International Journal of Sustainable Energy and Environmental Research

journal homepage: http://www.pakinsight.com/?ic=journal&journal=13

RENEWABLE SOURCES OF ENERGY FOR ECONOMIC DEVELOPMENT IN NIGERIA

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ABSTRACT

It has become widely acknowledged that the rising environmental and economic cost associated with fossil fuel energy has made Renewable Energy (RE) a basic requirement for the development of Nigeria's economy. The paper focuses on ways of generating electricity with renewable source of energy for economic development in Nigeria. Specifically, the Nigeria's energy scene, renewable energy potentials and barriers, as well as various national energy policies were analyzed and areas that require attention to achieve sustainable provision of RE were highlighted. Overall, achieving sustainable development in Nigeria lies in addressing the imminent energy crisis facing the country. While fossil fuels have increased in use and declined in supply, excessive usage of fuel wood is already creating environmental problems especially in the Sahel area. But RE brings together climate protection, poverty reduction, and technological progress.

Keywords: Renewable energy, Electricity, Economic development, Energy scene, Renewable energy potentials, Energy policies, Sustainable energy, Climate protection, Poverty reduction, Economic development

Contribution/ Originality

This study contributes in the existing literature on the renewable sources of energy in Nigeria by investigating the vast renewable energy resources and potentials in the country and suggested methods to improve energy generation for sustainable development.

1. INTRODUCTION

Economic development as a desirable phenomenon is associated with reduction in poverty, unemployment, and inequality among the vast majority of the population Seers (1969). While Nigeria like other developing countries strives to achieve and maintain a high level of economic

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development. However, sustainable development requires adequate energy supply. Obviously, energy is the backbone of any economy hence, the pivot within which all economic activities revolve around. Energy consumption is a pre-requisite for overall development, without sufficient supply in a country; it will be extremely difficult for any meaningful productive activities take place. Consequently, there will be low investment, unemployment, low income and declining national output (Garba and Bashir, 2002; Alam, 2006).

Nigeria is a vast country with a total landmass of 923,768 km^2, of which 910,771 km^2 (86%) of the area is land. It lies within latitude 4.32^o to 14^{o}N and longitude 2.72^o to 15^{o}E. Geo-Politically, the nation is divided into 6 Zones comprising of 36 states and the Federal Capital Territory (FCT) with a total population of 173.6 million (World Bank, 2013). Worldwide, the country is ranked as the 10th largest crude oil producer with fossil fuels reserve estimates of about 37.140 billion barrels of crude oil, 182 trillion cubic feet (ft^3) of natural gas, and 209 million short tons of coal (U. S. International Renewable Energy Agency, 2014).

Figure-1. Map of Nigeria

Source: http://www.aircraft-charter-world.com

While energy either from conventional or renewable sources is needed to generate electricity for industrial and domestic consumption, one of the most important challenges Nigeria faces in this 21st century is sustainable power supply. The country has been facing persistent electricity problems ranging from power generation down to transmission and distribution. The gap between the electricity demand and supply far exceed that of any other country in the world (Roadmap for Power Sector Reform (Road-Map for Power Sector Reform, 2013), despite the fact that the country is vastly rich in energy resources, with fossils such as crude oil, natural gas, coal as well as Renewable Energy (RE) sources like solar, wind, biomass, biogas, and hydro. For many years, industries, businesses, and homes have faced enormous challenges when accessing electricity to such an extent that stand by private generators have become an integral part of businesses (97%), and households in order to ensure continuous power supply. This inevitably led to higher per unit

cost to firms, and a prime reason why Nigerian firms are at disadvantage compared to, for instance Ghana where energy cost less than half as it does in Nigeria (World Bank, 2002; Omokaro, 2008).

In early 1980's Nigerian governments estimated that the growth of power requirements would be in the order of 20% per annum for the next 20 years (Zarma, 2006). Nevertheless, this estimate did not anticipate the rapid growth of personal computers and mobile communication usage that characterized the 1990's. In other words, the 20% is just a modest estimate of the annual energy growth requirement. Yet, even half of the required energy growth has never been achieved (Central Intelligence Agency, 2004). About 50 percent of the households in the country are not connected to the national electricity grid (Akpu, 2012), and the current average electricity generation of 3800 megawatts (MW) is not up to half of the average demand of more than 10,000MW (Energy Commission of Nigeria, 2013). In contrast, for a population of 52.9 million, South Africa generates 44,000MW while for its 200.4 million citizens, Brazil generates 100, 000MW (Okanlawan, 2013) Table 1.1 and 1.2 shows Nigerian electricity statistics in relation to some developing countries and United States (US).

Table-1.1. Total electricity generation and consumption (Billion Kilowatt-hours).

