AN ASSESSMENT OF NIGERIA WIND ENERGY POTENTIAL BASED ON TECHNICAL AND FINANCIAL ANALYSES

DIOHA M.O. *, DIOHA I. J. **, OLUGBOJI O. A. ***
*Mechanical Engineering Department, Federal University of Technology, Minna
** Energy Commission of Nigeria, Abuja
***Mechanical Engineering Department, Federal University of Technology, Minna
Corresponding Author: mdioha@ymail.com

Abstract- The energy requirement of Nigeria is increasing exponentially with little projects available to carter for this increasing demand. The primary source of energy in the country which is fossil fuel creates environmental pollution and is also finite in nature. Hence, there is a serious need to look for other alternative ways to meet up with the energy requirement of the country. This paper analysed some of the economic and sustainability benefits for Nigeria by deploying and integratingwind energy into her energy mix. The study was done with the RETScreen Clean Energy software tool, designed by Natural Resources Canada. The study began with a brief review of the various wind energy resource assessment done previously in the country and Maiduguri town was selected as the area of study from the reviews. The technical and financial analysesof the study showed that if the project is implemented it will be beneficial to Maiduguri town and Nigeria in the long run. The process of electricity generation from 100 units of VESTAS V80 in Maiduguri yielded MWh 525,600 and saves about 202,881.6 tonnes of CO_2. Without incentives, the financial analysis showed that the project is not financially viable with the equity payback greater than the project life. Key issues affecting the development of wind energy technology in Nigeria were also discussed.

Keywords: Maiduguri, RETScreen Software, Sustainability, Technical & Financial Analyses, Wind Energy

1. INTRODUCTION

Energy in Nigeria plays a vital role in shaping the economy of the country. It is seen as that crucial input that will fuel the country's industrial development in order to meet the increasing energy needs. The total installed electricity generation capacity in the country now is4,600 Megawatts with renewable energy penetration in Nigeria still at a nascent stage [1]. It is far below that of other widely known energy sources due to technological and economic drawbacks, in addition to deep rooted policy inertia. The only source of renewable energy in the country is hydro-power and biomass; wind and solar energy have only been deployed in minuscule amount[2]. Nigeria continues to remain in a deficit state with per capita electricity consumption at 148.93kwh and a projected electricity demand at 200,000 MW [3].

Today, Nigeria's electricity is supplied from hydro-power andthermal power stations across the country.However, seasonality makes the extent of water level at the different hydro-power stations variable, leading to inconsistent supply of power at times. Also, the thermal power stations have been endangered by inadequate supplies of natural gas thus, making continuous energy production from these installations difficult [4]. This has made many Nigerians to resort to other sources of power generation through the use of fossil fuel basedgenerators. The emissions from these generating sets have also been issues of critical global discussions because they release a lot of unhealthy gases to the atmosphere. As at 2001, nearly 27% of the total local government areas of Nigeria were not connected to the central grid and today, more than 80% of these areas are still notconnected; a national projection based on 13% Gross Domestic Product (GDP) growth rate showedthat energy demand will increase from 5700 MW in 2005 to 297000 MW in 2030 while supply should increase from 6400 MW to above 300,000 MW within the same time frame. In order to achieve this, there is need for an additional 12,000 MW every year to meet demand, costing for the period about $US500 billion [5].

However, the energy production within the country today is less than 5000 MW due to variations in the availability and poor maintenance of generating infrastructures. Hence, Nigeria still has a difficult way to go in achieving steady energy supply.Also the finite nature of fossil energy carriers which is our primary source of energy in the country and the growing climate problem makes renewable energy one way out for the nation. Nigeria is endowed with a lot of renewable energy resources including wind, solar, biomass etc.Wind energy is gaining importancegradually around the world, despite backed by old history of its usage, the technology is still new unlike solar; its availability undoubted, many countries are yet to see it as an alternative source of energy. Today, this renewable resource is not yet connected to the Nigeria electricity grid. However, the desire to find a permanentsolution to the energy crisis in Nigeria has prompted the Nigeria government as well as independent researchers to assess the potentials for wind energy in the

