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The Potential for Wind Energy in Nigeria

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ABSTRACT
This paper discusses some of the issues of wind energy development and utilization in Nigeria. It surveys the various initiatives of governments and researchers at assessing the prospects and availability of wind energy for electricity production and identifies indices suggesting wind availability. Inland, the wind is strongest in hilly regions of the North, while mountainous terrains of the middle belt and northern fringes have high potential for great wind energy harvest. However, due to varying topography and roughness of the country, large differences may exist within the same locality. Mean wind regimes in the north and south were also found to lie between 4.0 – 7.5 m/s and 3.0 – 3.5 m/s respectively at 10 m above the ground. It is suggested that Nigeria can adequately utilize wind for power generation over much of the country, if the identified challenges are overcome and the suggested strategies are implemented.

Keywords: Energy poverty, Environment, Nigeria, Wind energy technology, Sustainable energy.

1. INTRODUCTION
Energy has been and will still be the main stay of an economy. It is one of the most important factors of National development. Nigeria's energy is supplied from different hydro-power and thermal power stations. The country is located between longitude 8°E and latitude 10°N, and has two major seasons, wet and dry. The seasonality makes the extent of water availability at the different hydro-power stations variable, leading to intermittent supply at times of low water levels. Also, the thermal power stations have been bedeviled by lack of adequate supplies of natural gas from the various Niger Delta gas wells, thereby making continuous energy production from these installations difficult (Iwayemi [1]). This has left Nigerians at the mercy of private alternative power generation through the use of diesel and petrol generators. The emissions from these generating sets have also been subjects of critical global discussions because they release a lot of greenhouse gases to the atmosphere (Ajayi [2]; Nsikak and Ajayi [3]). As at 2001, about 25% of the 774 local government areas of Nigeria were not connected to the national grid and today, more than 80% of these areas are still not connected; a national projection based on 13% Gross Domestic Product growth rate revealed that energy demand will increase from 5746 MW in 2005 to 297900 MW in 2030 while supply should increase from 6440 MW to above 300,000 MW within the same period of years. To accomplish this, requires an additional 11,686 MW every year to meet demand, costing for the period about $US484.62 billion (Sambo [4]). However, current energy production within the

country is less than 3000 MW due to fluctuations in the availability and poor maintenance of generating equipments. Thus, Nigeria still has a long way to go in achieving energy sufficiency. Furthermore, the present generation mix needs augmenting with the aim of maximizing sustainable energy production.

At the same time, the population is increasing rapidly with present population put at over 140 million (NBS [5]). The ever increasing demand and meager supply of energy has been a great challenge to development, with increasing population not balanced by adequate energy development programmes. The incessant power generation failures has also grossly affected the economy and slowed the growth of rural and sub-rural settlements. The present energy supply system is such that favours improving energy and electricity supplies to cities and industrial areas, while, majority of those in rural areas depend on burning wood and traditional biomass for energy needs, due to lack of grid connection and access to modern energy sources, thereby causing deforestation, greenhouse gases emission and environmental pollution in these areas (Kersten [6]; Piebalgs [7]). The increasing population of the country side by side the total capacity and production of available power stations have placed the nation in a real situation of not being able to meet the energy need of the people (Ajayi and Ajanaku [8]). Moreover, one way out for the nation is in energy diversification, increasing the present energy sources which have been grossly inadequate and inconsistent to include renewable resources. These resources are cheap, easily accessible, naturally applicably, enormously available, environmentally friendly, non-depleting and non-toxic source of valuable and usable energy, under which is the wind energy. This paper is therefore used to address the issues of wind energy availability and utilization in Nigeria using the outcome of various initiatives by governments and indigenous researchers.