	2005	2006	2007	2008	2009	2010	2011
		Net Generation (B. KW/h)					
Nigeria	22.515	22.036	21.911	20.130	18.817	24.872	25.695
South Africa	227.948	235.467	245.643	239.694	230.611	241.935	243.375
Malaysia	77.966	84.762	91.987	91.987	109.756	117.957	123.304
Brazil	395.721	411.925	437.187	454.472	458.576	506.827	530.390
USA	4,055.423	406,4.702	4,156.745	4,119.387	3,950.332	4,125.059	4,100.140
		Net Consumption (B. KW/h)					
Nigeria	16.935	14.855	19.261	18.141	17.657	20.375	23.114
South Africa	205.045	210.633	220.478	213.633	204.574	214.992	218.303
Malaysia	69.121	75.253	81.922	84.004	102.792	109.834	115.338
Brazil	367.883	382.539	404.168	419.603	418.448	455.729	478.752
USA	3,810.984	3,816.845	3,890.231	3,865.159	3,723.803	3,886.403	3,882.600

Source: U. S. International Renewable Energy Agency (2014)

The electricity generation consists of electricity generated from fossil fuels such as petroleum, coal, and natural gas as well as those generated from renewable sources. Net generation excludes the amount of energy consumed in the generation process by the generating units. However, electric power consumption includes net electricity generated plus electricity imported minus electricity exported and electricity transmission and distribution losses. Net consumption also takes the energy consumed by the generating units into consideration.

Table-1.2. Electric power consumption per capita (KWh/capita)

	2005	2006	2007	2008	2009	2010	2011
Nigeria	129	111	138	126	120	135	149
South Africa	4,660	4,743	4,872	4,686	4,451	4,571	4,604
Malaysia	2,857	3,051	3,261	3,378	3,934	4,136	4,246
Brazil	2,016	2,073	2,169	2,233	2,202	2,381	2,438
USA	13,705	13,583	13,675	13,663	12,941	13,395	13,246

Source: World Bank (2013)

The information in Table 1.1 and 1.2 indicates the quagmire of the energy scene in Nigeria relative to other countries. In 2011, the net electricity generation in the country amounted to just 10.5% of South Africa, 20.8% Malaysia, 4.8% Brazil, and 0.6% of United States. Also, the electric power consumption per capita of 149kwh is so meager that it amounted to only 3.3%, 3.5%, 6%, and 1.2% per capita consumed in same countries respectively.

In addition to their depletion nature, the rising environment and economic costs (greenhouse gases CO_2, CO) associate with fossil fuel energy has made RE a basic requirement for development in Nigeria. Renewable bring together not only poverty reduction and climatic protection but also technological advancement and securing of jobs (Jurgen, 2004). In modern economic set up where developed countries advocates for globalization at the expense of developing countries, where information communication is crucial, and where virtually all economic activities require energy, the importance of RE resources in developing an effective national energy supply system cannot be over emphasized. The paper assesses renewable energy potentials for economic development in Nigeria. Essentially, it looks at how available renewable energy potentials can be exploited to augment energy supply in the country, thereby offering important information to policy makers and private investors in the energy sector. The next section reviews briefly the Nigerian energy scene. Section 3 deals with renewable energy potentials and policies. While section 4 is the discussion, the final section concludes the paper.

2. THE NIGERIAN ENERGY SCENE

Nigeria is naturally endowed with abundant fossil and non-fossil energy resources which, if well managed could satisfy all her domestic and industrial energy needs and serve as a foreign exchange earner (Eleri, 1995). Electricity generation in the country started as far back as 1886 when 2 small generating sets were installed to serve the then Lagos colony. While the first thermal power station was set up around 1920, Kainji, the first hydropower station was built in 1962. Then, the total installed power generating capacity was around 185 MW, which increased to 805 MW by 1970 and up to 2800 MW by 1983 (Bajpai and Suleiman, 1985). Before the commencement of the power sector reforms in 2003, where the government invites private investors to participate in the energy sector, the National Electric Power Authority (NEPA) now called Power Holding Company of Nigeria (PHCN) had the monopoly of generating, transmitting and distribution of electricity in the country. From 1968 to 1992, the installed power generation capacity increased by a factor of 6 to stand at 5,881.6 MW, after which no further additional generation capacity was made by the government up to 2005 (Nnaji *et al.*, 2010). In order to enhance energy supply in the country,

government set up a number of Independent Power Projects (IPPs) to generate electricity and sell it to PHCN. However, the projects' targets were not achieved because of bureaucratic bottleneck, poor support facilities, inadequate funding, and shortage of gas supply (Community Research Development Centre, 2007).