country [6].
Fagbenle *et al.* [7] investigated the wind energy potential of Nigeria and reported that about 3.0 m/s characterised the 1951 to 1960 surface wind data at 10 m height from twelve meteorological stations. The report also showed that mean wind speeds in the North were almost twice as high as those of the South, while the Jos station in Plateau State had the highest mean wind speed of about 3.6 m/s because of its high altitude plateaus. Ojosu and Salawu [8,9] also studied annual average wind data from 22 meteorological stations within the period of 1951–1975. Their report showed that the high-latitude Sokoto station was the windiest, having a monthly average wind speed of 5.12 m/s in the month of June and an annual mean wind speed of 3.92 m/s. Their report also showed that the middle belt and the southern parts had wind speed values of at most 2.0 m/s.
However, Fadare [10] recently showed that monthly mean wind speeds measurements from 1983 to 2003 ranging between 0.9 and 13.1 m/s characterise the nation's wind speed regime against those of earlier measurements.

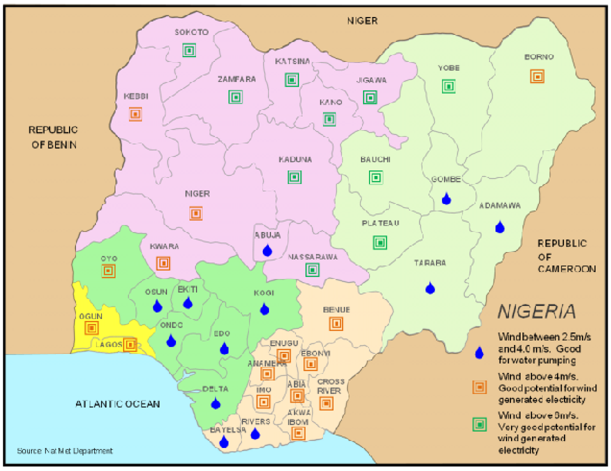


Fig. 1. Nigeria Wind Map Source: NEW ERA Energy

Based on the reported results and looking at the wind map of Nigeria, it can be concluded that Nigeria lie between low to moderate regimes, with the southern states having their meanWind profile at 10 m height in the range between 3.0 to3.5 m/s, andNorthern states with mean wind speeds of between 4.0 to 7.5 m/s. This means that,Nigeria has good wind resources over most part of the country especially the Northern region.
In view of the enormous potential of wind energy in Nigeria, there is a need to assess the potential role of wind energy in improving the performance of the Nigeria electricity sector and in turn the economic condition of the country. The present study, therefore, is aimed at analysing the economic and sustainability likelihood for Nigeria by benefiting from the use of wind energy to boost its energy sector. The study also seeks to determine the environmental benefits from using wind power based on the amount of greenhouse gas emissions that can be avoided. In addition, the research further enumerates some of the challenges facing the use of wind energy in Nigeria and also proffered possible solutions.

2. METHODOLOGY

The methodology used in this research work is mainly review of related literature and the use of the RETScreen4 software.

2.1. Area of Study

Maiduguri in Northern Nigeria was selected and studied for the viability of installing wind farms. The town was selected for this study because of the high wind speed been reported in the region.

Table 1. Climatic data of Maiduguri

TOWN	LATITUDE	LONGITUDE	ANNUAL WIND SPEED (m/s) measured at 10m
Maiduguri	11.9°N	13.3°N	3.8 m/s

Source: NASA

2.2 Software Programs

Various kind of computer analysis tools have been developed over the years for analysing wind energy systems, ranging from feasibility analysis to flow modelling such asWind Data Generator, RETSCreen, WAsP, QBlade, WindPRO among others. These analysis tools help to eliminate the expense of building prototypes, optimise the system components, estimate the amount of energy delivery from the system etc. In this study, the RETScreen4 software tool was used for analysing the financial and technical viability of integrating wind energy into the Nigeria energy mix.
This software is preferred to other analysis tools because it is user friendly and flexible without compromising on the technical details.