2. DEVELOPMENT OF WIND ENERGY IN NIGERIA

The wind, as a source of energy is gradually gaining prominence around the world, although backed by long history, the technology is still new unlike the sun; its availability undoubted, many countries are yet to embrace it. Today, wind power is not used in Nigeria, what is available are relics pointing to its previous usage. However, the desire to seek for a lasting solution to the energy situation of Nigeria has prompted the government as well as independent researchers to assess the nation's potentials for wind energy. The government appointed two groups of consultants to ascertain the potential for wind energy and also carry out wind resource surveys for the country (Ajayi [9]). Individual researchers on their part have made various assessments of potentials and availability to determine the magnitude of wind resources. Asiegbu and Iwuoha [10] studied the wind in Umidike, South-East, Nigeria and assessed its economic viability at a hub height of 65 m above the ground with annual mean wind speed of 5.36 m/s using 10 years (1994–2003) wind speed data. Fadare [11] carried out a statistical analysis of wind energy potential in Ibadan (a city in Oyo State of Nigeria), using the Weibull distribution function and 10 years (1995–2004) daily wind speed data. The outcome was that the city experiences average wind speed and power density of 2.947 m/s and 15.484 W/m^2; Ogbonnaya et al. [12] on the other hand worked on the prospects of wind energy in Nigeria using 4 years of wind data from seven cities (Enugu, Jos, Ikeja, Abuja, Warri, Sokoto and Calabar). The annual wind speed at 10 m above the ground varied from 2.3 to 3.4 m/s for sites along the coastal areas and 3.0 – 3.9 m/s for high land areas and semi-arid regions. It was also reported that monthly average wind power was reported as 50.1 W/m^2 and Sokoto is capable of a power potential as high as 97 MWh/yr. Further works by researchers are profiled in (Ajayi [9]). Each of these initiatives, in the limits of their uncertainties, have identified that great prospects exist for wind energy utilization for power

generation. Moreover, wind speeds are generally weak in the south except for the coastal regions and offshore, which are windy. Offshore areas from Lagos through Ondo, Delta, Rivers, Bayelsa to Akwa Ibom States were reported to have potentialities for harvesting strong wind energy throughout the year. Inland, the wind was reported strongest in the hilly regions of the North, while the mountainous terrains of the middle belt and northern fringes demonstrated high potential for great wind energy harvest. It was however observed that, due to varying topography and roughness of the country, large differences may exist within the same locality. The values for the wind speeds range from a low 1.4 to 3.0 m/s in the southern areas and 4.0 – 5.12 m/s in the extreme North, at 10 m height. Peak wind speed was shown to generally occur between April and August for most sites in the analysis (Ajayi [9]). Further analysis of these wind resources also revealed that the North, Central and South-East of the nation posses enormous potential for harvesting wind energy, with possible wind speeds reaching as high as 8.70 m/s in the north (Ajayi [13]).

Moreover, each of the aforementioned and other reports was based on measurements from few wind stations located within the country. For instance, Adekoya and Adewale [14] analyzed wind data of 30 stations, while Ajayi [13], analyzed ten years data from 10 wind stations. Increasing both the number of stations and reference years would increase the accuracy of the results. Thus, latest results (NIMET [15]) based on the outcome of using 40 years (1968 – 2007) available average wind data from the whole forty-four wind stations across the states of the federation showed that (Fig. 1), the country's wind regime is found to