The country's energy supply heavily relies on fossil fuels and fuel wood which are fast depleting (Oyedepo, 2013), with a projected rate of fossil fuel (crude oil) depletion in 40 years (Shaaban and Petinrin, 2014), and annual consumption of over 50 million metric tons of fuel wood, a level, which considering the various afforestation programs exceed the replenishment rate (Sambo, 2009). Coal was the first fossil fuel discovered and used before petroleum products and natural gas became the dominant source of fossil fuel energy. There are 23 grid connected generating plants in operation which supply commercial electricity in Nigeria with a total installed capacity of 10,396 MW and available average generation capacity of 3,800 MW which is grossly inadequate even to satisfy the domestic consumption (Ibidapo-Obe and Ajibola, 2011). Yet, for energy needs to be met in Nigeria, it will require a power generating capacity of 140,000 MW translate to per capita capacity of about 1000 MW considering the rapid population growth and increase in personal computers and mobile communication usage (Nnaji, 2012). Most energy generations were thermal based accounting for 83% of the total available generation while hydropower from 3 main plants accounts for 1,938 MW of the total installed capacity with available generation of 1,060 MW (Information Gateway for Renewable Energy and Energy Efficiency, 2013). According to Nigeria's Road-Map for Power Sector Reform (2013) energy generation capacity in 2012 was about 6,000 MW of which 4,730 MW (79%) comes from fossil fuel sources and 1,270 MW (21%) was from hydro sources. While the availability of power supply in the country is erratic and varies between 27% to 60% of the total installed capacity, 28% of the electricity generated is lost in the transmission and distribution process (Omokaro, 2008), due to physical deterioration of facilities, poor metering system and an increase in the incidence of power theft through illegal connections (Sambo, 2009). Table 2.1 shows various fossil fuels energy resources and their estimated reserve in the country.

Table-2.1. Fossil fuels energy resources

	2007	2008	2009	2010	2011	2012
			Crude Oil			
Production (Tb/day)	2,352.8	2,168.9	2,212.2	2,459.4	2,554.5	2,524.1
Consumption (Tb/day)	268.9	269.1	242.5	242.2	287.4	300
Reserved (billion barrel)	36.220	36.220	36.220	37.200	37.200	37.200
			Natural Gas			
Production (billion f^3)	1,148	1,159	912	1,024	1,107	1,190
Consumption (billion f^3)	374	433	348	178	191	244
Reserved (tri. f^3)	181.900	183.99	184.160	185.280	186.880	180.458
						Continue

			Coal			
Production (t. short tons)	25	35	37	42	35	35
Consumption (t. short t)	25	39	37	42	35	35
Reserved (m. short tons)	NA	NA	NA	NA	209	NA

Source: U. S. International Renewable Energy Agency (2014);

Note: Tb = thousand barrels; Br = barrels; tri = trillion; f^3 = cubic feet; t = thousand; NA = not available

Table 2.2 indicates the total primary energy production in Nigeria which includes production of both fossil fuels and non fossil renewable sources. And total primary energy consumption constituting consumption of same sources plus net electricity imports. Table 2.3 shows electrical energy installed and generation capacity in the country.

Table-2.2. Primary Energy production and consumption in Nigeria

	2005	2006	2007	2008	2009	2010	2011
Total primary energy production (Quadrillion Btu)	6.523	6.325	6.275	5.899	5.714	6.376	6.658
Total primary energy consumption (Quadrillion Btu)	1.081	1.029	0.987	1.070	0.882	0.730	0.839

Source: U. S. International Renewable Energy Agency (2014).

Table-2.3. Electrical Energy in Nigeria

	2005	2006	2007	2008	2009	2010	2011
Installed capacity (million Kwh)	5.898	5.900	5.900	5.900	5.900	5.900	5.900
Net Generation (Billion Kwh)	22.515	22.036	21.911	20.130	18.817	24.872	25.695
Net Consumption (Billion Kwh)	16.935	14.855	19.261	18.141	17.657	20.375	23.114
distribution losses (Billion kwh)	5.580	7.181	2.650	1.989	1.160	4.497	2.581

Source: U. S. International Renewable Energy Agency (2014).

Energy consumption units in Nigeria constitute households, industry, transportation, commercial, and agriculture. The energy consumption mix is dominated by fuel wood (50.72%), fossil fuels (41.28%), and hydropower (8%). Other source like nuclear, geothermal, and tidal are not yet part of the Nigeria's energy mix, either because they have been neglected or are at their early stage of development (Omokaro, 2008).

3.1. RENEWABLE ENERGY POTENTIALS IN NIGERIA

The global awareness of the phenomenon global warming together with the anticipated scarcity or even depletion of fossil fuel energy resources have galvanized many countries around

the world to develop an alternative and sustainable energy system through RE resources to sustain economic growth and development. Renewable energy comes from natural sources that are continuously replenished. The technologies associated with RE makes our households healthier, safer, and more affluent by improving our air quality, reducing our dependence on fossil fuels, controlling global warming, creating more jobs in the economy as well as protecting environmental values like habitat and water quality (International Renewable Energy Agency, 2014); (Natural Resources Defence Council, 2014). Nigerian government had to reshape her energy policies in line with the international community's consensus and policies on RE resources as a better source of energy. The immense potentials for renewable energy resources in Nigeria – wood, corn, biogas, wind, solar, and hydropower as shown in Table 3.1 is about 1.5 times that of fossil energy resources; in energy terms (Lawal, 2010), which when combined with the right framework could produce substantial amount of power to augment the energy supply in the country (Buzz, 2009). Table 3.2 shows RE electricity generation in Nigeria, relative to some countries.

