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EVALUATION OF RENEWABLE ENERGY RESOURCES POTENTIAL FOR SATISFYING ELECTRICITY NEEDS IN THE NIGER DELTA REGION

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ABSTRACT

The growing effects of global warming and sustainable energy production are a significant challenge in today's world. These challenges is more pre-eminent in growing economies and have remained so for many years, and might remain so for a foreseeable future if without any action. Nigeria is a growing economy that is endowed with ample energy resources. The conventional and renewable energy resources in Nigeria if adequately harnessed has the potential to meet the energy demand of both urban and rural Nigerians. Nevertheless, Nigeria has a low energy consumption rate when compared to other African countries. Nigeria's energy circumstance could best be seen as a country that is sustainably rich, yet lack power. Previous works have presented ways in which the available methods of harnessing sustainable energy sources can be improved. There are limited works on the feasibility of meeting energy demands for communities in the Nigeria Delta Region of Nigeria. In this work, the possibility of meeting the energy needs of Buguma a small community in the Niger Delta Region in a sustainable manner has been explored and presented. The primary goal of this work will be on the potentials of vast untapped renewable energy sources in Buguma. From the discussions presented in this work, it isimperativeto select and combine the available renewable energy resources carefully. This process must be planned and executed holistically to ensure that the unmet power needs in Buguma and possibly other developing communities can be addressed through a standalone system. The design and installation of a standalone system which can match the energy needs of Buguma and any other developing communities that are far from the existing national grids have been recommended.

Keywords: sustainable energy, renewable energy, solar energy, biomass, biogas, Buguma, Niger delta region.

1. INTRODUCTION

Energy is a vital component for development, and it is an essential input to the economic needs of present-daycivilisation. It is, without doubt, the driving force of industrialisation[1]. Access to energy is needed for economic and social opportunity such that no economy has advanced beyond a subsistence economy without guaranteeing that at least its population has access to energy services [2]. Energy is essential in meeting the basic needs of the poor and provision of social amenities to the rural population. The population growth rate of Nigeria is high at about 2.6% per annum. The country's dependence on oil and gas as the primary source of foreign exchange and policy instability has exposed the economy unduly to global energy dynamics. This dependence on oil and gas has led to the inefficiency of the government in meeting the needs of its populace. However, since the start of the democratic era in l999, the economy has developed into a private sector-driven economy with some policy frameworks established to improve the infrastructure needed for energy supply.

There is a need to effect a change in policy due to the growing population and the effect of such population on socio-economic growth of the country. National Energy Policy (NEP) is one of such policies established to improve the energy security of the country through the development of all energy resources. It also aims to provide appropriate, sustainable and reliable energy at realistic costs. The NEP promotes a cost-effective energy consumption rate and their applications in the energy sector. The contribution of electric energy to the economic growth and development of Nigeria as a country cannot be overemphasised. Nigeria has numerous energy resources. Despite this, the country is only able to efficiently generate 1600 MW out of 6000 MW of the installed generating capacity (less than 30%). Because most of the facilities are not well managed. The high energy losses (30% to 35%) from generation to billing in Nigeria is high compared with the US, where power losses are usually less than 7%, irrespective of the distances [3]. Moreover, a large percentage of the Nigeria population has a low collection and access rate to electricity in comparison with other developed economies.

Today, the country's generation of electricity is not at par with the persistent demand for electrical energy. Most of the citizens reside in the rural areas where the terrain is arduous, and also the access to fossil fuel and electricity grid is complicated due to the poor conditions of the roads. Most communities are located in areas that are quite far from the nearest common connection point of the utility grid system. If we look at some of the communities, they are lowly populated, and on top of it, they are not very educated, and the load density happens to be low. The latter is identified through the brief periods of peak load. Thus, one solution is for them to use the private diesel and petrol generators as their attempt to generate the electricity. Other than the expensive fuel and maintenance of diesel generators, other constraints namely the non-

availability of suitable access roads especially in the rainy season, when there were floods for several days have slowed down the delivery of the necessary fuel and other materials needed to run the generator [3].

