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Sustainable Energy Development in Nigeria: Overcoming Energy Poverty[1]

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ABSTRACT

Energy availabilty is crucial for the economic growth of any nation in the world today. Access to clean, affordable and reliable energy are necessities in achieving a sustainable development in the modern world. Energy poverty in a country can be said to be a situation where its citizens lack electric power to meet even their own basic needs such as lighthing and cooking. Nigeria, as a country described as the "giant of Africa and the most populated black nation in the world still faces the crisis of energy poverty. Nigeria is blessed with an abundant energy resources of both fossil fuels and renewable energy (RE), but the main challege is the country's inability to adequately and efficiently utilize these energy resources. This lack of efficent energy utilization has led to the near depletion of the fossil fuel resources within the country's boarder and the energy crisis afflicting Nigeria is expected to be on the rise if the government does not act immediately by the diversification of country's energy sources and exploit the abundant natural renewable resources avaliable in the country. This paper reviews the standpoint of efficent energy management with strategic concentration on the demand side energy savings and RE resource potential in Nigeria to ensure sustainable development. The energy situation in the country is reviewed with the consumption parttern of the various fossil fuel resources in the country. The paper also examined the various RE potentials, locations and present ways in which they can be harnessed for useful and uninterrupted energy supply. Some effective strategies and energy policy are presented in order to overcome the energy poverty situation in Nigeria.

Keywords: Sustainable Energy Development, Energy Poverty, Renewable Energy, Energy Savings, Nigeria
JEL Classifications: Q2, Q3, Q4

1. INTRODUCTION

Energy plays an important role in the socioeconomic and sustainable development in many nations of the world today. Uninterrupted energy supplies which are affordable, accessible, and eco-friendly on the long term ensure the future economic growth of a country. Security, climate change and public health are closely interrelated with energy (Ramchandra and Boucar, 2011). However, the standard of living in most countries is directly related to their per capita energy consumption. The energy crisis that is recently affecting the world all over is due to both the rapid increase in population and standard of living in many societies (Rai, 2004).

The Millennium Development Goals which includes eradicating extreme poverty, achieving universal primary education, ensuring environmental stability, agricultural productivity cannot be achieved without an improvement in the quality and quantity of energy services in developing countries (MDGB, 2015). The World Commission on Environment and Development (WCED) popularized the term "Sustainable Development" in its 1987 report entitled, "Our Common Future." Sustainable development was defined by the commission as "the development that meets the needs of the present without compromising the ability of future generation to meet their own needs" (WCED, 1987).

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The global quest for sustainable development has dramatically increased in our modern times and this raises the issues of a sustainable economic development and growth. Therefore, sustainable energy has become one of the most promising means of handling the challenges of energy demand problems of many consumers worldwide (Hvelplund, 2006). Strategies in sustainable energy development includes the major technological changes which are improvement in efficiency of energy production, demand side energy savings and replacement of fossil fuels by various forms of renewable energy (RE).

The level of productivity in the commercial, agricultural and industrial sector is related to their energy use which on the other hand determines the developmental level of a nation. Energy sources which include coal, petroleum, natural gas, nuclear fuels and biomass are used in everyday activities. However, fossil fuel constitute more than 80% of the global primary energy consumption and these can be observed in the production of electricity which is an important form of energy required in all sectors of the economy (Awwad and Mohammed, 2007).

The International Energy Agency (IEA) in its 2006 World Energy Outlook stated clearly that the energy market will be dominated by oil continuously into the foreseeable future and RE will contribute about 15% to the total primary energy requirements by 2030 (IEA, 2006). The growing demand for energy consumption has raised concerns by experts who argued that with the global energy consumption at its current pace, economically exploitable fossil fuel reserves will not exceed 40 years for oil, about 60 years for natural gas and 230 years for coal (Jean and Marc, 2007).

However, the emerging shale gas development has changed the estimate of natural gas which is expected to last for only 60 years. Beside the shale gas, other gas like tight gas and coal-bed methane (also known as coal seam gas) has transformed the energy market with estimated resources to be more than 200 years (ADB, 2014). Its discovery in the United States in 1998 and by 2012 was available in commercial quantity has raised some hopes and environmental questions about its impact on the environment (Stevens, 2012). In the African context, shale gas development is still in its infant stage. The African Development Bank (ADB) recently listed seven African countries (Algeria, Libya, Tunisia, Morocco, Mauritania, Western Sahara and South Africa) with technically recoverable shale gas reserves (ADB, 2014). This will eventually have significant impact in the countries in particular and the African continent in general.

A country experiencing energy poverty can be said to be a situation where its citizens lack electric power to meet even their own basic needs such as lighting and cooking. In this situation, a large number of people who are usually in the developing countries are negatively affected by their very low consumption of energy use, while some use dirty polluting fuels and others spend excessive time to obtain fuel in order to meet their basic needs. According to the Energy Poverty Action Initiative of the World Economic Forum (IEA, 2007), "Access to energy is fundamental to improve the quality of life and is a key imperative for economic development." However, energy poverty is closely associated with most developing countries and according to the IEA; almost 1.6 billion people lack access to electricity (IEA, 2007).

In Africa, access to clean sustainable energy which is essential for its social, political and economic development has been an immense challenge and this has thrown the continent into a state of developmental crisis. Nigeria which is known as "the giant of Africa" in terms of energy resources with a population of 174,507,539 which makes it the most populous country in the world (CIA, 2013) and gross domestic product (GDP) of $522 billion (Worldbank, 2014a) still suffers from energy poverty which is due to the lack of development in sustainable energy.

About 49% of Nigerians live in the rural (Worldbank, 2014b) areas where access to electricity and fossil fuel is difficult to obtain. The extension of the national electricity grid does not cover the whole country; therefore most villages don't have access to the electricity. This lack of electricity has caused the people to resort to the use of any available fossil fuel like petrol and diesel for electricity, kerosene and woods (fuel woods) for cooking. Moreover, the roads in which they ply in order to obtain the fossil fuel are bad and they meet a lot of cue at the petrol station where they will spend long hours trying to buy fuel.

Many researchers have studied the available RE resources in Nigeria; surprisingly, only few research works are available on sustainability of energy resources in Nigeria. We therefore make this contribution to the available literatures. The research question this paper presents is how can Nigeria overcome the energy poverty situation and ensure sustainability of its energy resources. Since Nigeria has an enormous amount of RE resources such as solar, wind, biomass and hydropower, there is a need to make a shift from fossil fuel to RE resources by its proper utilization and developing efficiency strategies in energy production on the supply side and energy savings on the demand side.

The main objectives of this paper is to (i) examine the energy consumption pattern in Nigeria (ii) Identify the various exploitable RE resources in Nigeria and its proper utilization (iii) Provide effective energy policy and Strategy in order to enhance sustainability and overcome energy poverty in Nigeria. The rest of this study is organized as follows; Section 2 gives the background of the study. Section 3 presents the situation of energy poverty in energy rich Nigeria. Nigeria's energy consumption pattern is given in Section 4. Section 5 looks into the electricity generation and consumption in Nigeria. Section 6 briefly discusses energy sustainability in Nigeria. Section 7 focuses on RE for sustainable development with subtitles on the various renewable energies and their potentials. The energy management practices in Nigeria are discussed in Section 8. An Overview of the Nigerian Energy Policy is given in Section 9. Some effective strategies and energy policies are provided in Section 10 while Section 11 concludes the study.

2. BACKGROUND

The research on RE resources and its potential in Nigeria has been carried out by many indigenous researchers. Biogas use have been assessed by Akinbami et al. (2001) where they identified the feedstock substrate for an economically biogas program that was feasible in Nigeria. According to the authors, 227,500 Tonnes of fresh animal waste are produced in Nigeria every day and since 0.03 m^3 of gas can be generated from 1 kg of fresh animal waste, 6.8 million m^3 of biogas can be produced in Nigeria daily. Opeh and Okezie (2011) explored ways in which biogas could be properly utilized for electricity generation and the production of domestic cooking gas across the rural and urban areas in Nigeria. Adeoti et al. (2000) carried out a project in harnessing the potential of biogas energy for cooking which was obtained from cattle dung and found out that it has good economic potential in Nigeria.

Adejumobi et al. (2013) used hydrological data to survey and analyze potential hydropower sites for rural electrification scheme in Nigeria. The authors however found out that theoretical electrical power which range from 5.13 KW to 5,000 KW from identified small hydropower (SHP) sites was enough to satisfy an average rural community in Nigeria. The hydroelectric power potential in Nigeria has been assessed by Akinbami (2001) and estimated to be more than 8,824 MW which has a potential to generate electricity of about 36,000 GWh. SHP development has been evaluated by Ohunakin et al. (2011) and they discovered that the effort by the Nigerian Government to diversify the country's energy source has not been adequate as there remain some barriers against SHP development in Nigeria.

The field of solar energy has seen a lot of indigenous researchers. According to Chineke and Igwiro (2008) an abundant amount of solar energy with daily solar radiation of about 5.25 kWh/m^2/day is been received in Nigeria which varies from 7 kWh/m^2/day in the northern part to 3.5 KWh/m^2/day in the southern part of Nigeria. Okoro and Madueme (2004) showed that the yearly incidence of solar energy on the ground is 2,300 kWh/m^2 which gives a total energy of about 2.100 × 10el2 kWh per year for Nigeria. Oji et al. (2012) presented the viabilities for power generation through the utilization of solar energy in Nigeria. However, a survey was carried out by Shehu (2012) on solar vendors and people living in the Northern Nigeria, the result of the survey showed that a large percentage are willing to switch to solar energy with incentives as motivation.

Wind energy study in Nigeria has been carried out by Adekoya and Adewale (1992), they analyzed the data of 30 stations for wind speeds and power flux densities which varied from 1.5 to 4.1 m/s and 5.7 to 22.5 w/m^2. Felix et al. (2012) described the wind energy potential in Nigeria and specified the conditions to be met before the wind generator can be connected to the existing grid. Other indigenous researchers in the field of wind energy are Fagbenle and Karayiannis (1994), Ngala et al. (2007) and Mnse and Ojo (2009).