Table-3.1. Renewable Energy resource in Nigeria

Resource	Capacity	Production	Utilization level
Large hydro power	10,000 MW	1,938 MW	1,938 MW
Small Hydro power	3,500 MW	30 MW	30 MW
Wind	2-4 m/s (annual average)	2-4m/s at 10m height	__
Fuel wood	11 million hectares of forest and woodlands	43.4 million tons of fuel wood/yr	43.4 million tons of fuel wood/yr
Animal waste	61 million tons/yr		0.781 million tons of waste/day
Solar Radiation	3.5-7.0kWh/m^2 - day	6 MWh/day	6 MWh/day
Crop Residue	83million tones/yr	0.256 million ton of assorted crops/day	__

Source: Renewable Energy Master Plan (2005); Sambo (2011); Shaaban and Petinrin (2014)

Table-3.2. RE electricity generation in Nigeria and some countries (Billion KW/h)

	2005	2006	2007	2008	2009	2010	2011
Nigeria	7.690	6.200	6.165	5.664	4.484	6.310	5.594
South Africa	1.637	3.190	1.244	1.518	1.716	2.427	2.370
Malaysia	5.134	6.378	6.423	7.384	8.356	7.691	9.453
Brazil	347.766	360.277	388.945	386.309	410.828	432.928	459.050
USA	370.472	398.746	364.979	392.736	429.652	440.231	527.490

Source: U. S. International Renewable Energy Agency (2014); World Bank (2013)

a. Hydropower

Energy from moving water is conceivably the largest source of renewable electricity in Nigeria. The country is fairly endowed with large and small rivers, and some few waterfalls and streams, within the present split of the country into eleven river basin authorities, which have been

dammed to produce hydroelectricity. With some of the rivers maintaining a minimum discharge all the year round, the hydropower has the potentials to supply uninterrupted electricity in the country. The total hydropower (large and small) energy generation capacity in Nigeria is around 14,750 MW. Yet, only 1,930 MW that is about 14% of the total capacity is being generated at Kainji, Shiroro and Jebba which represents 30% of the gross installed grid-connected electricity generation capacity of the country. The fact that large hydropower, in spite of its high capacity is still underexploited coupled with the advantages associated with Small Hydro Power (SHP) such as environmental impact, lesser civil work, generating power alongside irrigation, navigation, flood prevention and fisheries gave the SHP rapid consideration in Nigeria. Though Small Hydro Power sites exists virtually in all parts of the country with an estimated total capacity of 3,500 MW (about 23% of the entire hydropower potentials), in twelve states and four river basins there were over 278 unexploited SHP sites with the potential of generating 734.3 MW of electricity. Also, along the numerous river systems, a total of 70 micro dams, 126 mini dam and 86 small sites were identified as source of hydropower energy (Aliyu and Elegba, 1990). In addition to a total of 30 MW of SHP installed capacity in three states, 21 MW of hydropower energy is being generated by Nigerian Electricity Supply Company (NESCO) from six sites in Plateau state (Renewable Energy Master Plan, 2005). Based on the countries river systems, of the estimated 11,000 MW exploitable hydropower energy potentials in the country, only 19% is being tapped (Okafor and Joe, 2010).

To a greater extent hydropower capacity depends on the seasonal amount of rainfall, its distribution as well as the river systems, hence subject to periodic drought. Generally, total annual rainfall increases from about 500 mm depth in the northern part with precipitation lasting for over 4 months in a year to 3400 mm at the southern part of the country with precipitation that could be less than 8 months (Ohunakin, 2010). The under exploited hydropower energy could be well developed by ceasing the advantage of small rivers in the rural communities to set up SHP plants. This will not only provides affordable and accessible option to off-grid electricity services especially to rural populace but will also improve their economic activities.

b. Solar Energy

Solar energy is inexhaustible and cheaper and is now use to powers everything ranging from portable radios to homes, stores and neighborhoods (Natural Resources Defence Council, 2014). Being located within a high sunshine belt gave Nigeria enormous solar energy potentials. Solar radiation is fairly well distributed with average daily sunshine of 6.25 hours, ranging between 3.5 hours at the coastal area and 9.0 hours at the far northern boundary. Similarly, it has an annual average daily solar radiation of about 5.25 KW/m^2/day, varying between 3.5 KWm^2/day at the coastal area and 7.0 KWm^2/day at the northern boundary. Thus, Nigeria received about 4.85 x 10^{12} KWh of energy per day from the sun, which represents 1.082 million tons of oil equivalents (mote) per day, and is about 4,000 times the current daily crude oil production, and about 13,000 times that of natural gas daily production based on standard energy unit (Bala and Umar, 2000).