Furthermore, running a generator for 24 hours on a daily basis does not seem to be feasible. This results in the use of kerosene lamps, candles to name a few. Due to the use of conventional fuels leading to environmental degradation, what would be relevant is to foster Renewable Energy (RE) sources to render the environment eco-friendly. RE sources make some promising options for the energy and environmental challenges faced by the world today. The potential share of RE in the global electricity production increases together with the price of conventional fossil fuel. Nevertheless, their spatial and temporal availability and technological developments can confirm as to what extent renewables can make their contribution. Several studies have been conducted to determine their global production potentials according to different categories [4] that are made to indicate the extent to which RE is theoretically, technically and economically available for exploitation.

In developed countries, the available energy infrastructure permits relatively easy incorporation of RE into the system, whereas this is less likely to occur in Africa when it has nothing but weak energy infrastructure. Not many studies have tried to evaluate the RE potentials of the Niger Delta Region (NDR). Few studies have been able to determine its magnitude at different scales of potentials and contributions to the country's energy system. The estimation of the potential at different scales is crucial to stimulate investors and energy planners to serve in the energy sector. Recently RE has been proposed for the decentralised energy generation for remote areas that have steep terrains [4]. This work probes into the RE in Nigeria concerning the challenges and opportunities in Buguma, Nigeria. Buguma, as shown in Figure 1, is located in Rivers state, Nigeria. Buguma has latitude of 4.74 and longitude of 6.86, and it is situated at an elevation of 7 meters above the sea level. It has a population of 135,404 persons which has made it the second largest city in Rivers state. Rivers state is located in the NDR of Nigeria.

Figure-1. Location of Buguma on a map.
Source: Google image.

Communities in the NDR have a significant amount of crude oil, natural gas and a large body of water deposited. Moreover, they also have a lot of RE resources such as solar radiation, biomass and wind speed [5]. A better mix of energy sources could be palliative to NDR energy challenges. Therefore, with the use of the readily available RE resources of solar PV, biomass and the natural gas in gas turbine could help increase the power generation, reduce heat and the emission of greenhouse gases. The current study does not account for the economic analysis of the RE sources although it does account for the technical suitability and rural developing country's living situations. In this research solar, gas turbines and biomass energy are two of the RE sources selected for the assessment of their availability in the NDR. The stress on the standalone applications, since a large part of the Buguma populace, does not have to do with the national grid. The results of the assessment serve to answer the question to which extent the electricity from RE sources can help address the energy problems of Buguma residence and how far it contributes to the large-scale grid system. The rest of this paper is organised as follows; Section 2 details the present state of conventional energy generation in Nigeria. Section 3 highlights the government energy policies. The potentials of available RE and findings from the assessments are established in Section 4. Section 5 presents the discussions on the potentials and challenges of RE for energy provision in Buguma. Finally, the concluding remark is presented in section 6.

2. CONVENTIONAL ENERGY GENERATION IN NIGERIA

The conventional energy resources in Nigeria, includes over 4 billion metric tons of coal and lignite, 187 trillion cubic feet of gas and 36 billion barrel of oil [6]. However, oil is the dominant fuel source for electric energy production. Nigeria's installed electricity capacity is 7000 MW compared with South Africa which has 43,000 MW of electricity for a population size that is far lower than that of Nigeria [6]. Furthermore, the consumption level of electricity in Nigeria is low in comparison to other countries with corresponding energy resources and population sizes. This is irrespective of the fact that Nigeria is the most populous nation in Africa. The consumption of electricity per capita in Nigeria's is ranked among the lowest in the list of selected countries as illustrated in Figure-2.