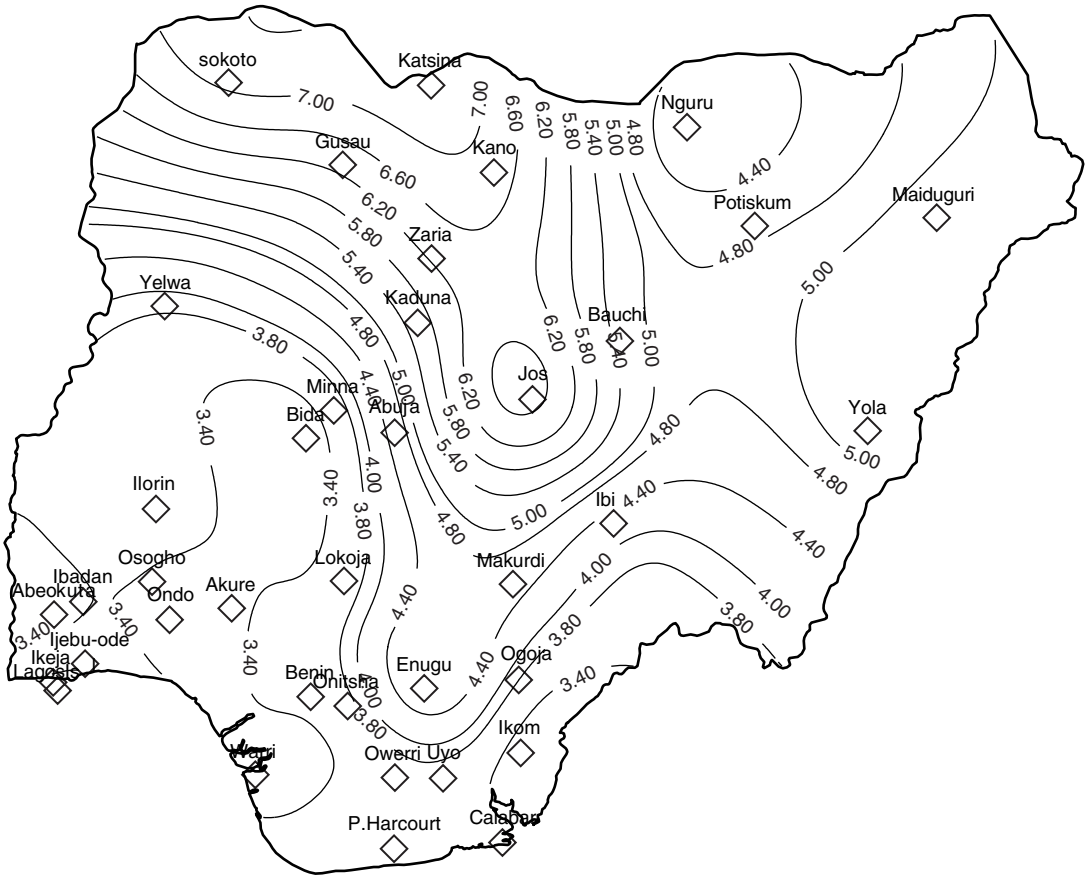

Figure 1: Isovents in m/s determined from 40 year's measurements at 10 m height, obtained from Nigeria meteorological department, Oshodi, Lagos State, Nigeria (NIMET [15]).

lie majorly between poor to moderate regimes, with the southern states having their mean wind profile at 10 m height in the range between 3.0 – 3.5 m/s, depending on the states, and Northern states capable with mean wind speeds of between 4.0 – 7.5 m/s. This means that, Nigeria has good wind resources over most part of the country. Although, wind speeds in the southern states are low, they can however be employed for standalone power generating systems using small scale wind turbines. This if employed, will be a major breakthrough for rural and sub-rural areas not connected to national electricity grid.

3. CHALLENGES FACING WIND ENERGY DEVELOPMENT

The factors that tend to limit wind energy development within the country include:

3.1. Non-Existent Policy, Legal or Regulatory Framework Relating to Wind Energy Technology

Identifying the crises state of Nigeria's energy system and knowing the prospects which are existent in wind for power generation within the country, the government needs to develop robust policy framework of legal and regulatory mechanisms that would encourage the development of wind energy technology (WET), attract foreign and indigenous investors and also set standards for wind farm creation and management. As at today, no popular fiscal, legal or regulatory policy exists for WET. Potential investors always will hope to see the level of seriousness which the governments have demonstrated and what opportunities have been put in place to enhance marketability of WET within the country before investing in their money. Such seriousness is basically demonstrated in policy documents that have been put in place. An example of such policy is the Denmark renewable energy policy (Meyer, [16]). This policy contain among many other things factors that have improved wind power development in Denmark for over 2 decades, making the country one of the leading nations utilizing wind energy for productive purposes. Part of the policy statement includes those that favour regulated feed-in tariff for electricity from wind and other renewables, different subsidies and remuneration rates for wind energy investors, the right to connect renewable generation to the national electricity grid, legal obligations for electric utilities to purchase wind energy and promotion of private individuals, farmers and cooperatives to own wind turbine installations. The overall goal of the Danish energy policy was to promote sustainable energy development and to comply with commitments to reduce greenhouse gas emission in an effort towards the mitigation of climate change (DME, [17]; DMEE, [18]). Germany and South Africa (SADME [19-20]) have also adapted the Danish energy policy to develop their own energy policy and Nigeria can do likewise. For Nigeria, the policy must contain like others, vital market components which will serve as incentives to willing investors. The act of making a single policy to represent for all energy sources (combining both renewable and nonrenewable or combining all renewable energy sources together) may not be very reassuring, because individual energy sources represents specific dynamics and should in policy development be individualized. In addition, such well rounded policy should contain among other issues, the quota of WET contribution to national portfolio on energy mix and this should be set and fixed for specific entry year probably say 2020. With this, the nation and the external public will be informed at what pace the WET development should go and what level of investment would be required.

3.2. Poor Government Motivation on WET

The governments although have been looking for ways of getting the nation out of the energy poverty, they have however not done enough at all levels to create enabling business

environment to promote and encourage WET development. It is well known that the initial capital cost for wind and other renewable energy technology is very high compared to other conventional energy sources, if however, the governments (local, state and federal) would give tax incentives or holidays to willing investors, remove/reduce custom duties payable on importation of WET, give subsidies to sales/purchases of WET applications, provide low or interest free loans through banks primarily for WET investors and also restructure the energy framework of the nation to include WET, the awareness level of the public will be enhanced and invariably there would be rapid embracing of the technology of wind for power generation.