Based on the country's land area of 924 x 10^3Km^2 and an average of 5.535 KWh/m^2/day, Nigeria has an average of 1.804 x 10^{15}KWh of incident solar energy annually. This annual solar energy insulation value is about 27times the amount of energy generated from fossil fuel resources

in energy units and over 115,000 times the electrical power produced in 1998 (Chendo, 2002). Thus, only about 3.7% of the national land area is needed to be utilized annually in order to collect from the sun, amount of energy equal to the nation's conventional energy reserves. In other words, the nation's energy demand could simply be met if only 0.1% of the total solar energy radiation on the land mass is converted at an efficiency of 1% (Bugaje, 2006). This is an obvious revelation of what a potential energy resource, solar energy is. Yet, in the country the current solar energy installation is insignificant relative to more than 200,000 off-grid installations of photovoltaic in South Africa. With more than 50% of households especially in the rural areas not connected to the national grid, solar energy could not only be used to supply electric power to villages and off-grid locations but could also generate power to augment the national grid as done by countries like Germany, Japan and USA (Buzz, 2009). With effective policies and technical expertise, the substantial solar radiation received could drastically reduce the wide gap between energy supply and demand in the country.

c. Biomass Energy

Biomass refers to energy derived from plant materials such as wood, corn, grasses, agricultural crops as well as animal dung. Being an energy resource, biomass could be use either as solid fuel or technologically converted to liquid or gaseous forms for the generation of electric, heat or fuel energy (Sambo, 2009). Available biomass resources in Nigeria includes fuel woods, forage grasses and shrubs, animal wastes and waste arising from forestry, agriculture, municipal and industrial activities, as well as, aquatic biomass. Crops such as Sweet sorghum, maize, sugarcane were the most promising feedstock for bio fuel production (Nnaji *et al.*, 2010). Plant biomass can be utilized as fuel for small-scale industries. It could also be fermented by anaerobic bacteria to produce a cheap fuel gas (biogases). Biogas production from agricultural residues, industrial, and municipal waste does not compete for land, water and fertilizers with food crops like is the case with bio ethanol and biodiesel production and, will reduce the menaces posed by these wastes. In Nigeria, identified feedstock substrates for an economically feasible biogas production include water lettuce, water hyacinth, dung, cassava leaves and processing waste, urban refuse, solid (including industrial) waste, agricultural residues and sewage (Akinbami, 2001). It has been estimated that Nigeria produces about 227,500 tons of fresh animal waste daily. Since 1 kg of fresh animal waste produces about $0.03M^3$ biogases, then Nigeria can potentially produce about 6.8 million M^3 of biogas every day from animal waste only. Although biogas technology is not common in Nigeria, various research works on the technology and policy aspects of biogas production has been carried by various scientists in the country. Some significant research has been done on reactor design that would lead to process optimization in the development of anaerobic digesters.

d. Wind Energy

Wind energy is an affordable, efficient and abundant source of domestic electricity which results from the uneven heating of the earth's surface by the sun. The resultant pressure in Nigeria is available at annual average speed of about 4.0 m/s at the extreme northern region and 2.0 m/s at the coastal region. With an air mass of 1.1 kg/m^3, wind energy intensity, perpendicular to the wind

direction, ranges between 4.4 W/ m^2 at the coastal area and 35.2 W/ m^2 at the far northern region (Sambo, 2009). Wind turbine is needed to harness wind's kinetic energy. The wind moves the turbine's blades, which transfer energy through a central hub to a generator. The generator in turn converts this mechanical energy to electrical energy (Natural Resources Defence Council, 2014). In the country, at a height of 10 m above the ground level total exploitable wind energy vary from 8 MWh/yr in Jemeta (Yola) to 51 MWh/yr in the mountainous area of Jos (Plateau State), and may reach as high as 97 MWh/yr in Sokoto (Energy Commission of Nigeria, 2004).

Though wind energy produces no any polluting emissions and uses fuel that's free, inexhaustible and immune from drastic price fluctuations, its share in the Nigerian energy supply mix is very low with no any commercial wind energy generation plant connected to the national grid. In addition to few stand-alone wind power plants installed to power water pumps in 5 northern states there is a 5 KW wind electricity conversion system for rural electrification set up in Sayyan Gidan Gada (Uzoma *et al.*, 2011). Other wind energy projects includes Electronic Wind Map (WIS) development for wind resources assessment, 10 MW wind farm in Katsina, and 2×215 KW and 70×3 KW wind turbines at UDUS and Zamfara states respectively (Sambo, 2011). Even though continuous effort is being made at research centre like Sokoto Energy Research Centre (SERC) to develop capability for the generation of wind energy, the wind energy potential in the country is yet to be utilized to improve the living standard of the populace especially the rural dwellers.