3. ENERGY POVERTY IN ENERGY RICH NIGERIA

Nigeria is blessed with abundant energy resources which range from conventional energy to RE. In terms of conventional energy resources, Nigeria is the largest oil producer and along with Libya accounts for the two thirds of the Continent's oil reserves (29). With 36.22 billion barrels of estimated oil reserves, Nigeria owns the sixth largest reserves of crude oil in the world (Oyedepo, 2012).

Nigeria ranks second as Africa's largest proven natural gas reserves after Algeria with 187 trillion SCF (NBS, 2007). Nigeria's oil and gas are found in commercial quantities in states located in the southern regions; Abia, Imo, Cross River, Rivers, Bayelsa and Delta state. These states are usually called Niger Delta; other places are the Bight of Bonny and Gulf of Guinea. Other conventional energy resources are coal and lignite with reserves of 2.175 billion tonnes, tar sands is 31 billion barrels of oil equivalent. Large hydropower reserves stands at 11.250 MW. Table 1 shows the conventional energy reserves in Nigeria and their potentials.

As earlier stated in the introduction, energy poverty is the situation where by the citizens of a country lack power to meet even their own basic needs. What makes Nigeria's situation even worst is that the country is richly blessed with various energy resources as can be seen in Table 1. However, sustainable development is lacking in the energy sector and this directly affects the mass of the country's population which still live below the poverty line. About 49% of Nigerians dwell in the rural areas and as such, lack electricity for lighting and kerosene for cooking. This has forced the rural dwellers to resort to the use of fuel woods.

It has been reported (IMCCDD, 2000) that over 50 million people consume fuel wood annually and this has caused an increase in deforestation and erosion in the Southern part of Nigeria. The rate of deforestation exceeds that of reforestation because deforestation rate is almost 350,000 hectares/year which is equivalent to 3.6% while reforestation is only 10% of the deforestation rate. This constitutes a major indoor pollution hazard as Eleri et al. (2011) reported that about 79,000 Nigerians die every year as a result of smoke inhalation from traditional three stone cooking fires. The number increased in 2013 according to a study conducted by the World Health Organization which shows that 98,000 Nigerian women die annually as a result of using fuel woods (RUWES, 2013).

The high amount of death due to smoke from fuel wood will continue to increase since there are inaccessible roads and lack of electricity in the rural areas. Kerosene which is better than fuel wood has its own challenges because the rural dwellers lack clean stoves for cooking and the kerosene is not readily available, and even if available, the price is very high for the rural people. Table 2 shows the percentage distribution of household in Nigeria by type of fuel for cooking in 2007 and 2008.

It is observed from the Table 2 that about 74% of households in 2007 depended on fuel wood as cooking fuel and this increased to 79% in 2008. Kerosene use by household reduced from 22.9% in 2007 to 18.5% in 2008, this can however be due to the cost of purchasing kerosene and also scarcity. Gas and electricity recorded the least with each having 0.7% in 2007, 0.6% for gas and 0.2% for electricity in 2008. This may be due to the poor electricity supply condition, lack of access and high cost of cooking gas.

Table 1: Conventional energy reserves in Nigeria and their potentials

Resource type	Reserves		Production	Domestic utilization
	Natural units	Energy units (Btoe)		(natural 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	–	–
Nuclear element	None	–	–	–

Source: NBS, 2007

Table 2: Percentage distribution of households by type of fuel for cooking in 2007 and 2008 (in parenthesis)

State	Electricity	Gas	Kerosene	Wood	Coal
Abia	0 (0.2)	0.7 (0.7)	25.8 (21.4)	73.6 (77.8)	0 (0)
Adamawa	0.5 (0.2)	0 (0.4)	6.2 (2.3)	93.4 (96.8)	0 (0.4)
Akwa Ibom	0 (0)	0.2 (1.5)	18.3 (15.7)	81 (82.4)	0.4 (0.3)
Anambra	0.4 (0)	0.3 (0.7)	26.8 (21.7)	72.2 (77.3)	0.3 (0.2)
Bauchi	0 (0)	0 (0.2)	2.1 (1.6)	97.6 (98.2)	0.3 (0)
Bayelsa	0.9 (0.8)	0 (0.4)	41.3 (47.5)	57.6 (51.4)	0.2 (0)
Benue	0 (0.2)	0.4 (0)	3.1 (2.8)	94.5 (96.5)	2 (0.5)
Borno	0 (0)	0 (0)	1.3 (2.1)	98.4 (94.3)	0.3 (3.6)
C/River	0 (0)	0.2 (0.2)	19.6 (13.6)	79.8 (86.3)	0.3 (0)
Delta	0 (0.3)	1.6 (1.2)	21.3 (36.6)	76.6 (61.6)	0.5 (0.2)
Ebonyi	0.1 (0)	0.8 (0)	9.2 (6.9)	90 (93.1)	0 (0)
Edo	2.1 (0.2)	0.1 (0)	18.6 (25.5)	78.7 (74.3)	0.5 (0)
Ekiti	0 (0.7)	0 (0.3)	24.2 (36.6)	74.3 (61.5)	1.5 (0.9)
Enugu	0.1 (0.2)	2.1 (0.7)	28.3 (21.3)	68.9 (77.3)	0.6 (0.5)
Gombe	2.1 (0.3)	0 (0)	5.5 (3.6)	92.4 (95.9)	0 (0.2)
Imo	0.2 (0.5)	0.7 (1)	13.6 (7.4)	85.1 (90.9)	0.4 (0.3)
Jigawa	1 (0.2)	0 (0.3)	3.9 (1.6)	95.1 (97.8)	0 (0.2)
Kaduna	0.3 (0.2)	1.2 (0)	9.8 (8.7)	88.5 (90.7)	0.2 (0.5)
Kano	1.3 (0.5)	0.1 (0.2)	3.4 (4.5)	94.9 (94.1)	0.3 (0.7)
Katsina	1.7 (0)	0 (0)	0.5 (2.2)	97.5 (97.8)	0.2 (0)
Kebbi	0.5 (0.2)	0.2 (0.4)	0 (4.8)	99.2 (94.6)	0.1 (0)
Kogi	0.3 (1)	0 (0.3)	12 (18.9)	86.6 (79.6)	1 (0.2)
Kwara	1.1 (0)	0 (0.2)	15.5 (12.7)	62 (74.3)	21.4 (12.7)
Lagos	2.8 (0)	3.8 (6.2)	89.7 (91.1)	3.1 (2.7)	0.6 (0)
Nassarawa	0 (0.5)	0 (0)	9.2 (7.9)	90.8 (91.1)	0 (0.5)
Niger	0.7 (0)	0 (0.2)	5.2 (9.6)	92.9 (89.3)	1.2 (0.9)
Ogun	2 (0)	0 (0.7)	48.8 (60.9)	49 (37.3)	0.3 (1.2)
Ondo	0.2 (0.2)	0.2 (0.3)	32.6 (17)	66.7 (82.5)	0.3 (0)
Osun	0.8 (1.2)	0.2 (0)	27.1 (45.7)	56 (49.6)	15.9 (3.5)
Oyo	0.1 (0)	1.3 (0.5)	44.7 (43.6)	50.2 (44.1)	3.8 (11.8)
Plateau	0.6 (0.2)	0.4 (1)	16.8 (10)	80.8 (88.8)	1.4 (0)
Rivers	0 (0.3)	2.8 (1.7)	31.3 (38.9)	65.2 (59.1)	0.7 (0)
Sokoto	0.6 (0.2)	0.3 (0)	2.5 (6.3)	96.2 (93.5)	0.5 (0)
Taraba	0 (0)	0 (0)	1 (2.6)	98.8 (97.4)	0.2 (0)
Yobe	0 (0)	0 (0)	0.9 (2.3)	98.7 (97.7)	0.4 (0)
Zamfara	0.1 (0)	0.1 (0)	4.1 (1.7)	95.5 (98.3)	0.3 (0)
FCT	0.7 (0.2)	3.4 (1.9)	34.5 (38.7)	57.4 (57.6)	4 (1.7)
Average	0.7 (0.2)	0.7 (0.6)	22.9 (18.5)	74.1 (79.6)	1.6 (1.1)

Source: CBN, 2008. FCT: Federal Capital Territory

Electricity on the other hand is a problem because the extension of the national grid does not get to most of the rural areas in Nigeria. This lack of electricity cause untold hardship to the rural dwellers who then have to buy small personal diesel/petrol generators in order to generate their own electricity. Electricity is also required for other basic developmental services like pipe borne water, health care, telecommunications and quality education. The absence of reliable energy supply which is affordable has left the rural dwellers socially backward and their economic potential untapped. The only solution will be to harness Nigeria's RE resources and incorporate it into the energy supply mix (Mnse and Ojo, 2009).

4. NIGERIA'S ENERGY CONSUMPTION PATTERN

Due to the high demand for energy, Nigeria suffers from inadequate supply of energy even as the country is blessed with abundant energy resources (Okafor and Joe-Uzuegbu, 2010). The energy consumption pattern in Nigeria can be divided into agriculture, commercial, household, industrial and transport sectors (ECN, 2003). Due to low development of other sectors, the household has the highest share of about 65% (Oyedepo, 2010). Energy is vital for the wellbeing of the citizens of any nation and electricity is one of the most important energy forms. Household electricity access is low in Nigeria where over 60% of its population with no access to electricity while semi-urban and rural dwellers have an estimate of 35% connectivity to the electricity grid (FGN, 2009).

The household major energy uses are basically for operating electrical appliances which takes about 3%, lighting takes 6% while the largest goes for cooking at 91% (ECN, 2005). Energy sources for domestic and commercial use in Nigeria include electricity, natural gas, kerosene; fuel wood and coal are shown in Table 2. While the less common sources are sawdust, crop residues like corn stalk, cassava sticks and dung from cattle. The people in the urban areas use mostly natural gas and kerosene for cooking; this depends on the income level as most low income earners use kerosene while high income earners use gas.

Table 3 shows the distribution of households by states and electricity supply in 2007 and 2008. This table covers the 36 states in Nigeria including the Federal Capital Territory. Households that did not have access to electricity was 41.4% in 2007 and 48% in 2008, and this may go higher due to the country's ever growing population. From Table 3, 47.3% of the household had access to electricity from the national grid (PHCN) in 2007 and the figure dropped to 40.4% in 2008. Rural electrification was just 0.9% which shows that not much progress have been recorded in the program. The household that depends on private generator which may be petrol or diesel increased from 2.7% in 2007 to 3.2% in 2008 while households complementing the power from the national grid with the use of generator rose from 5.8% in 2007 to 6.3% in 2008. Solar energy has not been well utilized in the household electricity supply as shown in Table 3.