2.3. RETScreen 4

RETScreen 4 International is a clean energy awareness, decision-support and capacity building tool. The core of the tool consists of a standardised and integrated clean energy project analysis software that can be used world-wide to evaluate the energy production, life-cycle costs and greenhouse gas emission reductions for various types of energy efficient and renewable energy technologies (RETs). The software also includes product, project and climate databases, and a detailed user manual. Each RETScreen technology model (e.g. Wind Energy Project, etc.) is developed within an individual Microsoft Excel spreadsheet "Workbook" file. It is managed under the leadership and ongoing financial support of CANMET ENERGY research centre of Natural Resources Canada's NRCan. RETScreen is developed in collaboration with a number of other governmental and multilateral organizations, and with technical support from large network of experts from industry, government and academia, such as NASA, UNEP, SWERA etc. [11]

Table 2. Summary of the basic parameters used for the Analyses

Wind Turbine Details Manufacturer Model Hub height Number of Units Cost per unit Power per turbine	 Vestas VESTASV80 - 2.0MW - 60m 60m 100 NGN 700,000,000 2000 KW
Electricity export rate	NGN/kWh 13.00
Transmission and Distribution (T&D) losses	30%
GHG credit fee	0%
Inflation rate	0%
Incentives and Grants	NGN 0.00
Project life	25yrs
Debt ratio	50%
Debt interest	25%
Debt term	15yrs
Fuel cost – proposed case	NGN 0.00

2.4. Simulation Method

The project type is of power generation (Central-grid), and the simulation method is considered as method 1. Method 1 was used because of its simplicity and to avoid ambiguous parameters. The Heating value reference is considered as Lower Heating Value. Higher heating value is typically used in cold locations like Canada and USA, while lower heating value is used in the rest of the world. Hence LHV was selected. This is of International wide software hence we can get the currency that we required. NigeriaNaira (NGN) was selected from the currency database and was used for the study. The climatic data condition for Maiduguri was also obtained from the climate database and was included in Site reference conditions.

3. RESULTS AND DISCUSSION

The analysis of the results involves both the technical and financial analysis for the viability of deploying wind energy in Nigeria and this was done with the results from the RETScreen 4 software. Some key issues facing the development of wind energy in Nigeria were also discussed.

3.1. Technical Analysis

Results from RETScreen 4 showed that deploying 100 units of VESTAS V80 to Maiduguri for power generation will yield MWh 525,600 which can be exported to the grid. The total energy yield is the total amount of energy generated by the system and in the case of grid-connected wind energy systems, the total amount of electricity that is injected into the central grid. Also, the analysis had a capacity factor of 30% which is the ratio of the actual output of a power plant over a period of time and its potential output if it had operated at full nameplate capacity the entire time.

The Greenhouse Gas (GHG) Emission analysis showed a net annual GHG emission reduction of 202,881.6 tonnes of CO_2 which is equivalent to 37,158 cars and light trucks not used. Comparing this value to the base case, the proposed case will cut short the emissions to 30%. In the long run it can earn the carbon credits to the project and it can support the additional revenue to the project.

The electricity yield from this project can power over 500,000 households. Think about how much carbon emission that it can potentially decrease; definitely enough to reduce the dangers of heating up the planet with toxic carbon emission. If Maiduguri alone cansave Nigeria this amount of GHG emissions; then it is very clear that Nigeria can benefit a lot and ensure sustainable energy production by exploring its wind energy potential.

3.2. Financial Analysis

The financial analysis of this study was done to determine the cost and intended benefits of implementing this project. The financial analysis began with the development of a base case scenario which includes the present cost of electricity and other financial parameters. Other scenarios were also developed from this base case to help analyse the effects of the various financing options on the project. The options considered for the analysis include grants and incentives, feed-in tariffs (FiT) and carbon credit financing.

The total annual cost, total annual savings and income, Pre-tax Internal Rate of Return (IRR)-assets and equity payback were considered to help determine how feasible the project will be. The total annual costs represent the yearly costs incurred to operate, maintain and finance the project. The total annual savings and income represents the annual savings and/or income realised due to the implementation of the proposed case. The Pre-tax IRR-assets represent the true interest yield provided by the project assets over its life before income tax while the Equity payback represents the length of time that it takes for the owner of a project to recoup its own initial investment

The cost of the wind turbine type used for this study was gotten from renowned online source (www.windustry.org). The total annual cost for the projected was estimated at NGN 9,074,090,246.

