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Research Paper

POWER SECTOR CHALLENGES AND RENEWABLE ENERGY POTENTIALS IN NIGERIA

Gwani M[1]* and Abubakar G A[1]

*Corresponding Author: **Gwani M** ✉ gwanimohammed@gmail.com

The negative impact of climate change on the environment and the harmful effect caused by the continuous dependency on fossil fuels has led to worldwide increasing interest energy generation from renewable energy source. Energy generation from renewable energy such as wind solar, biomass and hydro is the only option that can preserve our earth and the future generation. Nigeria is one of the most developing African countries in the world with a GDP of USD3,005.51 per capita (PPP basis), and steady GDP growth of 6.5 in 2014. To cope with the economic and industrial growth in Nigeria, the demand of energy is growing very rapidly. In this paper the challenges faced by the power sector and the potential of renewable energy in Nigeria is discussed. The present status of renewable energy in Nigeria has been also been discussed in the paper as well. The study reveals that the promotion of renewable energy development in Nigeria will go a long way to solving the challenges of the power sector and helps to reduce the amount of CO2 emission from the fossil fuel relied energy source.

Keywords: Renewable energy, Electricity, Power sector, Nigeria

INTRODUCTION

Energy is widely regarded as a propelling force behind any economic growth and indeed industrial production. Therefore, high grade energy resources will amplify the impact of technology and create tremendous economic growth (Adegbemi *et al.*, 2013). According to the estimation of the international Energy Agency, 53% of global energy consumption will be increased by 2030, with 70% of the growth coming from developing countries (Oh *et al.*, 2010). Nigeria lies in the western region of Africa with a land mass of 923,768 km^2. Nigeria is one of the most populous developing countries in the African continent with a population of over 170 million (Adebayo, 2014), Nigeria has GDP of 30051.61 per capita (PPP basis), and steady growth of 6.5% in 2013 (world bank) which represents 0.84% of the world economy and has reached up to $522.64 in 2013 (Fagbenle *et al.*, 2011). The oil and natural gas resources are the mainstay of the country's economy. The country oil and gas industry typically accounts for 75% of government revenue and 95% of total export revenue (Eia. US Energy Informaation Admission 2015). Nigeria is a country whose energy demand exceeds

[1] Department of Physics, Kebbi State University of Science and Technology, 1144 Aliero, Kebbi State, Nigeria.

supply from the national utility. Despite the country's abundance of petroleum and other natural resources, more than 60% of the country's population has no access to electricity and the annual electricity consumption per capita of the remaining 40% is about 109 kWh due to frequent power interruptions, load shedding and poor electricity infrastructure (Unido and Icshp, 2013). According to Nigeria's August 2013 Roadmap for Power Sector Reform, Nigeria's generation capacity was around 6,000 MW IN 2012, of which 4,730 MW (79%) as from fossil fuel sources and 1,270 MW by the end of 2013 (Reeep, 2014). In this paper, the challenges of the power sector in supplying stable electricity in the country and the status of renewable energy development in Nigeria have been discussed.

POWER SECTOR CHALLENGES IN NIGERIA

Electricity plays a very vital role in the socio-economic and technological development The demand for electricity in Nigeria has exceed the supply, with a population of 180 million, the demand is expected to rise from around 33 terawatt hours in 2011 to between 56 and 95 terawatt hours by 2020 which will results to an increase in peak load demand from around 5,000 MW to 9000 MW and 16000 MW by 2020 (Reeep, 2014). The crucial challenges facing the power sector in Nigeria is the issue of availability and sustainability to ensure the security and reliability of energy supply and the diversification of the various energy resources.For efficient implementation of developmental projects and economic growth in Nigeria diversification of energy resources is critical to avoid the continuous dependent on only a single source of energy (Energy Commison of Nigeria, 2003). The dominant sources of power generation in Nigeria are the natural gas and hydropower. Nigeria has an estimated technically exploitable potential of 20,000 MW (Unido and Icshp, 2013). Currently there are 23 grid-connected generating plants in operation in the Nigerian Electricity Supply Industry (NESI), with a total installed capacity of 10,396 MW and available capacity of 6,056 MW. Most generation is thermal based, with an installed capacity of 8,457.6 MW (81% of the total installed capacity) and an available capacity of 4,996 MW (83% of the total available capacity) (Reeep, 2014). The power sector in Nigeria is faced with the following challenges.