The potentials for other renewable energy resources like waves, geothermal, tidal and ocean thermal gradients remain un quantified in the country either because they have been neglected or are at early stage of development (Garba and Bashir, 2002; Omokaro, 2008). The available renewable energy resources when sufficiently developed and harnessed has the potentials to produce all the needed energy for economic development in Nigeria.

3.2. Renewable Energy Policy in Nigeria

Efficient utilization of energy resources in a country requires an excellent and comprehensive energy policy. It wasn't until 2003 that Nigeria got a comprehensive energy policy – National Energy Policy (NEP) which articulates for the use of all viable energy sources (fossil and RE) for sustainable development and with the active participation of the private sector. The NEP, particularly the renewable energy section, has amongst other things, the following main objectives:

- To enhance energy security in the nation through diversifying the energy supply mix;
- To increase energy access especially in the rural and semi urban areas based on RE resources;
- To facilitate employment creation and empowerment;
- To protect the environment and mitigate climate change; and
- Providing a road map for achieving a substantial share of the national energy supply mix through renewable energy, thereby facilitating the achievement of an optimal energy mix.

In an effort to boost up energy supply in the country the government of Nigeria (GON) represented by the energy Commission of Nigeria (ECN) in collaboration with United Nations Development Program (UNDP) formulated the Renewable Energy Master Plan (REMP) for Nigeria in 2005 which articulates the energy vision and sets out a pathway for increasing the role of

RE in achieving sustainable growth and development. The REMP is anchored against the background goals, values and targets embedded in some national policies – National Economic Empowerment and Development Strategy (NEEDS), National Energy Policy, National Policy on Integrated Rural Development, and the Millennium Development Goals (MDGs) to alleviate poverty and reverse global environmental damage. Thus, the country envisions a strong and prosperous economy driven by increase utilization of RE which will be exploited at quantities and prices that will promote equitable and sustainable development.

Overall, the REMP aimed to articulate a national vision, targets and a pathway for dealing with key development challenges facing Nigeria through the accelerated development and exploitation of renewable energy. That is, it will put in place the necessary framework in terms of legal instruments, technologies, manpower and market to ensure the set visions and targets are achieved. The specific objectives of the REMP include:

- Expanding access to energy services and increasing the standard of living, especially in the rural areas;
- Stimulating economic growth, employment and empowerment;
- Expanding the scope and quality of rural services, including schools, health services, water supply, information, entertainment and curtailing the migration to urban areas;
- Reducing environmental degradation and health risks, particularly to vulnerable groups such as women and children;
- Improving learning, capacity-building, research and development on various Renewable energy technologies in the country; and
- Providing a road map for achieving a substantial share of the national energy supply mix through renewable energy (Renewable Energy Master Plan, 2005).

The REMP sets explicit and verifiable targets for electricity to be achieved in short, medium and long term periods as shown in Table 3.3. While the short term targets for 2007 failed to be realized because of high investment cost, inadequate legal instrument for RE development, inadequate incentives for the sub-sector as well as lack of political will and inconsistency in Government policies (Sambo, 2011), the medium term targets of 2015 and the long term targets of 2025 may also not be achieved unless these problems are critically address.

To help improve the renewable energy policy in Nigeria, European Commission (EU) gave financial support of €27 million in 2013 and launched the Energizing Access to Sustainable Energy (EASE) program. Currently, a large part of the population in Nigeria either lack access to energy or relies on polluting fuels like fuel wood and charcoal with dear consequences on health and the environment.

Table-3.3. Targets for RE installed electricity capacity (MW)

Sources	**2007**	**2015**	**2025**
Wind	1	20	40
Solar PV	5	75	500
Solar thermal	-	1	5
			Continue

Small hydro	50	600	2000
Biomass	-	50	400
Total	56	746	2945

Source: Renewable Energy Master Plan, 2005

The EASE program intends to develop the enabling framework for RE and energy efficiency in Nigeria, focusing on the use of renewable energies by small and medium enterprises as well as households. The EU not only intent to significantly reduce the number of about 80% of rural dwellers who lack access to electricity in Nigeria, but also want to improve the wellbeing of those who do have access, since they suffer from incessant power failure (European Commission, 2013).

4. DISCUSSION

With a total population of over 170 million people (World Bank, 2013) the need for energy in Nigeria for domestic and industrial use cannot be overemphasized. As a country in dear need of energy, Nigeria presents a startling paradox, in spite of the enormous energy resources (fossils and renewable) the gap between energy demand and what is available is the biggest world over. Fossil fuels are not only subject to depletion and drastic price fluctuation but are also associated with heavy environmental damage, hence no longer best and sustainable source of energy. In this regard, though an estimate puts Nigeria's crude oil reserve at 37 billion barrels and natural gas at 182 trillion cubic feet, the country had to reshape her energy policy in line with the international community's consensus on turning to renewable energy resources as the best alternative energy source. In energy terms, the immense potential for renewable energy resources in Nigeria is about 1.5 times that of fossil energy resources. That is when fully harnessed, it can satisfy the country's energy requirements for economic development. Energy is required in different capacity to satisfy various needs. For instance, while large scale energy will be required for industrial use, village infrastructures and hospitals, medium scale will be needed for private houses and lighting columns while small scale for individual device like mobile phone, personal computers and radios.