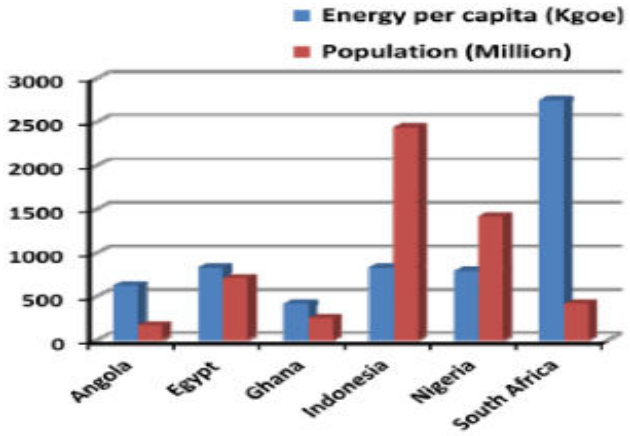

Figure-2. Nigeria's consumption of electric power per capita compared with some selected countries.

To meet the energy demands of Nigeria, a per capita power capacity of about 1000 Watts or a power generating capacity of 180,000 MW is needed [6]. Apparently, the Nigerian energy sector in a state of emergency comparing this requirement to the current generating capacity is about 7,000 MW. There is an urgent need for the Nigeria government to explore other energy resources. This is due to a projected rate of fossil fuel reduction in 4 decades and the devastating environmental complications associated with its use. Therefore, it is imperative for Nigeria to tapped its vast RE resources to avoid falling into an energy supply crisis Table-1 presents the conventional energy reserves in Nigeria and their potentials.

Table-1. Conventional energy reserves in Nigeria and their potentials.

Resource type	Reserves		Production	Domestic utilization (natural units)
	Natural units	Energy units		
Natural gas	187 trillion SCF	4.19	6 billion SCF/ day	3.4 billion SCF/day
Crude oil	36.22 billion barrels	5.03	2.5 million barrels/day	450,000 barrels/day
Tar sands	31 billion barrels of equivalent	4.31	Insignificant	Insignificant
Coal and lignite	2.175 billion ton	1.52	None	None
Nuclear element	None	None	None	None

3. GOVERNMENT ENERGY POLICIES

Nigeria had no comprehensive energy policy until 2003 when the energy policy was approved. The policy was called National Energy Policy (NEP). The primary objective of the NEP is to optimally use the nation's energy resources; both fossil and REs, for sustainable growth and to ensure the active participation of the private sectors in achieving such. The country seeks to attain self-sufficiency in electric power development with the hope of making reliable electricity available to the majority of its citizens by 2020. The NEP also seeks to explore different sources of energy to yield electricity. The Energy Commission of Nigeria (ECN), an agency for RE technology development and promotion in Nigeria, has the mandate to provide a well-planned energy policy coordination and performance monitoring for all of the energy sector. Furthermore, it gives guidelines for the utilisation of energy types for specific purposes. The ECN also builds upon the recommendations on the exploitation of new sources of energy. The major elements in the national policy position on RE development and utilisation and its technologies are presented in Table-2 [7].

Table-2. Major elements of RE development and utilisation and its technologies.

i	**To develop and harness RE resources of Nigeria and bring together all viable ones in the national energy mix**
ii	To Highlight the decentralised energy supply, especially in rural areas based on the RE resources
iii	To discourage people from using wood as a fuel
iv	To introduce efficient methods using biomass energy resources
v	To keep up to date with international development in RE technologies and applications

As an attempt to spur the energy sector, in 2006, the Renewable Energy Master plan (REMP) for Nigeria became part of the African strategy on emission reduction. The objectives of the REMP are as follows [8, 9]

a) To carry out strategies that will achieve a clean RE supply and establish mechanisms to build upon the sector based on international best practices, to demonstrate the extent of its viability for the private sector to participate.
b) To provide a comprehensive framework for the development of RE that will ensure that there is

- access to energy services is to all Nigerians;
- reduction in the emission of carbon dioxide;
- an improved standard of living, especially in the rural areas;