POLITICAL CHALLENGE

Good policy making plays a very important role in developing the power sector of any nation. Politics is a key factor in the challenges being faced by the power sector.To achieve the desired objectives in the development of an efficient power sector a political will to reform the power sector is very important this can be achieved by providing a level-playing ground for all the stakes holders in the Nigeria power sector. The power sector should provide a conducive political atmosphere for Independent Power Projects (IPPs) investment. Adequate security of lives and properties in areas with the sources of energy should be provided for the intended IPPs these include preventing vandalism of equipment such as construction, generation, transmission and distribution lines and the government should have the political will to ensure its sustainability when it becomes fully operational.

TECHNICAL CHALLENGE

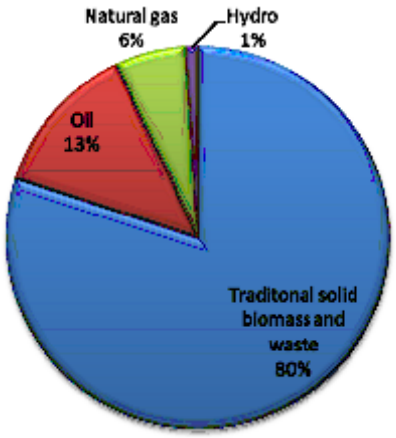
The power sector of the country is face with inefficient or obsolete equipment; most of the

equipment use today in the power sector are either out of date or are completely warned out. For efficient and sufficient power generation, transmission and distribution, a very serious attention should be paid to the existing transmission lines. the transmission network is overloaded with a wheeling capacity of less than 4000 MW and has a poor voltage profile in most parts of the network. According to Llugbo (2012) 40% of the electricity generation is lost during transmission to the national grid due to this obsolete equipment. To overcome these challenges, renewable energy application is seen as one of the sensible solutions which are being adopted by many countries around the world to address the issues of energy and environment simultaneously. In Nigeria, there seems to be renewed impetus in the growth of an alternative renewable energy, not because of the global challenges of climate change due to fossils fuel but because of the inadequate supply of electricity (Energy Commison of Nigeria, 2003).

TOTAL PRIMARY ENERGY CONSUMPTION

Nigeria is blessed with abundant primary energy resources, Nigeria primarily energy sources primarily comprise of crude oil, natural gas, coal, and tar sands. Also Renewable Energy (RE) such as solar, wind biomass and hydro, are currently being exploited (Energy Commison of Nigeria, April 2003). EIA estimates that in 2011, the total primary energy consumption in Nigeria was about 4.3 Quadrillion Btu (111,000 kilotons of oil equivalent). Of this, traditional biomass and waste accounted for 83% of total energy consumption. This high percentage share represents the used of biomass to meet off- the-grid cooking heating and cooking needs, mainly in rural areas. The world bank data for 2010 indicates that electrification rates for Nigeria were 50% for a country as a whole- thus leaving approximately 80 million people in Nigeria without access to electricity (EIA US Energy Information Administration). Nigeria has vast natural gas, coal and renewable energy resources that could be used for domestic electricity generation, yet lack policies to harness resources and develop or improve the current electricity infrastructure (Adebayo, 2014).

Figure 1: Total Energy Consumption in Nigeria 2012(Eia Us Energy Information Administration. Eia. U.S Energy Informaation Admission, 2015)



From Figure 1 it can be observed that renewable energy has not contributed to the primary energy consumption of Nigeria, this is due to the lack of interest on the government to pay more attention to renewable energy development in the country.