Of the 14,750 MW hydropower generation capacity only 1,930 MW (14%) is being generated which is gross under utilization of the hydroelectric potentials. The solar energy potential is so enormous that it only requires 3.7% of the total land area annually to collect from the sun, amount of energy equal to the nation's conventional energy reserves. So, based on standard energy unit, the daily energy received from the sun is about 4,000 times the current daily crude oil production, and about 13,000 times that of natural gas daily production. It means that when efficiently exploited, solar radiation could sufficiently bridge the gap between energy supply and demand in the country. Though being one of the biggest generators of garbage, biomass energy is not adequately harnessed because the biomass technology that could have saves households and animal farms the cost of refuse disposal is not developed. Wind energy is not only affordable and efficient renewable source of energy, but it produces no any polluting emissions yet its share in the country's energy supply mix is very low with no any commercial wind energy generation plant connected to the national grid. Other renewable energy resources in the country like waves, geothermal, tidal and ocean thermal gradients have either been neglected or are at early stage of development.

5. CONCLUSION AND RECOMMENDATIONS

Lack of adequate and sustainable energy supply in Nigeria has through its effects on various sectors of the economy adversely affects all development efforts in the country. Nigeria's abundant renewable energy resources have been largely neglected and it's high time these were actively employed to provide the necessary power generation levels. With the rapid increase in population, unless comprehensive measures are taken to overhaul the energy policy and regulatory framework, more Nigerians will in near future be without electricity. Renewable energy resources when fully developed and harnessed can produce all the needed energy in Nigeria, thereby bringing climate and environmental protection, poverty reduction, technological progress and securing of more jobs, hence, economic growth and development. If countries like Ghana, South Africa, and Brazil which are not endowed with crude oil and natural gas could generate substantial energy for economic development, Nigeria has no justification whatsoever in failing to generate and supply all its energy needs.

It is therefore, recommended that in order to restructure its power sector in a more efficient manner, and to provide a sound basis for economic development, Nigeria has to embark on a large scale energy sector reform that includes widening the range of options for generation with increase use of renewable resources. Also, to ensure an orderly development of renewable energy technologies and to assure quality of products, a testing and standards laboratory for RETS similar to that of South Africa should be established in Nigeria.

In addition, since the development of renewable energy source is linked to many other sectors like agriculture, small scale industries, poverty alleviation, then renewable energy projects should be implemented in tandem with activities in these sectors to ensure sufficient energy supply. All these could easily be done when there is sound political will and commitment.

REFERENCES

Akinbami, J.F.K., 2001. Renewable energy resources and technologies in Nigeria: Present situation, future prospects and policy framework. Mitigation and adaptation strategies for global change. Netherlands: Kluwer Academic Publishers, 6: 155-188.

Akpu, I.V., 2012. Energy future: The role of impact assessment. IAIA 12 Conference Proceedings, 32nd Annual Meeting of the International Association for Impact Assessment, May 27 Congresso de Alfândega, Portugal. Available from: www.iaia.org.

Alam, S.A., 2006. Use of biomass fuel in the brick-making industry of Sudan: Implication for deforestation and green house gas emission. M.Sc. Thesis, Department of forest Ecology, Helsinki University, Finland.

Aliyu, U.O. and S.B. Elegba, 1990. Prospects for small hydropower development for rural applications in Nigeria. Nigerian Journal of Renewable Energy, 1: 74-86.

Bajpai, S.C. and A.T. Suleiman, 1985. Cost effectiveness of photovoltaic plants in Nigeria by the year 2000. Sokoto Energy Research Centre. Nigeria: University of Sokoto.

Bala, E.J. and I.H. Umar, 2000. Government policies and programmes on the development of solar – photovoltaic sub-sector in Nigeria. Nigerian Journal of Renewable Energy, 8(1 & 2): 1-6.

Bugaje, I., 2006. Renewable energy for sustainable development in Africa: A review. Renewable and Sustainable Energy Reviews, 10(6): 603–612.

Buzz, S., 2009. Annual world solar photovoltaic industry report. Market buzz. Available from http://www.solarbuzz.com.

Central Intelligence Agency, 2004. The world fact book. Available from https://www.cia.gov/library/publications/the-world-factbook/.

Chendo, M.A., 2002. Non-conventional energy source: Development, diffusion and impact on human index in Nigeria. Nigerian Journal of Renewable Energy, 9(2): 91-102.

Community Research Development Centre, 2007. Promoting renewable energy and energy efficiency in Nigeria. Report of a One-Day Conference. Available from: http://www.credcentre.org.