The total annual savings and income of the project yielded NGN 6,832,800,000. The Pre-tax IRR-assets yielded a value of -2.3% with the equity payback greater than the project life. However, applying a meaningful incentive and grant to the analysis indicates that it is possible to have an equity payback far below the project life.

3.3 Key issues affecting Wind Energy deployment in Nigeria.

The challenges that tend to limit wind energy development in Nigeria can be considered in three factors:

I. *Economic factors:*Thehigh cost of wind energy system compared with larger scale conventional generation systems and the high upfront costs of wind energy systems compared with smaller scale conventional systems evenwhere competitive, tend to discourage people from investing in wind power technology. Also,lack of large scale projects in the country, to take advantage of the economies of scale tends to make investment in wind power so difficult. The government should provide appropriate incentives as that will go a long way to support the deployment and reduce the cost of wind energy technology.

II. *Political factors:* Absence of political targets for wind energy deployment and non-existence of tailored financial schemes for small and medium sized projects and businesses for semi-urban and rural areas limits the usage. There are also weak policy measures and weak national institutions for level playing field for wind energy in the country. The Nigerian government should establishfiscal, legal or regulatory policies that will favour the development of Wind Energy Technology in the country such as feed-in tariff. Potential investors always will hope to see the level of government commitment to deploying wind energy in the country before investing their money.

III. *Technological factors:* There isinadequate skilled technical manpower, limited manufacturing due to small national markets andlimited Research and Development with little or no linkages to entrepreneurial/manufacturing sector. Research efforts should be geared towards developing low cost materials for manufacturing wind turbines and wind resource assessment in the country as these will go a long way to reduce the huge initial capital outlay and also reduce the operation and maintenance cost.

4. CONCLUSION

This paper has been used to establish some of the economic and sustainability benefits Nigeria will get by harnessing her wind energy potential, using Maiduguri town as a case study. Notable among these benefits is the GHG emission reduction and financial implication of using wind energy. This paper particularly serves as an eye opener for allthose ignoring the importance of wind energy in the Nigeria energy mix, giving the immense benefits we can get from wind.

Analyses of the RETScreen results show that, the project when implemented will supply about MWh 525, 600 electricity annually, and also stands the chance of saving about 202,881.6 tonnes of CO_2 which would have been emitted by a fossil fuel fired thermal power plant generating the same amount of electricity. At the prevailing tariff conditions in the country, this project can be considered as not financially viable except if feed-in tariff scheme or other incentives are applied. However, the other non-financial benefits like the greenhouse gas emissions savings can, in the long run, help mitigate the adverse effects of the climate change problem facing the entire world.

The study also showed that although Nigeria is blessed with abundant supply of wind energy resources for power generation, she is still faced with some key economic, political and technological problems which are hindering the deployment of wind energy technology in the country. And unless these problems are addressed, the country will still remain in its current energy situation.

APPENDICES

A. Propose case power system

RETScreen Energy Model - Power project

Proposed case power system

Technology		Wind turbine	
Analysis type		⦿ Method 1 ○ Method 2 ○ Method 3	
Wind turbine			
Power capacity	kW	200,000.0	
Manufacturer		Vestas	
Model		VESTAS V80-2.0 MW - 60m	100 unit(s)
Capacity factor	%	30.0%	
Electricity exported to grid	MWh	525,600	
Electricity export rate	NGN/MWh	13,000.00	