RENEWABLE ENERGY (RE)

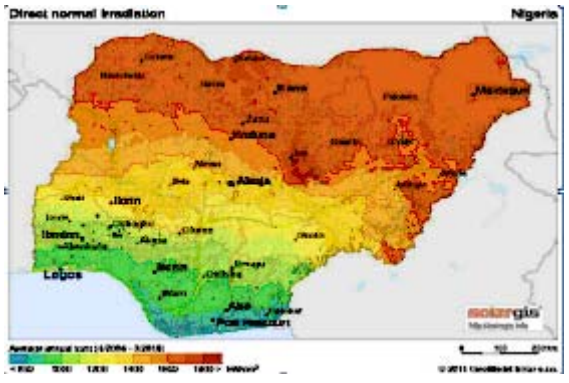
The rapid depletion of fossil fuel reserves as well as climate change has driven the world towards RE sources which are abundant, untapped, and

environmentally friendly (Islam *et al.*, 2009). Nigeria is endowed with sufficient renewable energy resources to meet its present and future energy requirements. However, hydropower is the only sustainable resources currently exploited and connected to the grid (Adebayo, 2014). It is an indisputable fact that Nigeria has one of the most problematic electricity sectors in the world, with an estimated installed electricity generation capacity of 8,644 MW, and available capacity of only approximately 3,718, to cater for the needs of a population of over 160 million people (Felix, 2013). Blessed with abundant renewable energy resources but the development pace is rather extremely slow and still at its infancy. The aforementioned renewable energy will be discussed, these include, solar, wind, hydro power and biomass.

SOLAR ENERGY

Solar energy is the conversion of sunlight into electricity via the use of solar cell installed in a solar panel. It is a green and renewable energy source. Photovoltaic cells produces electricity when sunlight excited electrons in the cells (Shafie *et al.*, 2011). Nigeria climatic condition, which is having sunshine throughout the year make it highly suitable for the development of solar energy most especially in the northern part of Nigeria. The estimated annual average of daily solar radiation vary fromas low as 3.5 kW/m^2/day in the coastal regions of the south to 7 kW/m^2/day in the northern border regions, and an annual average daily sunshine's hours vary from a high as greater than 8hrs in the northern border regions to as low as less than 6hrs/day in the coastal regions of the south (Abdulsalam *et al.*, 2012). On the average, Nigeria receives solar radiation at the level of about 19.8 MJm^{-2}day^{-1} Solar radiation is fairly well distributed, the minimum average is about 3.55 kWhm^{-2}day^{-1} and 3.4 kWhm^{-2}day^{-1} in Katsina and Calabar in January and August respectively, and the maximum average is 8.0 kWhm^{-2}day^{-1} for Nguru Yobe State in the month of May. With an average solar radiation level of about 5.5 kWhm^{-2}day^{-1} and prevailing efficiencies of commercial solar-electric generators. It is possible to generate 1850 x 10^3 GWh of solar electricity per year if solar collectors or modules were used to over 1% of Nigeria's land area of 923,773 Km^2. At the moment, the utilization of solar energy technologies in Nigeria is only limited to solar thermal applications, for which the technologies are already developed. However, solar electricity may be used to supply power to remote villages and locations that are far from the national grid. And can also be used to generate power for feeding into the national grid (Sambo, 2009). Although PV system has tremendous potential, especially for remote areas in Nigeria, the constraint against widespread adoption of solar PV system for lighting and powering household appliances are highlighted to include high cost of components and installation. This high cost of solar PV component and installation is due to the little or no effort and initiative of the government when compared to other countries that have less potential of solar energy for electricity generation. In Nigeria, the government