It is unfortunate that despite the recent efforts to reinvigorate the RE sector in Nigeria, the institutional framework is still very fragile, and the following must be addressed to give RE the much-needed momentum:

a) a proper national energy mapping should be carried out to access the actual RE potential to define realistic policy objectives that can lead to the design element selection;
b) a detailed standard and code of practice adequately introduced;
c) the role of RE in the overall energy policy and the national energy mix should be enhanced;
d) A RE research and development agenda should be adequately explained over the coming years with adequate funding;
e) quality personnel at both technical and engineering levels should be trained to ensure self-sufficiency;
f) the RE development with environmental factors and with energy efficiency should be integrated

Although Nigeria is blessed with abundant energy resources,She cannot satisfy the people's energy needs due to mismanagement. Government's over-dependency and excessive fixation on oil has hampered the development of alternative sources of energy, although the demand is high.

4. SOURCES OF RE WITH POTENTIAL FOR HYBRID POWER SYSTEM UTILIZATION IN BUGUMA

To provide a clean and environmentally friendly energy, RE provides a safe and feasible option. About 90% of the energy that has been accommodating the rural dwellers in Nigeria are from fuelwood [10]. It originates from non-nuclear and non-fossil sources in a way that can be renewed during the harvesting phase. Conversion and the use of fuelwood from these sources take place in a way that helps to avoid the wrong side of deforestation on the viability and rights of rural dwellers and the surrounding natural ecosystems. Apart from fuelwood, the practice of gas flaring by oil companies operating in the country is also a significant means through which greenhouse gases (GHGs) are emitted into the atmosphere. Nigeria is known as one of the highest producers of GHG emissions in Africa, and carbon dioxide (CO_2) emissions in the country are among the highest in the world [10, 11]. Some 45.8 billion kW of heat is released into the atmosphere of the NDR from flaring 1.8 billion ft^3 of gas on a daily basis. Gas flaring has thereby increased the temperature and made some areas inconvenient as residential areas.

A total of about 125.5 million m^3 of gas were produced in the Niger Delta between 1970 and 1986, in which 102.3 million m^3were flared while only 2.6 million m3was used as fuel by oil producing companies, and about 14.6 million m^3were sold to other consumers. The high dependency on the burning of fossil fuel can be obviated through the use of RE sources. Also, the flared gasses can be changed to methanol and used as fuel for both industrial and domestic purposes. The potential of RE in Nigeria is about 1.5 times that of fossil energy resources; in energy terms [4]. Hydro, solar, biomass and wind have a high potential to improve and make a difference on the low-level access of electricity in Nigeria. The sources, capacity and potential of each RE resource, shown in Table-3 [12], shall be elaborated in the following paragraphs.

Table-3. Renewable energy resources. Source: Renewable Energy Master Plan(2009).

Resource type	Reserves		Production	Domestic utilization (natural units)
	Natural units	Energy units (Btoe)		
Small Hydropower	3500 MW	0.34 (over 40 years)	30 MW	30 MW
Large Hydropower	11,250 MW	0.8 (over 40 years)	1938 MW	1938 MW
Wind	2–4 m/sat10mheight (main land)	0.0003 (4 m/s @ 12% probability, 70 m height, 20 m rotor, 0.1% land area, 40 years		
Solar Radiation	3.5–7.0kWh/m2/day (4.2 million MWh/day using 0.1%landarea)	5.2 (40 years and 0.1% land area)	6 MWh/day	6 MWh/day
Biomass				
Fuel wood	11 million hectares of forest and wood land		0.120 million ton/day	0.120 million ton/day
Animal waste	211 million assorted animals			None
Energy crops and agric residue	28.2 million hectares of arable land (30% of total land)			None