In the urban areas, petrol and diesel are used mostly in the transportation sector. The supply of petroleum products are sometimes halted due scarcity which has a negative effect on

Table 3: Percentage distribution of households by state and electricity supply in 2007 and 2008 (in Parenthesis)

State	PHCN only	Rural electrification only	Private generator only	PHCN/ generator	Rural electrification/ generator	Solar energy	None
Abia	44.5 (45.7)	0.1 (1.3)	5.9 (6.5)	15.2 (13.5)	0.5 (1.8)	0 (0)	33.8 (31.1)
Adamawa	22.3 (22.6)	0 (0)	1 (3.4)	4.9 (3.9)	0.5 (0.4)	0 (0)	71.4 (69.8)
Akwa Ibom	46.3 (40.6)	2.7 (1.7)	3.3 (7.9)	7.6 (5.9)	1.9 (0.2)	0 (0.2)	38.3 (44.6)
Anambra	58 (61.9)	4.1 (0)	0.2 (3)	6.8 (7.9)	0 (2.3)	0 (0)	30.9 (24.4)
Bauchi	38.7 (31.4)	0 (5.3)	0 (0)	2.8 (3.2)	0 (0)	0 (0)	58.5 (60.2)
Bayelsa	10.3 (21.6)	10.1 (23.3)	13.3 (8.6)	5.8 (7.5)	37.8 (12.2)	0.5 (0)	22.2 (36.9)
Benue	15.7 (22.8)	0 (0)	2.8 (4.2)	2.5 (0.9)	0.5 (0.2)	0 (0)	78.6 (72)
Borno	19.4 (15.2)	4.6 (0)	10.6 (3.8)	0.9 (3.6)	0.1 (0)	0 (0.2)	64.5 (77.3)
C/River	54.1 (40.6)	0.5 (0.3)	3.2 (3.4)	1.7 (9)	3.4 (0.3)	0 (0)	37.1 (46.3)
Delta	62.7 (56.8)	0 (0)	2.5 (2.9)	3 (7.5)	1.6 (3.1)	0 (0)	30.2 (29.6)
Ebonyi	14.7 (12.3)	5 (8.3)	5 (3.2)	0.3 (2.5)	1.5 (5.6)	0 (0)	73.5 (68.1)
Edo	80.7 (77.7)	0 (1.9)	1.5 (2)	0.9 (3.2)	0 (0)	0.1 (0)	16.9 (15.2)
Ekiti	56.7 (61)	0 (0)	1.2 (1.6)	0.8 (5.2)	0 (0.2)	0 (0)	41.3 (32.1)
Enugu	45.6 (44.9)	0.2 (0.5)	3.6 (3.6)	5.5 (4.8)	0.3 (0.3)	0 (0)	44.8 (45.8)
Gombe	50.7 (39.5)	0 (0.9)	0 (0.9)	0 (3.4)	0 (0)	0 (0)	49.3 (55.4)
Imo	68.5 (69.5)	1.4 (0.3)	5.2 (4.6)	4.1 (12.8)	0.1 (0.2)	0 (0)	20.8 (12.6)
Jigawa	39.4 (41.6)	0 (0.2)	0.2 (0.2)	0.4 (1.4)	0 (0.2)	0 (0)	60 (56.5)
Kaduna	53.5 (46.2)	0.5 (0.2)	1.2 (1.8)	2.9 (8.2)	0.2 (1.2)	0 (0)	41.8 (42.4)
Kano	59.6 (42.6)	0 (0)	0 (0.3)	0.8 (0.8)	0 (0)	0 (0)	39.6 (56.2)
Katsina	31 (36.2)	0 (1)	0.1 (0.2)	6.8 (2.9)	0.2 (0)	0 (0)	62 (59.7)
Kebbi	44.2 (42.7)	0 (0)	1.5 (0.4)	1.7 (2.5)	0 (0)	0 (0)	52.6 (54.4)
Kogi	52.1 (39.5)	0 (1.7)	2.3 (4.5)	2.4 (5.2)	0.3 (1)	0 (0)	43 (48.1)
Kwara	54.9 (56.4)	0 (0)	1.5 (1.5)	4.7 (3.6)	0.5 (0)	0 (0)	38.3 (38.5)
Lagos	67.3 (57)	0.1 (0)	0.5 (0.9)	30.8 (40.9)	1.1 (0.9)	0 (0)	0.2 (0.3)
Nassarawa	27.7 (21.3)	0 (0.2)	2.2 (2.4)	6.2 (3.6)	0.4 (1.9)	0 (0)	63.6 (70.6)
Niger	42.5 (35.6)	0 (0)	0.3 (6.2)	1.4 (1.6)	0 (0)	0 (0)	55.9 (56.6)
Ogun	71.3 (69.8)	0.4 (0)	0.3 (0.8)	0.9 (8.5)	0.1 (0.3)	0 (0)	27.1 (20.4)
Ondo	58 (50.3)	0 (1.7)	4.3 (3.8)	3.4 (2.2)	5.3 (0)	0 (0)	29 (41.9)
Osun	67.6 (63.6)	1.6 (0)	0.3 (1.2)	0.5 (1.4)	0 (0)	0 (0)	29.9 (33.9)
Oyo	57.3 (47.5)	0.9 (0)	0.2 (5.3)	11.8 (8.2)	0 (0.2)	0 (0)	29.8 (38.8)
Plateau	23.8 (18.8)	2.4 (1.4)	3.3 (5.7)	3.8 (2.1)	1.1 (0.7)	0 (0)	65.6 (71.3)
Rivers	24.6 (41)	7.4 (0.7)	16.3 (13.8)	4.7 (11.9)	10.4 (10.9)	0 (0)	36.6 (21.7)
Sokoto	35.7 (29.8)	0.3 (0)	0.7 (0.2)	0.8 (0.3)	2.3 (0.2)	0 (0)	60.3 (69.5)
Taraba	3.7 (2.8)	0.7 (0)	2.4 (1.2)	1.7 (5.9)	0.3 (1.4)	0.1 (0)	91 (88.8)
Yobe	16.2 (18.1)	0.4 (0.7)	0.1 (0.7)	0.3 (2.1)	0.2 (0.4)	0 (0)	82.9 (78)
Zamfara	24.7 (21.5)	0 (0.2)	0.3 (0.2)	2.4 (0.5)	0 (0)	0 (0.5)	72.7 (77.1)
FCT	36.6 (38.3)	0 (0.3)	11.7 (10.6)	19.8 (23.7)	0.6 (0.2)	0 (0)	31.3 (26.9)
Average	47.3 (40.4)	1.1 (0.9)	2.7 (3.2)	5.8 (6.3)	1.6 (1.1)	0 (0)	41.4 (48)

Source: CBN, 2008. FCT: Federal Capital Territory

economic growth because it restrict people's movements and cause an increase in the price of basic commodities. The power plants that supplies electricity to the national grid also runs on natural gas and heavy oils which come directly from the Nigerian Gas Company and various oil companies may be affected by the scarcity of petroleum products.

Besides the scarcity of petroleum products, the menace of pipe line vandalism may also disrupts the supply of petroleum products to the plants. Other power plants that run on natural gas are also affected. The issue of gas flaring has been a serious challenge to the government as effort are been made to channel this associated gas that's been flared to the power plants for more productive use. Coal has long been edged out due to lack of demand since the energy sector is focused on oil and gas. The production has long declined due to the conversion of railway engines from coal to diesel in 1966 and the shutdown of the coal fired electricity generating station after the Nigerian civil war by the then National Electric Power Authority (Enibe and Odukwe, 1990).

5. ELECTRICITY GENERATION AND CONSUMPTION IN NIGERIA

The electricity generation in Nigeria rose from a few kilowatts that were used by the colonial masters in Lagos in 1896 when two small generating sets were installed to the total installed capacity of about 185 MW in 1961 and was increased to 805 MW by 1970 and later 2800 MW in 1983 (Vincent and Yusuf, 2014) (Bajpai and Suleiman, 1985). The total installed capacity of generating stations in Nigeria is given in Table 4.

From the Table 4 it is observed that the Jebba Hydro station has the highest utilization rate while Sapele thermal plant has the lowest utilization rate. The highest installed capacity comes from Egbin while the highest output comes from Kainji hydro station. In all the power plants, hydro plants have higher utilization rate than thermal plants. This may be due to the high level of gas flaring as Nigeria ranks second as the largest natural gas flaring in the world.

Table 4: Electricity generation in Nigeria's power stations

Station	Energy source	Year inaugurated	Installed capacity (in MW)	Current output (in MW)	No of units	Output as % of installed capacity
Oji	Thermal	1956	30	NA	4	NA
Delta	Thermal	1966-99	900	366	20	40.67
Kainji	Hydro	1968-78	760	445	12	58.55
Ijora	Thermal	1978	60	8	3	13.33
Sapele	Thermal	1978-1981	1020	62	10	6.08
Afam	Thermal	1978-1982	960	85	18	8.85
Jebba	Hydro	1983-1984	560	339	6	60.54
Egbin	Thermal	1985-1987	1320	243	6	18.41
Shiroro	Hydro	1989-1990	600	281	6	46.83
Total			6210	1829	85	29.45

Source: Bello-Imam, 2009

The overall utilization rate is low and this result in the shortage of electricity supply which has a significant effect on economic growth. According to the Nigerian Bureau of Statistics (NBS), the electricity sector has never contributed more than 1% to the economic growth and 2% of the economic value added of Nigeria, only 0.22% of economic growth and 0.32% of economic value have been contributed (NBS, 2009). The shortage in electricity supply has forced its consumers to depend solely on petrol or diesel generators. Figure 1 shows the electricity production and consumption pattern in Nigeria.

Table 5 shows the proportion of electricity consumption by each sector from 1970 to 2008. From the table, industrial electricity consumption reduced from 62.9% in 1970 to 20.0% in 2008 while there have been a significant increase in the residential electricity consumption from 37.1% in 1970 to 55.3% in 2008. This fall in electricity consumption in the industrial sector may be due to the reliance of most industries on generator in order to run their business. The South African mobile phone company MTN who operates the largest mobile phone company in Nigeria is estimated to have installed 6,000 generators to supply its base stations for up to 19 h a day. This cost the company $5.5 million a month on diesel in order to run the generators (Lawal, 2007; Shaaban and Petinrin, 2014).