Figure 2: Solar Map of Nigeria

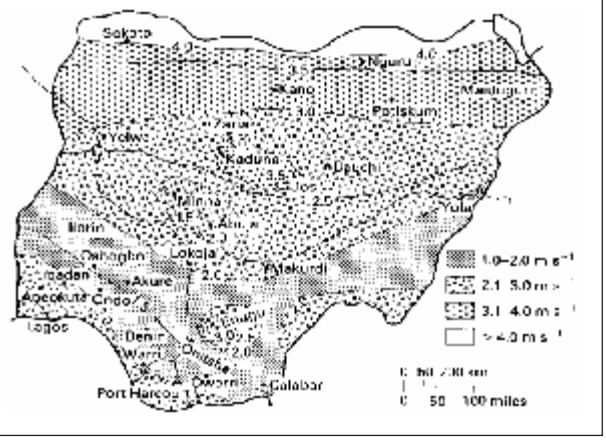


policies are skewed in favor of conventional sources of power at the expense of the renewables sources (Ogunleye and Awogbemi, 2010).

Wind

The potential for wind energy generation in Nigeria depends on the availability of wind resource that varies with location. Understanding the site specific nature of wind is a crucial step in planning wind energy project. Detailed knowledge of wind on sites is needed to estimate the performance of wind energy project(Shafie *et al.*, 2011). In Nigeria, wind energy is available at annual average speeds of about 2.0 m/s at the coastal region and 4.0 m/s at the far northern region of the country. With an air density of 1.1 kg/m^3, the wind energy intensity perpendicular to the wind directions ranges between 4.4 W/m at the coastal areas and 53.2 W/m at the far northern region of Nigeria (Sambo, 2009). At present, the share of wind energy in the national energy consumption has remained very low with no wind power plants connected to the national grid, although, the technologies for harnessing the wind energy in Nigeria have, over the years been tried in the northern parts of the country, mainly for water pumping water in old Sokoto and Kano states as well as in Katsina, Bauchi and Plateau state. Presently, a 5 kW wind energy conversion system for village electrification has been installed at Sayyan Gidan Gada, in Sokoto State. Other attempt are been made at the Sokoto Energy Research Centre (SERC) and Abubakar Tafawa Balewa University. Bauchi to develop capability for the production of wind energy technologies (Sambo, 2009).

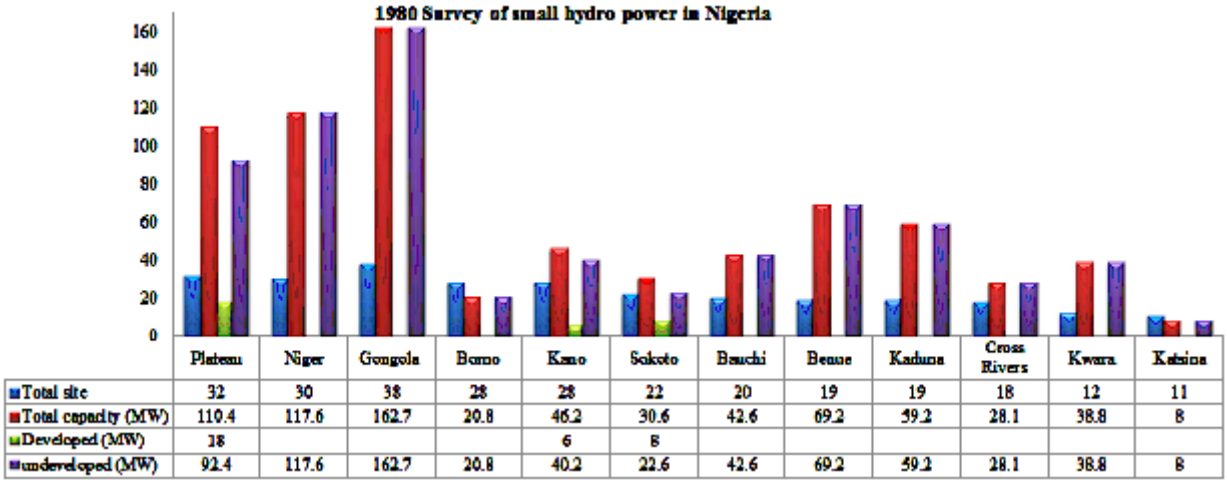
Figure 3: Nigeria Annual Average Wind Speeds Distribution (At 10 M Height) Showing Four Different Wind Speed Regimes (Adaramola and Oyewola, 2011)