3.3. Lack of Adequate Research and Development

Research and Development (R & D) tailored towards WET in the nation have been few, slow and not encouraging. The available data have not also been adequately employed to develop physical models that would translate the huge resources of wind to power. Until recently, what was available was small data system pointing to the availability of wind as a source of potential electricity production within the nation. Basic researches into the act of tapping wind for electricity have been non-existent within the country. This is because, such practices involve funding and such funds have not been available anywhere for access by wind energy researchers. More so, research tailored towards development of low cost materials for wind turbines and other renewable energy technology applications should begin. This will invariably eliminate the huge initial capital involved in starting Wind energy business and also further reduce the operating and management cost of the technology. Other areas of research include more robust wind resource assessment for the nation to cover both onshore and offshore areas. This may involve establishing more wind stations across the states and geopolitical zones of the nation for data collection, development of suitable national wind atlas, such that could be used in wind power assessments at specific sites, site specific assessment of performance of wind turbines, development and validation of novel wind turbines that generates high amount of electricity at moderate/low wind regimes, also research into best ways of integrating wind turbines to the grid may be carried out.

3.4. Lack of Focus on the Renewable Energy Master Plan

One of the two federal government initiatives at resolving the country's energy poverty led to the creation of the nation's Renewable Energy Master Plan in 2005 (ECN-UNDP [21]). This master plan stipulates that the country should endeavour to increase the energy generation capacity from 5000 MW to 16000 MW by 2015 through the exploration of renewable energy resources. As at present, there has not been single grid generation of electricity from renewable energy sources probably as a result of government's lack of focus and commitment to the plan. The governments at all levels need to be committed to a plan they have initiated and agreed to if there must be meaningful development. The renewable energy master plan will be a vital resource if there can be serious devotion to the suggestions contained therein. Part of this suggestions include suspension of the Renewable Energy (RE) import duties, integration of RE into non-energy sector policies, establishment of national RE development agency, standardization of RE products and establishment of RE fund to provide incentives, micro-credits schemes, training and also fund R & D (ECN – UNDP [21]). Moreover, there may be a useful need for the master plan to be broken down into renewable source components, with each addressing expected contributions from particular type of renewable resources.

3.5. Lack of Statistical or Computational Representative Models for Predicting Wind Energy Resource Potentials of the Nation

Even though only few results are available on the prospects of wind energy in Nigeria, none of them have created representative models that can be used to evaluate or forecast at any time the amount of wind energy and wind power fluxes per annum that will correspond to particular sets of wind speeds for the nation. The development of such models will be based on historical wind data for different sites and states across the nation and through regression and other statistical distributions, a predictive model which can be used at any time for forecasting the wind power situation of a place can be successfully developed. The model will be vital at foreknowing the amount of energy harvestable from particular states, zone or whole nation when the available data on the locations are converted to statistically significant models, also, such model could be used in a way to determine the most probable wind speed of a site and also justify what size of wind investments and returns could be possible at different places within the nation and also it can serve as a complimentary information source for a wind atlas. Investors are always willing to know beforehand the viability of a product in the market before entering into that market. This is equally true for wind investors. Having a model which can be used by them to check what size of energy will be derived from the available wind data of a place would greatly enhance their investment decision and promote WET development in the country. Further simulating such model to make it amenable to the computer will be added advantage.

3.6. Lack of Adequate Funding

Lack of adequate funding have invariably been a major setback in the growth of WET and other renewable energy technology in Nigeria. Annually, the percentages of the federal budget to education and science and technology ministries have not been encouraging. With the meager sum made available to these ministries, much productive research and development may not be started or supported. The corporate bodies also would need to be encouraged to collaborate with research institutions to fund researches aimed at national development, some of which include wind-for-power projects (both small and medium scale turbines), nationwide wind energy resource assessment, development of adequate and explanatory national wind atlas/map that would provide information on quantity, distribution, quality and utilization possibilities to determine the commercial feasibility of wind energy generation and decision making on investment (ECN-UNDP [21]) and development of national wind turbine tests and certification (Meyer, [16]).

3.7. Other Challenges

Apart from all the earlier mentioned challenges which if overcome will move the nation forward in utilizing wind for power generation, there are other challenges which include lack of awareness and technical ineptitude. The level of awareness on the viability of wind as a good prospect for electricity or power generation is very low in the country. Majority of the schools' curriculum lack adequate expository information on wind and other renewable resources, the technology, potentialities and their environmental situations. The mass media too has not helped in any way, hardly can information regarding wind energy utilization or technology be seen on the pages of newspaper or heard discussed on television or radio. This lack of awareness has also led to high level technical ineptitude, thereby making adoption of wind as veritable source of power generation a difficulty (Ajayi [9]).