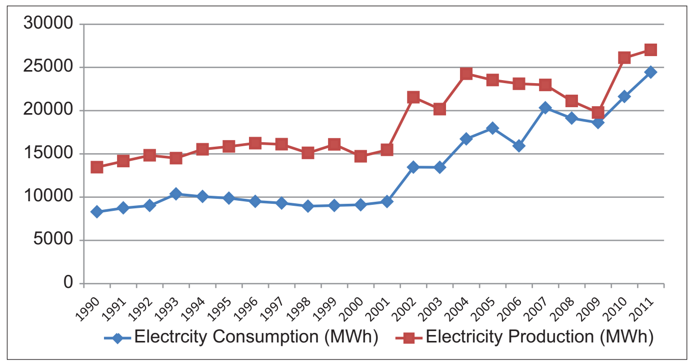
In Moyo (2012) study, power outages have a negative and significant effect on productivity, particularly on small firms. Oseni (2012) analysis revealed that the net power outage cost incurred per kW by an average firm is enough to hire and pay the annual salary of two additional workers at the current minimum wage in Nigeria. Oseni (2012) concluded that with an improvement of just 776 MW, 1.6 million jobs could be created.

Electricity loss is another issue that requires urgent attention. This can be seen in Table 6 which shows the distribution losses in the Nigerian electricity industry from 1980 to 2009. The loss rose from 30.5% in 1980 and reached its maximum peak of 46.9% in 1996, but has reduced to 9.4% as of 2008. These losses are due to the poor state of transmission lines which go long distances before it gets to the distributor and final electricity consumers. Other factors include illegal connections, inaccurate billing and homes without meters.

6. ENERGY SUSTAINABILITY

Energy sustainability has become a major topic around the world. Most nations are moving to a greener economy by reducing their much dependence on conventional fuel, embracing RE and adopting it into their national energy mix. However, the global anticipation for the depletion of conventional energy has forced most nations to develop a more sustainable energy system.

Figure 1: Electrcity prodcution and consumption in Nigeria



Source: NBS, 2009

Energy sustainability involves the sustainable use of energy in the overall energy system which includes processes and technologies for harnessing of energy resources, their conversion to useful energy forms, energy transport and storage, and the utilization of energy to provide energy service like lighting in homes, office, streets and cooking.

Nigeria's energy mix still contain more of conventional energy for both off-grid and on-grid electric supply. These conventional fuels are dirty, costly and pollute the environment which contributes to climate change. The proper utilization of RE resources combined with efficient supply of fossil fuel with cleaner technology will aid in the reduction of environmental pollution caused by improper energy use and help Nigeria improve her economy. As easy as it may sound, there is still the problem of affordability and adaptability because most people in Nigeria are poor and not enlighten on the advantages of RE technologies. Moreover, the acceptance of RE will be a reality and it will be of great importance to make the shift now in order to prevent energy scarcity and slow down the pace of global warming.

7. RE FOR SUSTAINABLE DEVELOPMENT

RE has an important role to play in the rural and urban areas in order to meet their future energy needs (Hui, 1997). The

Table 5: Electricity consumption pattern in Nigeria in MW per hour

Year	Total	Industrial	% of total	Residential	% of total	Commercial and public services	% of total
1970	145.3	91.4	62.9	53.9	37.1	NA	NA
1971	181.1	114.9	63.5	66.2	36.5	NA	NA
1972	211.1	138.2	65.5	72.9	34.5	NA	NA
1973	232.7	146.1	62.8	86.6	37.2	NA	NA
1974	266.2	163.2	61.3	103	38.7	NA	NA
1975	318.7	200.4	62.9	118.3	37.1	NA	NA
1976	369.8	214.6	58	155.2	42	NA	NA
1977	435.7	253	58.1	182.7	41.9	NA	NA
1978	504.4	157.7	31.3	253.2	50.2	93.5	18.5
1979	460.1	160.3	34.8	221.9	48.2	77.9	16.9
1980	536.9	199.7	37.2	243.1	45.3	94.1	17.5
1981	335.9	121	36.0	193.6	57.6	21.3	6.4
1982	685.6	262	38.4	344.5	50.6	79.1	11.6
1983	696.7	254.4	36.5	358	51.4	84.3	12.1
1984	625.5	217.2	34.7	326.6	52.2	81.7	13.1
1985	717.4	259.8	36.2	372	51.9	85.6	11.9
1986	841.8	280.5	33.3	476.6	56.6	84.7	10.1
1987	852.9	294.1	34.5	468.6	54.9	90.2	10.6
1988	853.5	291.1	34.1	443.8	52	118.6	13.9
1989	976.8	257.9	26.4	523.6	53.6	195.3	20
1990	888.5	230.1	25.6	450.8	50.3	217.6	24.3
1991	946.6	253.7	26.8	459.3	48.5	254.1	26.8
1992	993	245.3	24.7	481.6	48.5	266.1	26.8
1993	1141.4	237.4	20.8	592.4	51.9	311.6	27.3
1994	1115	233.3	21.3	575	52.5	306.7	28
1995	1050.9	218.7	20.3	552.6	51.3	279.6	26
1996	1033.3	235.3	22.8	518	50.1	280	27.1
1997	1009.6	236.8	23.5	508.3	50.3	264.5	26.2
1998	972.8	218.9	22.5	500	51.4	253.9	26.1
1999	883.7	191.8	21.7	455.1	51.5	236.8	26.8
2000	1017.3	223.8	22	518.8	51	274.7	27
2001	1104.7	241.9	21.9	564.5	51.1	298.3	27
2002	1271.6	146.2	11.5	752.8	59.2	372.6	29.3
2003	1519.5	196	12.9	905.6	59.6	417.9	27.5
2004	1825.8	398	21.8	938.5	51.4	489.3	26.8
2005	1873.1	182.3	9.7	1194.3	63.8	496.6	26.5
2006	1742.94	383.45	22.0	894.07	51.3	465.41	26.7
2007	2245.57	494.07	22.0	1151.95	51.3	599.55	26.7
2008	2113.83	422.72	20.0	1168.96	55.3	522.15	24.7

Source: ECN (2005), EIA (2010)

development and proper utilization of RE should be given high priority, especially now that the issue of climate change and global warming is negatively affecting the world. Developed and developing countries are now adopting renewables in order to achieve sustainability.

Nigeria is richly blessed with an abundant amount of RE resources that needs to be fully harnessed, developed and properly utilized in order to reduce poverty, overcome energy poverty and enhance sustainable development. Nigeria's RE resources are presented in Table 7 and discussed as follows;

7.1. Biomass

Biomass energy refers to the energy that is developed from organic materials like scrap lumber, forest debris, crops, manure and some type of waste residues. Biomass is an indirect form of solar energy because it arises due to photosynthesis. The biomass resources found in Nigeria includes wood, shrubs and forage grasses animal wastes, wastes from forestry, agriculture, industries and municipal areas. Nigeria's biomass resources have been estimated at 88 × 102 MJ. Biomass energy from plants can be used as fuel for small-scale industries or fermented by anaerobic bacteria to produce a cheap and versatile biogas (Garba and Bashir, 2002).

Fuel wood is the most common form of biomass in Nigeria with about 80 million m3 used annually for cooking and other various domestic purposes (Sambo, 2005a). The energy content of fuel wood that is utilized is 6.0 × 109 MJ out of which only between 5% and 12% is used for cooking and other domestic use respectively (Lawal, 2007). In addition, an increasing demand for wood by furniture and construction industries is causing the rapid depletion of biomass resources in Nigeria.

Shrubs and forage grasses have been estimated to produce 200 million tons of dry biomass which will release up to 2.28 × 106 MJ of energy (Oyedepo, 2014). Due to high dependence on fuel woods for cooking and heating by rural dwellers in Nigeria, 350,000 ha of forest and vegetation are lost annually while this is much lower than the afforestation rate of 50,000 ha per annum (Sambo, 2009a). However, soil erosion and desert encroachment are going to be the result of all these activities if the situation is not put under control. This can be achieved by discouraging the use of fire wood through the introduction of solar stoves which should be affordable.

The introduction of the three-stone stove with efficiency of as low as 15% which was developed locally by the Energy Commission of Nigeria (ECN) through its energy research centers at the University of Nigeria, Nsukka and Usman Dan Fodio University, Sokoto will ensure the reduction of fuel wood consumption (Sambo, 2009a).

Table 6: Distribution losses in the Nigerian electricity industry, 1980-2009

Year	Installed capacity in MW	Total net generation in MW	Load factor	Distribution loss in MW	Loss ratio
1980	2507	783.9	31.3	239.0	30.5
1981	2755	895.0	32.5	234.0	26.1
1982	2872	929.2	32.4	236.5	25.5
1983	3192	945.5	29.6	239.0	25.3
1984	3572	978.7	27.4	273.3	27.9
1985	4192	1133.4	27.0	383.3	33.8
1986	4574	1300.9	28.4	339.2	26.1
1987	4574	1227.5	26.8	388.4	31.6
1988	4574	1273.4	27.8	431.2	33.9
1989	4960	1398.5	28.2	434.5	31.1
1990	5958	1373.2	23.0	445.4	32.4
1991	5959	1554.0	26.1	607.8	39.1
1992	5881	1626.4	27.7	653.2	40.2
1993	5881	1588.2	27.0	632.4	39.8
1994	5881	1698.3	28.9	774.1	45.6
1995	5881	1585.5	27.0	682.8	43.1
1996	5888	1640.1	27.9	768.9	46.9
1997	5888	1677.7	28.5	777.7	46.4
1998	5888	1681.5	28.6	702.9	41.8
1999	5888	1761.6	29.9	805.1	45.7
2000	5888	1613.1	27.4	641.3	39.8
2001	5888	1693.7	28.8	683.4	40.4
2002	5888	2163.6	36.7	726.4	33.6
2003	5898	2209.1	37.5	769.3	34.8
2004	5898	2645.0	44.8	861.3	32.6
2005	5898	2571.2	43.6	637.0	24.8
2006	5898	2523.9	42.8	819.7	32.5
2007	5898	2623.1	44.5	302.5	11.5
2008	5898	2409.8	40.9	227.1	9.4
2009	6210	1829	29.5	NA	NA

Source: Oseni (2011)

Biomass is an important RE source, but the sustainability of its production needs to be understood clearly. Nigeria should properly use its woods, municipal waste, oil palm products, sugar cane and rich husk for biogas energy production. As been practiced in South Africa and Malaysia, sugar mill companies in Nigeria can make use of their cane residues and waste, while paper and packaging mills can utilize their waste biomass to generate process steam (Shaaban and Petinrin, 2014). Table 8 shows Nigeria's biomass resources, their estimated quantities and energy values.