Hydropower

Hydropower dams can and have made important and significant contributions to human development, it is a renewable sources of energy and produces negligible amounts of greenhouse gases. It also stores large amount of electricity at low cost and can be adjusted to meet consumer demand, furthermore, hydro dams are multipurpose and are built primarily for social-economic development like irrigation, water supply, food control electric power and improvement of navigation (Ong *et al.*, 2011). The potential of hydro power in Nigeria is very high as the country is endowed with large rivers and some few natural falls and dams. Hydro power is regarded as one of the major source of electricity generation and supply in Nigeria. The total potential of hydropower in Nigeria is about 14,750 MW. However, only 1,930 MW, (14%) of that potential is currently being generated at the 3 major dams (Kanji, shiroro and Jebba dams) which represent about 30% of gross installed grid-connected electricity generation capacity of Nigeria (Shaaban and Petinrin, 2014). In spite of the high potential of hydro power in Nigeria, hydro electric energy is still underexploit in Nigeria, in view of this, Small Hydropower (SHP) has gained rapid consideration this is due to its inherent advantages such as reduce cost and

Figure 4: 1980 Survey of SHP in Nigeria



	Plateau	Niger	Gongola	Borno	Kano	Sokoto	Bauchi	Benue	Kaduna	Cross Rivers	Kwara	Katsina
Total site	32	30	38	28	28	22	20	19	19	18	12	11
Total capacity (MW)	110.4	117.6	162.7	20.8	46.2	30.6	42.6	69.2	59.2	28.1	38.8	8
Developed (MW)	18				6	8						
undeveloped (MW)	92.4	117.6	162.7	20.8	40.2	22.6	42.6	69.2	59.2	28.1	38.8	8

maintenance. Based on the 1980 survey Figure 4, 734 MW of SHP can be harnessed from 277 sites, the potential of the SHP is estimated at 3500 MW, representing 23% of the Nigeria 's total hydro power potential (Sambo, 2009).

Biomass

Biomass refers to any woody based material from plant that store energy through photosynthesis, substantial amounts of fuel wood, agricultural crops and residues, empty fruits bunches; animal wastes and leaves are used by households and industries. Biomass is considered as one of the renewable energy sources with a the highest potential to contribute to the energy needs of modern society for both the industrialized and developing countries (Ong *et al.*, 2011). The Biomass resources of Nigeria can be identified as wood biomass, forage grasses and shrubs, residues and wastes (forestry, agricultural, municipal and industrial) as well as aquatic biomass (Sambo, 2005). Nigeria is very rich in biomass resources, the estimated biomass resource in Nigeria is 8 x 10^2 MJ. Plant biomass can be used as fuel for small-scale industries and it can also be fermented by anaerobic bacteria to produce a very versatile and cheap biogas(Shaaban and Petinrin, 2014). Biomass is important because of its high share of the total primary energy consumption. The total bioenergy capacity bad on the recoverable energy potential from Fuelwood, agro-waste, saw dust and municipal solid waste is estimated at over 710.1333 MJ as shown in Table 1.

Table 1: Estimated Quantities Biomass Resources in Nigeria (Sambo, 2009)

Resource	Quantity (million tons)	Energy Value ('000MJ)
Fuelwood	39.1000	531.0000
Agro-waste	11.2444	147.7000
Saw dust	1.8000	31.4333
Municipal solid waste	4.0750	-

The most widely used domestic Biomass resource is the Fuel wood especially in the rural area by the low income earners (Sambo, 2009).