A. Solar energy

The NDR has a location and climatic conditions that are favourable for the harnessing and implementation of thermal and photovoltaic (PV) systems. The amount of energy in the sunlight reaching the earth is equivalent to around 10, 000 that the world needs for energy. The sun's position as viewed from the earth latitudes 15 degrees N and 35 degrees N is the region with the most solar energy. This semiarid region is mainly located in Africa, the Middle East, the Western United States and India. Nigeria which is in West Africa falls within this tremendous solar energy potential. On the whole, solar radiation in the country has a proper distribution with the average daily sunshine of about 6 hrs and average solar radiation about 19.8 MJm^{-2} day-1. Sambo [8] noted in his report it is possible to generate 1850 x103 GWh of solar electricity annually considering the improved efficiencies of commercial solar panels if solar collectors or module can cover 1% of Nigeria's land mass. This would be more than one hundred times the current grid electricity consumption level in the country. Lately, (PV) electricity has received a considerable amount of attention in both developing and developed countries and it is fast becoming an accessible technology.

B. Biomass energy

Biomass refers to an indirect form of solar energy because it comes from photosynthesis. Fuelwood is the most established form of biomass energy. Nigeria has an abundance of biomass resources such as wood, forage grasses and shrubs, wastes arising from forestry, agricultural, municipal and industrial activities, as well as aquatic biomass. The nation's biomass resources have been estimated at $8x10^2$ MJ. Plant biomass would be used as fuel for small-scale industries. It could also be fermented by anaerobic bacteria for the production of very versatile and cheap biogas [13]. Apart from fuelwood, it is also used for paper products, sawn-wood, plywood and electric poles. As for energy use, 80 million m^3 of fuelwood is utilised in Nigeria annually for cooking and other home purposes. The energy content of fuelwood is $6x10^9$ MJ, and from this, only between 5% and 12% is profitably used for cooking and other domestic uses. Fuelwood and charcoal constituted between 32% and 40% of the total primary energy consumption over the period between 1989 and 2000. National demand was estimated to be 39 million ton of fuelwood in the year 2000. Estimates show that 200 million ton of dry biomass can be obtained from forage grasses and shrubs, freeing about $2.28x10^6$ MJ of energy [14]. Table-4 illustrates different biomass resources and their estimated quantities in the country.

Table-4. Biomass resources estimated quantities in Nigeria.

Resources	Quantity (Million ton)	Energy value (MJ)
Fuelwood	39.1	531.0
Agro-Waste	11.244	147.7
Saw Dust	1.8	31.433
Municipal Solid Waste	4.075	-

Biomass is undoubtedlya primarysource of RE, but the sustainability of its production has to be well comprehended. Nigeria which has a vast range of biomass resources just like South Africa and Malaysia (which has almost the same weather, vegetation and at similar equatorial disposition with Nigeria) should make use of its oil palm products, woods, municipal waste, rice and sugar cane husk for biogas energy production. Most especially, sugar mill companies in the country can take advantage of their cane residues and waste, while paper and packaging mills can make use of the waste biomass to generate process steam, as done in Malaysia and South Africa. This

biomass energy could be changed to liquid fuel for cooking rather than fuelwood, thus lowering the rate of GHG emissions remarkably.

C. Biogas

Biogas is the product of the bacterial decomposition of organic matter without the air, by the biodegradation of organic material under anaerobic conditions. Some of the biogas raw materials include animal dung, industrial wastes, household wastes and air dry crop residues. The mixture of various types of wastes creates more biogas energy [15]. Biogas is very practical for a significant number of applications in the agriculture, household and industrial sectors. Its utilisation instead of diesel, fuelwood, charcoal, and kerosene lowers the rate of GHG emissions. Additionally, it has shown zero risks to health; does not have a foul odour and it burns with a clean bluish, spotless flame thereby making the cooking utensils and kitchens far from messy. Identified feedstock substrate is deemed an economically feasible biogas program in Nigeria. Nigeria generates about 227,500 tons of new animals every day,and 20 kg of municipal solid wastes per capita is produced yearly [7]. About 0.03 m^3 of gas can be produced from 1 kg of fresh animal wastes. Thus, Nigeria has the potential to produce 6.8 million m^3 of biogas daily. Biogas production will not only enhance the energy production, but it has the potential to mitigate the menace and nuisance of urban waste. Biogas has yet to be listed in the energy mix in Nigeria. Furthermore, it is the only entrance to energy provision in communities living in rural areas. Mini- and micro-hydro- power, solar PV, biomass and wind energy should be used to make sure that the electricity can reach isolated areas. RE can also relax the overstretched ecosystem and supply the energy required for the fast-paced development primarily by motivating the establishment of small-scale industries and by curbing the migration from the rural to urban centres. The efficient harnessing of RE technologies to supplement energy generated from fossil fuel resources would elevate the reliability of electricity supply. It will also reduce the emissions of the carbon dioxide, energy insecurity, offset fossil fuelled grid electricity. Thus, improving the availability of energy for socioeconomic activities and the standard of living of Nigerian citizens.