7.1.1. Biogas

Biogas is produced from anaerobic digestion of agricultural and animal waste in the absence of air. It has an estimated temperature in the range of 65°C to 750°C and its 20% lighter than air. Biogas is similar to LPG gas because it has no color, odor, and burns with a brilliant blue flame. Its caloric value has been estimated to be about 20 MJ/m^3 and burns with the efficiency of about 55% in a conventional biogas stove. The gas contains the mixture of carbon IV oxide, hydrogen sulfide, methane, nitrogen and water vapor (Opeh and Okezie, 2011). Raw materials for biogas include animal dung, waste from industry, farmlands and household.

Biogas application is a suitable form of energy for household, agricultural and industrial sectors of the economy. It is a useful substitute for diesel, fuel wood, charcoal and kerosene which on the other hand reduces greenhouse gas (GHG) emissions and has no health risk because it burns clean (Akinbami et al. 2001). In the rural areas of Nigeria, feed stock have been identified and considered economically feasible. The feed stock includes cassava leaves, dung, solid waste, water hyacinth, water lettuce, agricultural residues, urban refuse and sewage (Akinbami et al., 1996).

Studies have shown that Nigeria produces about 227,500 t of fresh animal wastes daily and 20 kg of municipal solid wastes per capita annually (Adeoti, 1998). 1 kg of fresh animal wastes can produce about 0.03 m^3 of gas; therefore 6.8 million m^3 of biogas can be produced daily in Nigeria. The research conducted by Adeoti (1998) showed that a 6.0 m^3 of family-sized biogas digester can produce about 2.7 m^3 of biogas per day to satisfy the cooking needs of a family composed of nine persons. The initial

Table 7: Renewable energy resources in Nigeria and their potential

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/s at 10 m height (main land)	0.0003 (4 m/s @ 12% probability, 70 m height, 20 m rotor, 0.1% land area, 40 years	–	–
Solar Radiation	3.5-7.0 kWh/m^2/day (4.2 million MWh/day using 0.1% land area)	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 Excess of 1.2 m ton/day	-	0.120 million ton/day	0.120 million ton/day
Animal waste	211 million assorted animals	-	0.781 million ton of waste/day	None
Energy crops and agricultural residue	28.2 million hectares of arable land (=30% of total land)	-	0.256 million ton of assorted crops/day	None

Source: ECN, 2009

cost of the project was US $500 (which is NGN 80,100 in Nigeria naira); annual expenditure was NGN 11,200 while the benefit was NGN 25,000. The project which seems to have a good economic potential may be too expensive for the low income earners who resides mostly in the rural areas. If some measures are not taken to bring down the cost or assist the low income earners economically, the low income household may not accept the use of biogas (Garba and Bashir, 2002).

It is of great importance for the government to establish some biogas plants in the country as the technology can generate to aid in the development of the country's energy sector more rapidly as the raw materials needed to feed the biogas plants are relatively abundant in the country (Opeh and Okezie, 2011). Besides the use of biogas for household consumption and electricity generation, other areas like the transport sector could also benefit for this renewable option. The production of biogas in Nigeria will not only develop the energy sector but also aid in the reduction of urban waste.

7.2. Hydro

Essentially, hydropower systems rely on the potential energy difference between the levels of water in reservoirs dams or lakes and their discharge tail-water levels downstream. The water turbine which converts the potential energy of water to shaft rotation is coupled to suitable generator (Sambo, 2005a). Hydropower is conceivably regarded as the main source of electricity generation and supply in Nigeria due to its endowment of large rivers, waterfalls and dams. However, only large hydropower technology is the prominent commercial RE technology in the electricity supply mix of the country. Economy of scale has enabled large hydropower technology to take a large proportion of the entire commercial RE resources for electricity generation under any GHG emission constraints (Balogun, 2010).

Besides the problem of water level, hydropower can supply power uninterruptedly. Nigeria's total hydropower potential stands at 14,750 MW, but only 1930 MW which represents 14% is currently generated at Kanji, Shiroro and Jebba which represents about 30% of the gross installed grid connected generation capacity in Nigeria (CBN, 2005). This assessment is for the large hydropower which was the type in operation before the 1973 oil crisis.

Nigeria's hydropower potential has not been fully exploited. However, SHP has received a lot of attention of late around the world. The attention is due to the inherent advantages of SHP in reducing environmental impact, minimal civil works and the possibility of power generation together with flood prevention, irrigation and fishery. Nigeria's SHP is estimated at 3500MW which represents about 23% of the whole country's total hydro potential (Shaaban and Petinrin, 2014) and this can be seen in Table 7.

Table 8: Nigeria's Biomass resources, estimated quantities and energy values

Resources	Quantity (million ton)	Energy value (000 MJ)
Fuelwood	39.1	531.0
Agro-waste	11.244	147.7
Saw dust	1.8	31.433
Municipal solid waste	4.075	-

Source: Sambo, 2009a

A study carried out in twelve states and four river basins showed that over 278 unexploited SHP sites with total potential of 734.2 MW were identified (64). Three of the states that were surveyed had a total of 30 MW installed SHP capacity in operation and they include Kano, Sokoto and Plateau. The Nigerian Electricity Supply Company is currently generating 21 MW from six other sites in Plateau state. Currently, about 5% of the available SHP capacity is being exploited while others are deferred for future development. However, only 32 MW out of the 734.2 MW were developed. Table 9 shows the small hydro potential in Nigeria that was surveyed while Table 10 shows the small hydro scheme in existence in Nigeria. Figure 2 shows the various water ways in Nigeria.

Establishment of more SHP across the country will help rural dwellers have access to electricity. This can be achieved by setting up SHP in rural areas that have small rivers in their rural communities. This will transform the rural areas into urban centers and enhance various economic activities that will in turn improve the wellbeing of the rural dwellers.

7.3. Solar Energy

Solar energy is the most promising RE sources in view of its apparent limitless potentials. The sun radiates its energy at the rate of about 3.8×1023 kW/s. Most of this energy is transmitted radially as electromagnetic radiation which comes from about 1.5 kW/m^2 at the boundary of the atmosphere. After traversing the atmosphere, a square meter of the earth's surface can receive as much as 1 kW of solar power, averaging to about 0.5 over all hours of daylight. The huge energy resource from the sun is available for about 26% of the day (Muhammad, 2012).

Solar energy can provide a cheap and abundant energy for communities whose connection to the utility grid may not be economical due to their remote physical location from the nearest

Figure 2. Nigerian water ways

Source: SAFTY4SEA

Table 9: Small hydropower potentials in Nigeria

State (Pre 1980)	River basin	Total sites	Hydropower potential Developed (MW)	Undeveloped (MW)	Total capacity (MW)
Sokoto	Sokoto-Rima	22	8.0	22.6	30.6
Katsina	Sokoto-Rima	11		8.0	8.0
Niger	Niger	30		117.6	117.6
Kaduna	Niger	19		59.2	59.2
Kwara	Niger	12		38.8	38.8
Kano	Hadeija-Jamaare	28	6.0	40.2	46.2
Borno	Chad	28		20.8	20.8
Bauchi	Upper Benue	20		42.6	42.6
Gongola	Upper Benue	38		162.7	162.7
Plateau	Lower Benue	32	18.0	92.4	110.4
Benue	Lower Benue	19		69.2	69.2
Cross Rivers	Cross Rivers	18		28.1	28.1
Total		277	32	702.2	734.2

Source: Sambo, 2009b

Table 10: Small hydropower schemes in existence in Nigeria

River	State	Installed capacity (MW)
Bagel I	Plateau	1
Bagel II	Plateau	2
Ouree	Plateau	2
Kuna	Plateau	8
Lere	Plateau	4
Lere	Plateau	4
Bakalori	Sokoto	3
Tiga	Kano	6
Total		30

Source: Sambo, 2009b

grid connection point. Solar energy is a very good alternative source of energy in rural areas in Nigeria. It aids in the rapid development of small scale industries and reduces rural-urban migration (Ojosu, 1990). Nigeria is located within a high sunshine belt and solar radiation is well distributed. The annual average of the total solar radiation varies from about 25.2 MJ/m^2/day (7.0 kWh/m^2 day) in the northern region to about 12.6 MJ/m^2 day (3.5 kWh/m^2 day) in the southern region. Assuming an arithmetic average of 18.9 MJ/m^3 day (5.3 kWh/m^2 day), then Nigeria has an estimated 17,459,215.2 million MJ/day (17.439 TJ/day) of solar energy falling on its 923,768 km^2 land area. The annual average intensity is 6898.5 MJ/m^2 year or 1934.5 kWh/m^2 year (Oyedepo, 2014).

Since the average sunshine per day is 6.5 h, the annual solar energy value is about 27 times the country's total fossil fuel resource in energy units and is over 115,000 times the electrical power generated (Augustine and Nnabuchi, 2009). This implies that about 3.7% of the land area in Nigeria can collect an amount of solar energy that is equivalent to the conventional energy reserves in the country. This is in agreement with Oji et al. (2012) study where the minimum solar harnessing power in some parts of Nigeria is more than enough to power an average 3-bed room flat and 2-room apartment that make use of low-power consuming appliances. The monthly average of daily sun for 28 states in Nigeria for 25 years are given in Table 11 and the yearly average of daily sun in Nigeria is shown in Figure 3.

The level of solar energy awareness and acceptance has already gain grounds in the northern part of Nigeria as presented in the survey carried out by Shehu (2012). Other studies, surveys and pilot projects have been undertaken by the Sokoto Energy Research Center and the National Center for Energy Research and Development under the supervision of ECN. They have put in place solar PV-water pumping and electrification, solar-thermal installations like solar cooking stoves, crop drying, incubators and chick-brooding.