Eleri, E.O., 1995. Nigeria: Energy for sustainable development. Journal of Energy and Development, 19(1): 104.

Energy Commission of Nigeria, 2004. Proceedings of the renewable energy conference: Energetic Solution Conference, Abuja/Calabar, Nigeria.

Energy Commission of Nigeria, 2013. Energy statistics. Available from http://www.energy.gov.ng/index.php.

European Commission, 2013. New EU support for renewable energy policy in Nigeria. Available from http://ec.europa.eu/commission_2010-2014/piebalgs/index_en.htm.

Garba, B. and A.M. Bashir, 2002. Managing energy resources in Nigeria. Studies on energy consumption pattern in selected rural arears in Sokoto State. Nigerian Journal of Renewable Energy, 10(1 & 2): 97-107.

Ibidapo-Obe, O. and O.E. Ajibola, 2011. Towards a renewable energy development for rural power sufficiency. Proceedings of International Conference on Innovations in Engineering and Technology. Nigeria, University of Lagos.

Information Gateway for Renewable Energy and Energy Efficiency, 2013. Energy profile Nigeria. Available from http://www.reegle.info/countries/nigeria.

International Renewable Energy Agency, 2014. Rethinking energy: Towards a new power system. Available from http://www.irena.org/rethinking/.

Jurgen, T., 2004. Energetic solution. An International Conference on Making Renewable Energy a Reality. Bonn, Germany.

Lawal, N.S., 2010. Renewable energy as a solution to Nigerian energy crisis. Vaasan Ammattikorkeakoulu, Vasa Yrkeshogskola, University of Applied Sciences.

Natural Resources Defence Council, 2014. Renewable energy for America: Harvesting the benefit of home-grown renewable energy. Available from http://www.nrdc.org/energy/renewables/.

Nnaji, B., 2012. Investment opportunities in the Nigerian power sector. Nigeria Business and Investment Summit, London. Available from http://www.newworldnigeria.com/pdf/HMPPowerSectorReformsPresentation [Accessed 30 July 2012].

Nnaji, C.E., C.C. Uzoma and J.O. Chukwu, 2010. The role of renewable energy resources in poverty alleviation and sustainable development in Nigeria. Continental Journal Social Sciences, 3: 31 – 37.

Ohunakin, O.S., 2010. Energy utilization and renewable energy sources in Nigeria. Journal of Engineering and Applied Sciences, 5(2): 171–177.

Okafor, E.N. and U. Joe, 2010. Challenges to development of renewable energy for electricity power sector in Nigeria. International Journal of Academic Research, 2(2): 211- 216.

Okanlawan, L., 2013. Nigeria: Renewable energy opportunities blossoming. Available from http://www.renewableenergy.com/rea/u/lanre.

Omokaro, O., 2008. Energy development in a fossil fuel economy: The Nigerian experience. Report of a National Dialogue to Promote Renewable Energy and Energy Efficiency in Nigeria.

Oyedepo, S.O., 2013. Energy in perspective of sustainable development in Nigeria. Sustainable Energy, 1(2): 14-25.

Renewable Energy Master Plan, 2005. Final draft report. Energy Commission of Nigeria and United Nations Development Programme.

Road-Map for Power Sector Reform, 2013. The process leading to sustained electricity supply is on course. Presidential Task Force on Power. Available from http://www.nigeriapowerreform.ord.

Sambo, A.S., 2009. Strategic developments in renewable energy in Nigeria. International Association for Energy Economics. Third Quarter: 15 –19.

Sambo, A.S., 2011. Renewable energy policy and plans in Nigeria. Power Kick. Nicon luxury hotel, Abuja.

Seers, D., 1969. The meaning of development. Eleventh World Conference on Society for International Development, New Delhi.

Shaaban, M. and J.O. Petinrin, 2014. Renewable energy potentials in Nigeria: Meeting rural energy needs. Renewable and Sustainable Energy Reviews, 29: 72–84. Available from http://www.elsevier.com/authorsrights.

U. S. International Renewable Energy Agency, 2014. International energy statistics. Available from http://www.eia.gov.

Uzoma, C.C., C.E. Nnaji, C.N. Ibeto, C.G. Okpara, O.O. Nwoke, I.O. Obi and O.U. Oparaku, 2011. Renewable energy penetration in Nigeria: A study of the South-East zone. Continental Journal of Environmental Sciences, 5(1): 1 –5.

World Bank, 2002. Energy solution. Renewable Energy Conference. Abuja/Calabar, Nigeria. Available from: www.wwindea.org/wiki/.

World Bank, 2013. World development indicators 2012. Washington DC, USA: The World Bank. Available from: http://documents.worldbank.org/curated/en/2013.

Zarma, I.H., 2006. Hydro power resources in Nigeria. 2nd Hydropower for Today Conference, Hangzhai. China.