4. SUGGESTIONS/STRATEGIES TO ENCOURAGE WET

In addition to the aforementioned suggestions to overcoming the various identified challenges, there are other strategies/suggestions which if implemented could move the nation forward in the drive to utilizing wind for energy development. These include amending the land use act of 1979 to encourage wind farm establishment. This invariably will involve the activities of town planning and rural development authorities so that policies that favour wind farm development would be entrenched in the act in such a way that it will be difficult to alter in future. Investors willing to embark on WET through establishment of wind farms across the country will need enough land to do so; such land should necessarily be inexpensive. Also areas marked for wind farms will need to be devoid of wind breaks, so, the nation's planning authorities will need to develop appropriate standards for establishing wind farms. There is also a need to integrate WET into the Independent Power Project of Nigeria. This should be done in such a way that encourages people and industries to individually own their standalone wind energy applications and also avenues for linking excess generation with the national grid should be developed. Another very important step is integrating WET into the rural development plan. While planning for the development of rural areas in order to encourage rural-urban integration, the concerned authorities must take note of the advantages of wind energy for power generation and how such can be used to power communities not connected to national grid. Thus, it will be very good if wind-for-power and solar-for-power could be considered as complementary standalone energy sources for rural development rather than the present state of some no power rural communities. Other strategies that could also be embraced include leveling the playing field in the energy market between nonrenewable and renewable energy sources, focusing on the developments of wind farms and technologies, creating sustainable markets for the sale of wind energy within the country and developing a suitable wind map for the nation to serve as information resource for the public and willing wind energy investors.

In addition to the aforementioned, the present electricity tariffs in Nigeria still need a further review to encourage wind energy technology and other renewable energy development. This is because prior to current electricity regime, the Nigerian electricity tariffs had put the cost of electricity per kWh at an average subsidized range of \$US (0.05 ± 0.01) for all grades of consumers beginning from residential consumers with single phase meters to commercials with three phase meters. However, the current regime has the Multi - Year Tariff Order (MYTO) come to effect and would run for 15 years beginning from July 2008. This MYTO is introduced to address the low electricity tariffs of the nation, which has become a major concern of existing players of the sector, as well as encourage the emergence of independent power producers. It sets tariffs at levels that support the viability and growth of the Nigerian electricity supply industry. Moreover, to cushion the effect of the rate increase, the Government will provide subsidies in the first three years of its introduction and thereafter, the consumers will be expected to pay the full estimated cost-reflective tariff with effect from 2011. The current average electricity tariffs across all levels of consumers have been up by 10% of the pre – MYTO regime and a tariff of about \$US 0.02 has been fixed for wholesale generation and \$US 0.07 distribution for over the next 5 years. It is expected that all tariffs will be increasing afterwards as time went by (ECN-UNDP [21]; NERC [22]; VNTWG [23]). While this tariff order is in implementation, it will be encouraging if the government also considers developing a regulated feed-in tariff regime for electricity from wind and other renewable sources. This will encourage growth of WET and the nation may gradually by this be looking towards ending the energy crises through adequate development of wind and

other renewable energy frontiers and more so, be looking forward to a better national contribution in the ongoing global struggle aimed at improving climate change mitigation.

5. CONCLUSION

This study has been used to address the issues of Nigeria energy situation vis-à-vis the assessment of utilization of wind energy in the country. It is found that although Nigeria is blessed with abundant supply of wind energy resources for power generation, she is still engrossed with high level of energy poverty which have invariably affected development and impinged negatively on economic growth with some parts of the country especially the rural areas lacking access to modern resources which come with availability of electric power. However, latest results showed that the Southern and Northern states of the federation are capable of experiencing mean wind speeds of between 3.0 – 3.5 m/s and 4.0 – 7.5 m/s. On the beaufort scale, the country is rated between 1 – 3 in the southern states and between 3 – 4 in the northern states. Meaning that, there is huge prospect within the country for power generation through wind if associated challenges hindering wind energy technology (WET) advancement are overcome. Some of these challenges include non-existent policy, legal or regulatory framework relating to wind energy technology, poor government motivation on WET, lack of adequate research and development tailored towards WET, and lack of national statistical or computational representative model to mention a few, thus, pointing to the fact that if the government at all levels work together to amend the land use act of 1979 to encourage wind farm establishment, provide incentives for willing investors, incorporate WET into the nation's independent power project plan, show focus and commitment towards the renewable energy master plan, integrate WET into the rural development plan and also cooperate with private sectors to provide needed funds for meaningful research and development, the country's energy situation will be on a better run.

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