Table 11: Maximum, minimum and yearly average global solar radiation (kWh/m^2/day)

Stations	Location Lat. 1N	Location Long 1E	Altitude (m)	Max[a]	Min[b]	Monthly average
Abeokuta	7.25	3.42	150	4.819	3.474	4.258
Abuja	9.27	7.03	305	5.899	4.359	5.337
Akure	7.25	5.08	295	5.172	3.811	4.485
Azare	11.8	10.3	380	6.028	5.022	5.571
Bauchi	10.37	9.8	666.5	6.134	4.886	5.714
Beni City	6.32	5.6	77.52	4.615	3.616	4.202
Calabar	4.97	8.35	6.314	4.545	3.324	3.925
Enugu	6.47	7.55	141.5	5.085	3.974	4.539
Ibadan	7.43	3.9	227.23	5.185	3.622	4.616
Ilorin	8.48	4.58	307.3	5.544	4.096	4.979
Jos	9.87	4.97	1285.58	6.536	4.539	5.653
Kaduna	10.6	7.45	645.38	6.107	4.446	5.672
Kano	12.05	8.53	472.14	6.391	5.563	6.003
Katsina	13.02	7.68	517.2	5.855	3.656	4.766
Lagos	6.58	3.33	39.35	5.013	3.771	4.256
Lokoja	7.78	6.74	151.4	5.639	4.68	5.035
Maiduguri	11.85	13.08	383.8	6.754	5.426	6.176
Makurdi	7.73	8.53	112.85	5.656	4.41	5.077
Minna	9.62	6.53	258.64	5.897	4.41	5.427
New Bussa	9.7	4.48	152	5.533	4.15	4.952
Nguru	12.9	10.47	342	8.004	6.326	6.966
Obudu	6.63	9.08	305	5.151	3.375	4.224
Oweri	5.48	7.03	120	4.649	3.684	4.146
Port Harcourt	4.85	7.02	19.55	4.576	3.543	4.023
Serti	7.5	11.3	610	4.727	3.972	4.488
Sokoto	13.02	5.25	350.75	6.29	5.221	5.92
Wari	5.52	5.73	6.1	4.237	3.261	3.748
Yola	9.23	12.47	186.05	6.371	4.974	5.774

[a]Average for the months of March, April and May. [b]Average for the months of July and August. Source: Okoro et al. 2007

However, solar technology has not penetrated deep into the rural areas especially in the off-grid areas that still make use of candle and kerosene lamps for lighting their homes at night. An effective policy should be created to foster the development of solar energy in Nigeria to aid in the reduction of the poverty situation in the rural areas of Nigeria.

7.4. Wind Energy

Wind is a natural phenomenon related to the movement of air masses caused primarily by the different solar heating of the earth's surface. Seasonal variation from the energy received from the sun affects the strength and direction of the wind. The ease with which aero-turbines transform energy in moving air to rotary mechanical energy suggests the use of electrical devices to convert wind energy to electricity. For many years, wind energy has been used for water pumping and milling of grains (Sambo, 2005). Wind energy generation has gained a worldwide recognition and it's the fastest RE market in the world. The global cumulative installed capacity of wind power slowly increased from 6100 MW in 1996 to 158,505 MW in 2009 and it was expected to be over 238 GW by the end of 2014 which will aid in the reduction of GHG emissions (WWEA, 2009). Since 2009, 49 countries have increased their installed capacity while 82 countries are generating electricity from wind energy.

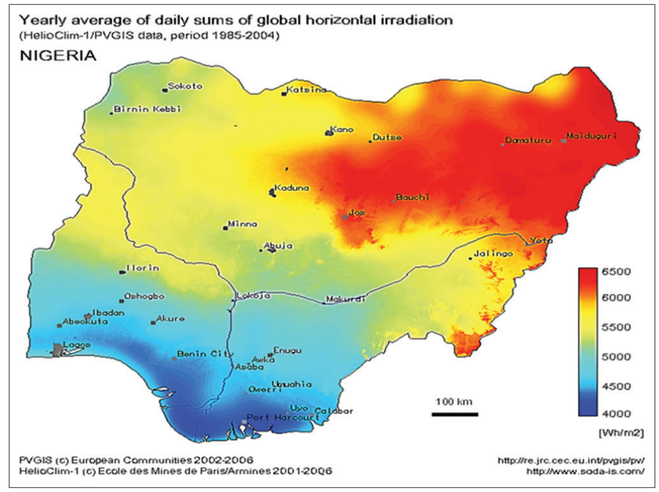
In Africa, Egypt, Morocco and Tunisia were the leading countries in 2009 with installed capacities of 430 MW, 253 MW and 54 MW respectively (Adaramola and Oyewola, 2011). In Nigeria, wind energy reserves at 10m height shows that some sites have wind regime between 1.0 and 5.1 m/s. These wind regimes are classified into four regimes much includes >4.0 m/s; 3.1-4.0 m/s; 2.1-3.0 m/s and 1.0-2.0 m/s. Therefore Nigeria is located in a moderate wind regime. The wind speed in southern Nigeria is relatively poor except for the coastal regions and offshore which is windy and have strong potential for wind energy utilization (Oyedepo, 2014).

According to a study carried out by the ECN (Sambo, 2005b) which showed that the total exploitable wind energy reserves at 10 m height may vary from 8 MWh/year. in Yola to 51 MW/yr. in the mountainous area of Jos, this could reach as high as 97 MWh/year in Sokoto. Besides the study carried out by the ECN, many indigenous researchers have analyzed wind data from various part of the country and these data includes the wind speed and power flux densities. Also the wind energy potential and condition to be met before the wind turbine could be connected to the utility grid was also studied in the literatures.

Adekoya and Adewale (1992) gave potential estimate of wind speeds in ten selected sites within the country. The results were compared with result of the calculated wind speed using climate model Mainz, and it gave a discrepancy of -4.3% to 4.1%, which lies within an acceptable limit of error (Shaaban and Petinrin, 2014). The results are presented in Table 12 and Table 13 gives the estimated gross energy yield while Table 14 shows the estimated wind energy potential of some selected states in Nigeria. Figure 4 shows the wind energy location in Nigeria.

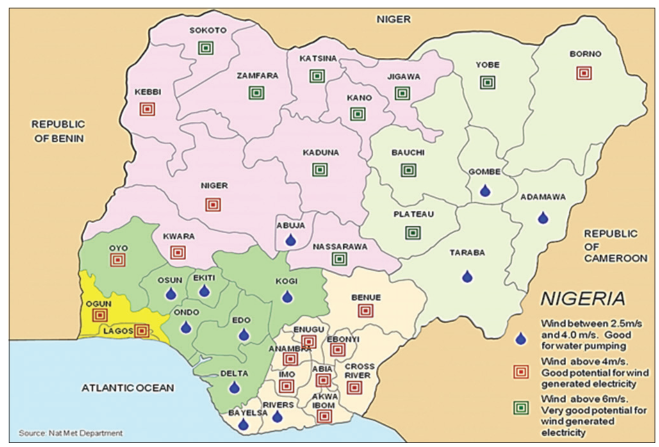
According to Shaaban and Petinrin (2014), if the medium generation capacity of 5 MW/km^2 with (a) d 30% capacity factor and (b) only 1% of effective wind area of the selected states has a potential to generate electricity of about 50,046 MWh/year. The

Figure 3: Yearly average of daily sun in Nigeria



Source: SODA-IS

Figure 4: Wind energy locations in Nigeria



Source: NEENIGERIA

detailed potentials and wind energy densities at 25 m height of the 22 selected states in Nigeria are presented in Table 15.

Currently, there are no commercial wind power plants in the country that is connected to the national grid. The few power plants are the ones installed in the 1960s in 5 northern states and the 5 kW wind electricity conversion system installed in Sayyan Gidan Gada in Sokoto state. However, the latest development in wind energy generation in Nigeria is the installation of wind turbine that is ongoing in Katsina state which is expected to generate 20 MW of electricity when completed. The harnessing of the wind energy potential is too slow; most communities in the northern part of the country are not connected to the electricity grid. The federal government needs to do more in the area of wind power especially in the northern part where the wind speed is high.

8. ENERGY MANAGEMENT

Land, capital, labor and energy are important production factors which require proper management. The cost of energy production could be equivalent to the cost of saving it, so there is need for an

Table 12: Summary of the measured data of annual wind speeds

Site	Land-use type	Altitude (m a.s.l)	Height (m)	Wind speed (m/s)		Differences (%)
				Measured	KLIMM	
Enugu	Complex landscape	466	30	4.6	4.4	−4.3
Jos	Complex landscape	1344	30	5.2	5.1	−1.9
Pankshin	Complex landscape	1355	40	4.9	4.7	−4.1
Sokoto	Plain surface	352	30	5.4	5.2	−3.7
Kano	Plain surface	340	30	4.9	5.1	4.1
Gumel	Plain surface	393	30	4.1	4.2	2.4
Maiduguri	Plain surface	373	30	4.7	4.6	−3
Ibi	River valley	300	30	3.6	3.3	−8.3
Gembu	Highly complex landscape	1800	40	5	5.2	1
Lagos	Coastal area	2	30	4.7	4.9	4.3

Source: Shehu (2012), Adekoya and Adewale (1992)

Table 13: Estimated gross energy yield

Site	Gross energy yield measurement (MWh)		
	Model FL 100, 100/20 Rotor dia. 21.0 m Hub height 34.5 m 100/20	Model FL 250, 250/50 Rotor dia. 29.5 m Hub height 42.0 m 250/50	Model V52, 850/52 Rotor dia. 52.0 m Hub height 44.0 m
Enugu	92.9	217.9	734.20
Jos	129.6	299	1025.80
Pankshin	117.1	272.1	936.60
Sokoto	153.5	358.8	1235.80
Kano	116.3	281.2	963.60
Gumel	73.4	197.2	681.40
Maiduguri	102.7	262.2	906.10
Ibi	49.8	141.3	481.20
Gembu	112.9	253.9	855.30
Lagos	129.3	386.1	1402.80

Source: Shehu (2012), Adekoya and Adewale (1992)

efficient use of energy. In order to improve energy efficiency, we need not to only look at the physical efficiency of the technical equipment and facilities but also the overall economic efficiency of the energy system (Unachukwu, 2003).