5. POTENTIALS AND CHALLENGES OF RENEWABLE ENERGY FOR SATISFYING ELECTRICITY NEEDS IN BUGUMA

There are great opportunities that can be explored for the usage of RE technologies in applications, where electricity, thermal energy or mechanical power, are the fundamental things needed. However, accounting for specific features of the energy sector in Nigeria and the characteristics of the RE, comparable to non-renewable energy, there is a higher prediction for RE in rural communities. Energy serves to be a vital ingredient for the socioeconomic growth and fast-paced development. Modern economic events are very much dependent on petroleum products and electricity. However, there is a very noticeable restriction in the economic and demand capacity in the extension of the latter RE sources from urban to the rural areas. Energy demand levels of rural dwellers are low, and only 18% of rural dwellers have access to electricity while almost 81% of the urban dwellers have some access to it. Moreover, despite the fact that kerosene can be boughtin some urban centres at pump price, its retail price in rural areas is often higher[3]. Wind, solar PV and micro-hydro systems have proven to be cheaper on a lifetime basis, than grid electricity or diesel generators in situations where loads are low, and they are located far from the grid. The dotted nature and low power demand levels of rural load centres may be indicative of the use of decentralised and small-scale power supply systems to which wind, solar PV and micro-hydro power and other RE power generators are found to be suitable.

A sustainable project implementation approach will require the government, the private sector and consumers to engage themselves in joint participation. RE resources such as wind, solar PV, biomass and Small Hydro Power (SHP) are, in general, distributed well across the country. The concept of Integrated Rural Village Energy Supply (IRVES) was established by the Nigerian government so that the energy needs of rural communities for the many socioeconomic activities, energy resources for these communities, energy-related environmental issues, as well as the skills and trainability of its workforce can be met and can materialise. Energy supply and consumption system for the community would then be developed, aided by the available RE-oriented energy resources, to cater for the needs sustainably. Capacity building programs and post-project management will be provided to improve the sustainability. The broader adoption of modern RE technologies, with proper government support, can offer an excellent alternative to conventional firewood-based technologies; used mostly by the people in rural areas. Large-scale introduction of biogas technology and solar cookers can lower the share of fuelwood in the energy mix [1]. This does not only improve the living standard of the rural population in Nigeria, as far as the education, economic, and social aspects are concerned, but also reduces the exposure to indoor smoke pollution, associated with fuelwood burning, which poses some serious health problems. The mortality rate, in Nigeria, is one of the highest in the world. Thus the wellbeing of rural Nigerians needs to be improved.

Some challenges that have to do with the development have emerged, and RE commercialisation for the distribution of power generation in Nigeria is already in the picture. In many developing countries, electricity supply does not receive proper subsidy due to the continued economic and financial problems. Regardless of the current outstanding progress in RE application in some developing countries, a better utilisation would not be such a distant idea provided the constraints to successful exploitation are recognised and confronted via proactive policies. We cannot dismiss the idea that ascending the energy ladder entails the transition from combustible renewables to more efficient and cleaner methods of exploitation and diversification of other RE resources through a modern approach. The possibility of this

transition depends on the potential source of income for individuals because as the income increases, consumers would climb up the energy ladder [3] for cleaner and more comfortable energy sources. Technological delay, poorly formed political will, economic ups and downs, inadequate level of awareness and educational background, financial corruption and bureaucratic ineffectiveness stand to be the key challenges to the Nigerian RE development. Each challenge and the convergence of all are the main weakness of RE investment despite the many incentives for exploitation. This has seriously ruined the socio-economic welfare of most of the populace, especially in rural places. It was reported that about 300 million people had been freed from the chains of poverty in China since 1990 by giving them more access to modern energy, indicating that there is an unstoppable correlation.

