 1994-1997. doi:10.2172/12148
26. Muljadi, E., Butterfield, C., Chacon, J., & Romanowitz, H. (2006). Power quality aspects in a wind power plant. *2006 IEEE Power Engineering Society General Meeting*. doi:10.1109/pes.2006.1709244
27. Musial, W., Beiter, P., Tegen, S., & Smith, A. (2016). Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs. doi:10.2172/1338174
28. Orths, A. G., & Eriksen, P. B. (2012). Wind Power in the Danish Power System. *Wind Power in Power Systems,*517-548. doi:10.1002/9781119941842.ch23
29. Ringim, A. S., & Aliyu, D. (2018). Bird species' richness, relative abundance and conservation status in protected and unprotected areas of the Hadejia-Nguru Wetlands, north-east Nigeria. *Zoologist (The),16*(1), 12. doi:10.4314/tzool.v16i1.3