The improvement in practices and products that reduces the energy necessary to provide services like heating, cooking, cooling, entertainment, transport, manufacturing etc. is referred to energy efficiency. More work is carried out with energy efficient products that require less energy (Sarah, 2002). Investment in energy efficiency helps militate against GHG emission and aid in the reduction of fossil fuel use.

Sustainable development cannot be achieved without proper energy efficiency. The rapid development and industrialization going on in the world will require proper energy efficiency in order to achieve energy sustainability. In Nigeria, the rate of energy efficiency is very poor; this can be attributed to the high degree of energy loss due to energy wastage. Energy saving has great potential for the three most energy consuming sectors in Nigeria which are the household, transport and industry. The household has the highest amount of energy loss due to the use of inefficient traditional three stone stove with low efficiency of between 5% and 12%. This can be improved by the use of improved fuel wood stoves. Energy can also be saved in the household sector by the switching over from incandescent bulbs to energy saving bulbs because only about 5% out of the total energy is used for light energy; the rest which is 95% is used for heat energy. However, the cost of energy saving bulbs is quiet high in Nigeria and most people especially in the rural area would prefer to buy the cheap N30 to N100 incandescent light bulbs than the N200 energy saving bulbs.

In 2009, the Sustainable Lighting Program in Mexico energized the Mexico Green Policies by replacing over four million incandescent light bulbs with energy saving eco-friendly bulbs. The project was expected to cover more than 11 million families in 2012 (REN21plus). This gesture could be replicated by the Nigerian government to aid in energy efficiency. The indiscriminate use of electricity by urban dwellers is another issue that requires attention. Switching-off electric bulbs and appliances would save both the government and the consumer's money on electrical bills on the side of the consumers and cost of running power plants on the side of the government/electrical utility supplier. The purchase of used or 'Second hand' appliances which consumes much energy needs to be stopped, this practice has been on for a very long time and the government has done nothing in order to stop the influx of this rejected appliances which range from Television to DVD sets.

In the transportation sector, efficiency could also be achieved by placing a ban on the importation of used vehicles (known locally as "Tokunbo") and encourage the use of fuel efficient vehicles. Energy consumption could also be reduced in the Industrial sector by putting off electrical machinery on no-load condition, plugging steam leaks and avoiding material wastages (Oyedepo, 2014). Energy efficiency practice could be achieved in Nigeria if the government creates awareness for the potential and importance of energy efficiency on one hand and facilitate the rapid integration of RE technologies in both household and the national grid.

However, the demand side energy management in Nigeria can be improved by the application of the following steps:

- Ensure the importation of energy efficient vehicles, appliances and machinery.
- Import electric transformers that are strong enough to function when overloaded to accommodate the peculiarities of the Power Sector in Nigeria.

Table 14: Estimated wind energy potentials

Selected State	Area (km²)	Wind area (%)	Effective wind area (km²)	1% area (km²)	Potential capacity (MW)	Potential generation (MWh/year)
Adamawa	37,957	45	170,80	171	854	2244
Bauchi	48,197	50	24,098	241	1204	3166
Borno	72,767	100	72,767	728	3638	9561
Gombe	17,428	100	17,428	174	871	2290
Jigawa	23,415	100	23,415	234	1170	3076
Kaduna	44,217	60	26,530	265	1326	3486
Kano	20,389	90	18,350	184	917	2411
Katsina	23,822	100	23,822	238	1191	3130
Kebbi	36,320	25	9080	91	454	1193
Plateau	26,539	90	23,885	239	1194	3138
Sokoto	32,146	90	28,931	289	1446	3801
Taraba	58,180	40	23,672	237	1183	3110
Yobe	44,880	100	44,880	449	2244	5897
Zamfara	33,667	80 and	26,933	269	1346	3539
Total				3809	19,043	50,046

Source: Shehu (2012), Adekoya and Adewale (1992)

Table 15: Wind energy estimates at 25 m height

Site	Mean wind speed at 25 m level (m/s)	Monthly mean wind energy (KWh)	Annual wind energy (KWh)	Annual wind energy from a wind turbine (KWh)	
				10 m blade diameter	25 m blade diameter
Benin city	2.135	2.32	27.86	2,18.81	13,673.78
Calabar	1.702	1.12	13.42	1.053.69	6587.53
Enugu	3.372	7.83	93.91	7375.75	46,097.96
Ibadan	2.62	4.15	49.78	3909.70	24,436.19
Ilorin	2.078	1.23	14.73	1157.06	7230.57
Jos	4.43	16.05	192.64	15,129.60	94,559.98
Kaduna	3.605	9.91	188.88	936.81	58,355.08
Kano	3.516	8.57	102.86	8078.61	50,491.28
Lagos (Ikeja)	2.671	4.36	52.32	4099.78	25,682.52
Lokoja	2.235	2.6	31.21	4451.23	15,320.17
Maiduguri	3.486	8.42	101.01	7933.61	49,583.17
Mina	1.589	1.05	12.60	989.60	6185.01
Makurdi	2.689	4.44	53.27	4183.51	26,148.85
Nguru	4.259	14.48	173.74	14,645.19	85,284.42
Oshogbo	1.625	1.07	12.81	1006.60	6288.09
Port Harcourt	2.64	4.17	49.98	3925.48	24,533.88
Potiskum	3.636	9.44	113.25	8894.35	55,591.46
Sokoto	4.476	16.47	197.68	15,525.75	97,035.94
Warri	2.027	2.02	24.20	19,00.66	11,879.15
Yelwa	3.36	7.76	93.13	7314.88	45,714.59
Yola	1.824	1.45	17.34	1.361.88	8511.75
Zaria	2.891	5.32	63.88	5,017.26	31,357.02
Total		134.23	1680.50	120, 078.90	790,548.39

Source: Shehu (2012), Adekoya and Adewale (1992)

- Intensify Research and Development (R and D) efforts in increasing local content materials in the design and construction of energy efficient buildings.
- Develop and implement an equipment power labelling programme.
- Put in place measures to cut down on electricity transmission and distribution losses.
- Adopt a tariff structure and other schemes which promote demand and supply side management of electricity consumption.
- Embark on studies that deal with supply side management and demand side management for the power sector to reduce electricity loss.
- Educate the public on the benefits of energy efficiency.

9. OVERVIEW OF THE NIGERIAN ENERGY POLICY

Energy policy is the manner in which a country uses in addressing the issue of energy development and this includes energy production, distribution and consumption. The aspect of energy policy may include legislation, incentives to investment, guidelines for energy conversion, international treaties, taxation and other public policy techniques. It is important for a country to create a comprehensive and coherent energy policy in order to achieve an efficient utilization of its energy resources. However, the creation of an energy policy does not guarantee the proper utilization of a country's energy resources. Before the Federal Government of Nigeria approved the energy policy in the year 2003, there was no comprehensive energy policy. The established energy policy was called the National Energy Policy (NEP) which was developed by the ECN. The NEP sets out government policy on the production, supply and consumption of energy reflecting the perspective of its overall needs and options.

The main goal of the policy is to create energy security through a robust energy supply mix by diversifying the energy supply and energy carriers based on the principle of "an energy economy in which modern RE increases its share of energy consumed and provides affordable access to energy throughout Nigeria, thus contributing to sustainable development and environmental conservation" (NEP, 2006). Importantly, the national policy already outlines the key elements for development and application of RE as:

- To promote decentralized energy supply, especially in rural areas, based on RE resources
- To develop, promote and harness RE resources of the country and incorporate all viable ones into the national energy mix
- To promote efficient methods in the use of biomass energy resources
- To de-emphasize and discourage the use of wood as fuel
- To keep abreast of international developments in RE technologies and applications.

In an effort to translate the RE component of the NEP into an actionable plan, the ECN in 2005 developed the RE Master Plan (REMP) to complement the NEP, which reiterated the government's pledge to support the development, demonstration and implementation of RE sources for both small and large applications. To create the appropriate enabling environment for the promotion of RE, the REMP identified the need for appropriate financial and legal instruments, technology development, awareness raising, capacity building and education as the strategic areas to be paid attention and further sets specific goals for each of those areas. The REMP aims at a 10% RE contribution to the national energy mix by 2020 through the adoption of a renewable portfolio standard (RPS).

A RPS is a requirement for electric utilities to supply a specific amount of electricity to customers. This can be achieved through the purchase of RE certificates (REC) from suppliers with a larger share of renewables in their energy mix. Other measures considered are the creation of innovative fiscal and market incentives to grow RE industries, as well as preferential customs duty exemptions for imported RE technology components.

However, the lack of implementation of the master plan has meant that the 10% target of RE mix in the energy supply cannot be achieved. The REMP is presently being subjected to a review, likely resulting in the setting of new targets. It will be essential that any future targets set for the attainment of a RE energy mix should be backed by legislation to ensure compliance, which is presently lacking. The National Policy and Guidelines on Renewable Electricity was introduced in 2006 with the main aim to expand the market for renewable electricity by 5% of the total electricity generation by 2016. The strategy for achieving this target includes: encouraging local manufacture and assembly of RE components, provision of subsidies, and establishment of technical standards for RE components and introduction of feed-in-tariffs (FiTs). The strategy is yet to be fully adopted as the reforms in the energy sector are still ongoing and decisions on tariffs and subsidies for RE and other incentives have not yet been taken.

The National Energy Master Plan developed by the ECN in 2006 acknowledged the imminent dangers of the fossil fuel driven economy, its global environmental concerns and the expediency of adopting a less carbon intensive and environmentally friendly development pathway, and recommended urgent action to diversify the economy and create a sustainable energy supply mix.

A National Gas Master Plan of 2008 envisages a wholesale transition to decentralized privately held electricity generation gas plants from the erstwhile public power utility. The plan also aims to stem the huge waste associated with gas flaring and to put to more productive use the nation's large gas reserves. What the Gas Master Plan does not clearly mention is that the utilization of compressed natural gas can play a major role in transforming the nation's transportation sector if adopted on a large scale. Clear benefits are evident, for example in the Lagos State Bus Rapid System, which recorded a 13% reduction in CO2 and 20% in other GHG emissions.