GEOTHERMAL ENERGY

Geothermal energy is a thermal energy generated and stored in the earth interior. 20% of geothermal energy of the earth originates from the original formation of the planet, and 80% originates from radioactive decay of minerals (Turcotte and Suhubert, 2002). Geothermal energy is an abundant resource of renewable energy; it has successfully catered to both industrial and domestic energy requirements in several parts of the world over the past few decades. Being a relatively clean and renewable resource, it has been a preferred choice for an alternative energy. It is produced when underground heat is transferred by water that is heated as it passes through hot rocks or shallows magma bodies located at depths of a few hundred metres to a few kilometers (Harsh and Sukanta, 2007). Geothermal energy resource consist of thermal energy from the earth's interior stored in hot dry rocks as well as rocks with trapped steam or liquid water. In Nigeria, the geological structure of the country influences geothermal exploration extent within each geological province. these geothermal technology is yet to be exploit (Kurowska and Schoeneich, 2010). Geothermal energy can be successfully exploited in Nigeria as the surficial manifestations of these resources suggest the occurrence in the country. Currently there are two Known Geothermal Resources Areas (KGRAs) in Nigeria; the Ikogosi warm springs of Ondo state and the Wikki warm springs of Bauchi state, these surficial effusions results from the circulations of water to great depths through faults in the basement complex of the area. Within sedimentary areas, high potential gradient trends are identified in the Lagos sub basin, the Okitipupa ridge, the Auchi-agbebe of he Benin flank/hinge line, and the Abakaliki Anticlinorium. Although this potentials are yet to be harness, it can reduce the country dependency on fossil fuels and increase focus on such renewable energy resources, mitigating the negative climatic impacts. And improve the electric power challenges facing the nation. The country dependence on the oil sector and low funding for research and development may be the major cause of not exploiting the verse potential of Geothermal energy in Nigeria, also inadequate skills and technology involved in exploration also contribute to lack of harnessing the geothermal energy in Nigeria.

RECOMMENDATION

Today, in the absence of a concerted effort to combat climate change, renewable energy competitiveness has a great advantage in the market place. In view of these, the following recommendations were made.

- The government should establish, support and implement policies that will promote Renewable energy development and deployment.
- Feed-in Tariffs of renewable energy should be included in the Renewable Energy Act, 2011 to provide for the establishment and implementation of special tariff system to catalyze the generation of renewable energy.
- The creation of enabling environment by the government by providing incentives combined with access to financing from traditional and/ or non-traditional sources.
- Provision of capacity building and awareness

which include training and education of people in renewable energy development and the promotion of the energy efficiency and conservation to enlighten the public and create awareness to enhance effective communication between national and local government bodies on renewable energy projects.

- Establishment of energy efficiency agency that will be charge with the responsibility of developing, implementation and revision of policies related renewable energy.
- The need to develop global, national, and local strategies to address CO_2 emissions through technology policy and innovations.

CONCLUSION

Renewable energy is considered as a viable option to the current energy crises and challenges facing Nigeria, this renewable energy if properly harnessed and utilized will meet the energy demand of the populace in Nigeria. An overview of the power sector challenges in Nigeria has been presented in detail in this paper. The study examined the plentiful resources of RE, the current capacity and its potential for electricity generation to meet the demand of the Nigerian population. The Promotion of renewable Energy development in Nigeria will go a long way to solve the challenges of the power sector and reduce the amount of CO_2 emission from the fossil fuel relied energy source. Therefore through a comprehensive policy and a dedicated political and social support in implementing them, Nigeria could be one of the largest Producers in renewable and sustainable energy in Africa and the world at large.

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Hyderabad, INDIA. Ph: +91-09441351700, 09059645577
E-mail: editorijlerst@gmail.com or editor@ijerst.com
Website: www.ijerst.com