B. Emission Analysis

☑ Emission Analysis

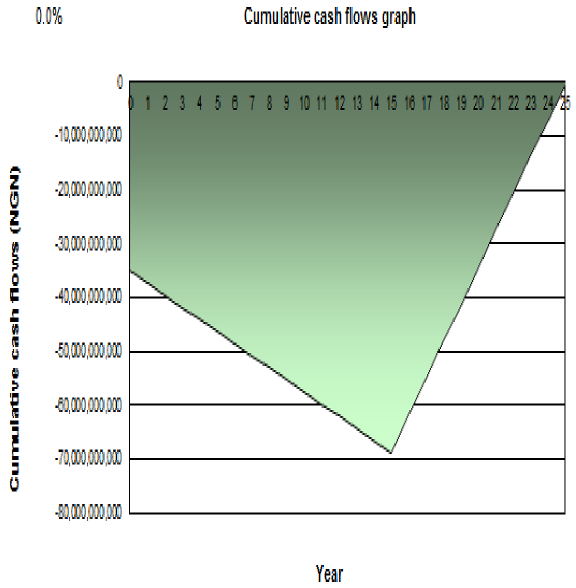
Base case electricity system (Baseline) Country - region	Fuel type	GHG emission factor (excl. T&D) tCO2/MWh	T&D losses %	GHG emission factor tCO2/MWh	
Nigeria	All types	0.386	30.0%	0.551	
Electricity exported to grid	MWh	525,600	T&D losses	30.0%	
GHG emission					
Base case	tCO2	289,830.9			
Proposed case	tCO2	86,949.3			
Gross annual GHG emission reduction	tCO2	202,881.6			
GHG credits transaction fee	%				
Net annual GHG emission reduction	tCO2	202,881.6	is equivalent to	37,158	Ca
GHG reduction income					
GHG reduction credit rate	NGN/tCO2				

C. Financial Analysis

Financial Analysis

Financial parameters		
Inflation rate	%	0.0%
Project life	yr	25
Debt ratio	%	50%
Debt interest rate	%	25.00%
Debt term	yr	15
Initial costs		
Power system	NGN	70,000,000,000
Other	NGN	
Total initial costs	NGN	70,000,000,000
Incentives and grants	NGN	
Annual costs and debt payments		
O&M (savings) costs	NGN	5,000,000
Fuel cost - proposed case	NGN	0
Debt payments - 15 yrs	NGN	9,069,090,246
	NGN	
Total annual costs	NGN	9,074,090,246
Annual savings and income		
Fuel cost - base case	NGN	0
Electricity export income	NGN	6,832,800,000
	NGN	
Total annual savings and income	NGN	6,832,800,000
Financial viability		
Pre-tax IRR - equity	%	0.0%
Pre-tax IRR - assets	%	-2.3%
Simple payback	yr	10.3
Equity payback	yr	> project

D. Cumulative cash flows graph



REFERENCES

[1] Power generation in Nigeria, cited (14/12/15) from (http://venturesafrica.com/power-generation-in-nigeria-now-4600-megawatts-will-this-speed-up-the-impending-electricity-tariff-hike/)

[2] Energy usage in Nigeria, cited (14/12/15) from(http://www.vanguardngr.com/2015/08/promoting-renewable-energy-use-in-nigeria/)

[3]Per capita power consumption in Nigeria, cited (20/12/15) from (http://www.tradingeconomics.com/nigeria/electric-power-consumption-kwh-per-capita-wb-data.html)

[4] Iwayemi, A., Nigeria's dual energy problems: Policy issues and challenges, *International Association for energy economics, Fourth Quarter*, 2008, available online [www.iaee.org/ en/publications/newsletterdl.aspx?id=53, accessed 21 December 2009], 17–21.

[5] Sambo, A.S., Matching Electricity with demand in Nigeria, *International Association for energy economics, Fourth Quarter*, 2008, available online [https://www.iaee.org/ documents/newsletterarticles/408sambo.pdf], 32–36.

[6] Oluseyi O. A, The Potential for Wind Energy in Nigeria, Wind Engineering, Volume 34, NO. 3, 2010 PP 303–312.

[7] Fagbenle, R.O.; Fasade, A.O.; Amuludun, A.K.; Lala, P.O. Wind energy potential of Nigeria. In Proceedings of 12th Biennial Conference of West Africa Science Association, University of Ife, Osogbo, Nigeria, 20–26 July 1980.

[8] Ojosu, J.O.; Salawu, R.I. A Survey of wind energy potential in Nigeria. *Sol. Wind Technol.* 1990, *7*, 155–167.

[9] Ojosu, J.O.; Salawu, R.I. An evaluation of wind energy potential as a power generation source in Nigeria. *Sol. Wind Technol.* 1990, *7*, 663–673.

[10] Fadare, D.A. The application of artificial neural networks to mapping of wind speed profile for energy application in Nigeria. *Appl. Energy* 2010, *87*, 934–942.

[11]Retscreen,*Retscreen user manual*, cited (1/1/16) from (http://www.retscreen.net/ang/d_t_guide.php)