The Nigerian Atomic Energy Commission was established to explore Nigeria's nuclear energy potentials for peaceful purposes. Given the expected expansion of electricity demands by the growing population, the ECN has called for an activation of a Nigerian nuclear programme and the Nigerian Atomic Energy Commission is already undertaking preliminary steps. This is however curious when considered against the background that the Vision 2020 does not include atomic energy in its proposed energy mix. After the nuclear accident in Fukushima, Japan, and given the long-term huge costs of producing atomic power, pursuing the nuclear path seems like an outdated strategy. Even though nuclear is said to contribute 16% of global electricity, high cost and liabilities, major safety and waste management issues, exacerbated by the weak regulatory environment, make nuclear energy less attractive for the timely provision of energy access to the poor. Unsurprisingly, countries like Germany are gradually abandoning nuclear energy (Vincent and Yusuf, 2014). A summary of the various energy forms and policies are given in Table 16.

10. EFFECTIVE STRATEGIES AND ENERGY POLICY

In order to overcome energy poverty in Nigeria, access to modern energy must be provided. Energy poverty is not only in the rural areas but also in the urban areas. The following proposed strategy and energy policies may help in the alleviation of energy poverty in Nigeria.

10.1. Energy Efficiency

Energy efficiency is the technological solution for the reduction of energy loss in an existing system. In other words, it is an improvement in the practices and product which aids in the

Table 16: Energy forms and policies

Energy form	Polices
Natural gas	Utilize the nation's natural gas reserves into the energy mix More gas exploration Eliminate flaring by 2008 Encourage privatization
Oil	Increase refining capacity Endorse exploration looking for more oil reserves Derive more economic benefit from oil reserves Privatize the oil industry
Goal	Resuscitation of coal industry for export in an environmentally friendly manner
Tar Sands	Encourage tar sands exploration driven by the private sector Extract oil from tar sands
Nuclear	Pursue nuclear as part of energy mix
Hydropower	Fully harness the hydropower potential (in particular small- scale) through environmentally friendly means and through the private sector Promoting rural electrification through SHP
Solar	Help develop the capabilities to utilize solar energy
Wind	Help develop the capabilities to utilize wind energy
Hydrogen	Help develop local production capabilities for hydrogen energy
Biomass	Promote biomass as an alternative energy source
Fuelwood	Promote the use of alternative energy source to fuelwood De-emphasize fuelwood as part of the nation's energy mix
Other REs	Will remain interested in other emerging energy sources

Source: Kennedy-Darling et al. 2008

reduction of energy use but still provide the same amount of service or useful output (Patterson, 1996). Investment in energy efficiency comes with long term benefits, such as a reduced energy consumption, local environmental enhancement and overall economic development.

Energy efficiency is crucial for a sustainable development in Nigeria and around the world. As earlier discussed (Section 8), the level of energy efficiency in Nigeria is unacceptable. The three sectors in Nigeria: household, transport and industrial sectors need to employ modern practice of energy efficiency. The federal government has to initiate policies that can checkmate the lack of proper energy usage that has cost the nation a lot of money.

According to the IEA, improved energy efficiency in buildings, industrial processes and transportation could reduce the world's energy needs in 2050 by one third, and help in the control of GHG emission (Prindle et al., 2007). If the level of energy efficiency in Nigeria improves, then the government can channel the funds for building new power station to other sectors of the economy that requires development. Even at the current electricity generation which is less than 5000 MW can still serve the country if the practice of energy efficiency is absorbed be the citizens of Nigeria. This is possible because energy will be saved in one part of the county and can be used to service another part.

On the issue of rapid deforestation due to inefficient utilization of fuel wood (or firewood as it's locally called), the ECN should do more in commercializing the three-stone stove which has improved efficiency. Also, the solar stove should be made more affordable for the rural dwellers so that there can be a reduction in the amount of fuel wood consumption to ensure energy sustainability.

10.2. FiTs

FiTs is a scheme used by the government of a country to improve the development of RE. FiTs provides incentives for small domestic and business renewables. The incentives are given depending on the technology, size of installation, kWh generated and quality of resource (Klein et al. 2007). There has been a rapid increase in RE FiTs around the world recently with about 65 countries implementing on form of FiTs as of 2012 (Couture and Gagnon, 2010). This resulted in the installation of 87% photovoltaic capacity and 64% of global wind installation (Nganga, 2012).

In Africa, Algeria, Egypt, Kenya, Mauritius, Rwanda, South Africa and Tanzania have already implemented the FiTs, while Botswana, Ethiopia, Ghana, Namibia and Nigeria are still in the developmental stage of establishing FiTs. The FiTs will improve the present state of RE in the country. Home owners, industries and various communities will be encouraged to generate and sell electricity from the RE source to the national grid. FiTs can create a potential source of income for the poor rural dwellers as well as the low income earners in the urban areas. However, its successful implementation depends on the support of the government, civil society and private investors. Thus, more effort needs to be put in place to ensure that FiTs become a reality just like other African countries that are presently using the scheme. Funds coming from the Subsidy Re-Investment and Empowerment Program could be used for payment of FiTs.

10.3. REC, RPS and Renewable Obligation (RO)

Besides the RES, the RPS and RO are alike in the sense that the government sets a percentage of electricity to be generated from RE source, assigns an actor like electricity consumers and suppliers to meet a specified percentage or be penalized if the percentage is not achieved. In RES, the consumers and electricity supplies trade RE consumption or production credits in order to meet the goals of RPS. A standardized certificate is given which proves that the energy from RE source. This certificate also contains the rules for trading that separate renewable attributes from the associated physical energy. This will enable a proper market for RE to be created independent of actual electricity sales and flows.

If these various mechanisms (REC, RES and RO) are adopted and implemented in Nigeria, there will be an improvement in the application of RE which will in turn reduce the much dependence on fossil fuel.

10.4. Decentralized Energy System

RE has the potential of providing uninterrupted clean energy in the rural and sub-urban areas which have no connection to the utility grid. Decentralized energy system includes portable solar lanterns and home PV systems, mini and micro hydropower, small wind turbines and large wind farms. These systems beside large wind farms do not require costly transmission lines. The energy from the decentralized systems could be shared within various household in the rural communities to help them meet their energy needs like lighting. Moreover, large companies or small firms could replicate these renewable technologies and hence ensure sustainability.

10.5. Energy Mix

The rate of rapid industrialization coupled with the high demand for energy by both the household and transport sector cannot depend on the current energy mix in Nigeria. The generating stations in Nigeria which consist of thermal and hydropower station (Table 4) is not enough to satisfy the country's energy demand.

The government needs to keep up with the changing times and build wind farms and solar farms in areas of their respective high potential within the country. These should be integrated into the national grid in order to improve energy supply and diversify the energy mix with various options. Biomass and SHP should be established in rural communities since the potentials are high in the rural areas. These will reduce the hardship caused by lack of clean energy in the rural areas.

10.6. Provision of More Funds for the Energy Sector

The power sector or energy sector is a capital intensive sector and requires a lot of funds for the set-up and operation. The government should allocate more funds to the energy sector since it's the backbone of the country's economic development. A public private partnership should be established in order to raise funds. The government should also do more to invite foreign investors into the energy sector as Nigeria is now the fastest growing economy in Africa.

10.7. Integration between the Power Sector and Oil Companies

It is important for the government to establish more integration between the electricity sector and the oil companies in Nigeria. This will strengthen the market linkages between the two sectors such that associated gas produced by the companies will be demanded more locally to generate electricity instead of flaring it. This will reduce the level of the gas being flared in the country which in turn benefit the environment and also increase electricity generation.

10.8. Research and Development

The current state of research and development (R and D) is still in its infant stage. Very few centers apart from the ECN are carrying out R and D in the field of RE. The area of energy efficiency has seen absolutely no R and D effort. Hence, the government and concerned private companies needs to intensify efforts in the establishment of more R and D centers while strengthen the existing ones on ground. This will enable technology transfer and home-base commercialization of RE technologies.

10.9. Standards Development for Renewables

The government should ensure that the Standard Organization of Nigeria (SON) adopt or create standards that will check the influx of poor quality renewables into the country. This has discouraged some potential consumers from purchasing RE products such as solar panels, inverters, and energy saving systems. Some standards that could be adopted by the SON are provided in Emodi et al. (2014).

10.10. Electricity Grid Enhancement and Security

The national utility grid needs a lot of enhancement in order to adjust the demands of the current times. Most of the current grid enhancement include; Phasor Measurement Units, strain gauge, infrared sensors, magnetic sensors, accelerometers. Others are Flexible Alternating Current Transmission Systems, Frequency Support Ancillary Service. On the issue of security, the Nigerian government should do more to ensure security of fuel for the various power stations in the country. This can be achieved by channeling associated gasses that are been flared by oil companies to the power plants or the government should ensure that power plants (gas electricity generation plant) are built close to where these oil companies operate (Emodi and Yusuf, 2015).

11. CONCLUSION

It is fairly settled in the literature that energy poverty can only be overcome by a sustainable energy development. For a sustainable energy development to be achieved there needs to be an efficient, reliable and decentralized energy system in the economy which is based on a clean energy source. There is a nexus or linkage between energy efficiency and RE; these are the two pillars and foundation for sustainable energy. Nigeria is blessed with abundant energy resources which include both fossil fuel and RE resources. The country's inefficient utilization of its resources has led to the energy poverty situation currently experienced in Nigeria.

Most of the populace lives in the rural areas which are located quite far off from the electricity grid. This has caused the rural dwellers to depend heavily on fuel wood for cooking using inefficient cooking stoves and expensive or scarce petrol for their electricity needs. The urban dwellers also experience energy poverty because they lack proper energy management practice.

This study is advocating for the proper utilization of the RE resources as well as improving energy efficiency in Nigeria in order to close the gap between energy supply and demand. The country's current energy situation, consumption pattern, RE potentials and their application were elaborated in this study. It was discovered that many government policies on RE development lack proper implementation and there is no energy efficiency policy that has been initiated.

The government needs to diversify the energy mix in the country by integrating RE into the energy mix, adopt the mechanisms which promote RE development and set up policies that will ensure proper energy efficiency within the country. This will ensure that the energy poverty situation in the country is overcome and the Nigerian energy market is elevated to international standards in access, quality, quantity and reliability. Also, one of the top government priority which is the "Vision 2020" that seeks to put Nigeria as one of the top 20 economies in the world by 2020 will be achieved.

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