6. CONCLUSIONS

A significant number of the Buguma populace are rural dwellers, and they are located at a distance from the nearest national grid connection. Buguma is blessed an appreciable amount of natural gas, crude oil and abundant RE resources. This paper evaluates the prospects of using RE for meeting the energy demand in Buguma. Buguma, a community in the NDR has been chosen as a case study for this work. With the RE sources available in Buguma, a carefully planned and designed hybrid microgrid can be economically viable. The potential of using RE for rural electrification in Buguma has been accessed. Solar PV and biomass and biogas generations are the major potential contributors to RE sources. Further study should be done to ascertain the feasibility of these RE resources being utilised in smart microgrid generation for the electrification of Buguma community.

REFERENCES

[1] S. O. SO. 2008. Renewable Energy Potentials and Rural Energy Scenario in Nigeria. Renewable Energy for Rural Industrialization and Development in Nigeria, UNIDO.

[2] O. S. Ohunakin. 2010. Energy utilization and renewable energy sources in Nigeria. Journal of Engineering and Applied Sciences. 50(2): 171-177.

[3] M. Shaaban and J. Petinrin. 2014. Renewable energy potentials in Nigeria: meeting rural energy needs. Renewable and Sustainable Energy Reviews. 29: 72-84.

[4] F. O. Igbinovia and G. Fandi. An Overview of Renewable Energy Potentials In Nigeria: Prospects, Challenges And The Way Forward.

[5] N. Idris, H. Lamin, M. Ladan, and B. Yusuf. 2012. Nigeria's wind energy potentials: the path to a diversified electricity generation-mix. Int. J. Mod. Eng. Res. 2(4): 2434-2437.

[6] S. O. Oyedepo. 2012. On energy for sustainable development in Nigeria. Renewable and sustainable energy reviews. 16(5): 2583-2598.

[7] N. V. Emodi. 2016. The Energy Sector in Nigeria. in Energy Policies for Sustainable Development Strategies: Springer. pp. 9-67.

[8] A. S. Sambo. 2009. Strategic developments in renewable energy in Nigeria. International Association for Energy Economics. 16(3): 15-19.

[9] I. Bugaje. 2006. Renewable energy for sustainable development in Africa: a review. Renewable and Sustainable Energy Reviews. 10(6): 603-612.

[10] S. O. Oyedepo. 2014. Towards achieving energy for sustainable development in Nigeria. Renewable and sustainable energy reviews. 34: 255-272.

[11] M. Ishisone. 2004. Gas flaring in the Niger Delta: The potential benefits of its reduction on the local economy and environment. Retrieved on December. 10: 13.

[12] C. Ezugwu. 2015. Renewable Energy Resources in Nigeria: Sources, Problems and Prospects. Journal of Clean Energy Technologies. 3(1): 68-71.

[13] Y.-O. N. Udoakah and M. D. Umoh. 2014. Sustainably meeting the energy needs of Nigeria: The renewable options. in Energy Conference (ENERGYCON), 2014 IEEE International, pp. 326-332: IEEE.

[14] T. Chineke, O. Nwofor, and U. Okoro. 2010. Optimal benefits of utilizing renewable energy technologies in Nigeria and the CIBS quadrangle: A review. Bayero Journal of Pure and Applied Sciences. 3(1).

[15] A. B. Karki. 2009. Biogas as renewable energy from organic waste. Biotechnology. 10: 1-9.