

# Development of Renewable Energy Resources for Sustainable Energy Use in Nigeria

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## ABSTRACT

This review examines the potentials of renewable energy resources in Nigeria which is aimed at reducing dependence on the carbon-based energy sources. The theoretical and technical potentials of renewable energy resources (solar radiation, biogas, wind, and hydropower energy) indicated that Nigeria has strong potential of meeting energy demand for agricultural, domestic and industrial without relying on fossil fuel. An average daily solar radiation (Rs) and wind energy of 12.1MJ/m<sup>2</sup> to 28.5 MJ/m<sup>2</sup>, 3.3 m/s to 7.0 m/s in the coastal to the northern part of the country could generate 427,000MW, hydropower, biogas and wind energy were estimated to have energy potentials of 11,000MW and 6.6 million (m<sup>3</sup>) of biogas daily. The CO<sub>2</sub> emits from renewable energy source is very low when compared with the conventional energy source and this makes it to be environmentally and human friendly. The current energy stress in Nigeria can be improved by formulating robust energy-based policies and researches capable of achieving some level of renewable energy development. Thus, strong intership between the developed world where lot of discoveries and breakthrough had made on the subject matter and developing is greatly encouraged.

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**Key words:** *Potential, Renewable energy resources, CO<sub>2</sub>, Convectonal energy, Energy demand and Policies*



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## Introduction

This development results to moving towards alternative energy sources which are environmentally-friendly, cost effective, transportable and sustainable without health hazard.

Energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation [1]. Socio-economic development of any nation depends on accessibility and affordability of meeting required clean, modern and sustainable energy supply. However, energy from fossil fuel is non-renewable, depleting and major source of greenhouse emission which causes ozone layer depletion and leads to climate change. Population increase in Nigeria put pressure on demand energy at 28.4% annually [5]. The current global energy problem can be attributed to insufficient fossil fuel supplies and excessive greenhouse gas emissions resulting from increasing fossil fuel consumption [2]. Now carbon emission, greenhouse emissions are serious issues for environment pollution and climate change that have been forefront to the global community [3]. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly [1].

Security, climate change, and public health are closely interrelated with energy [4]. Today's development in the advanced countries has resulted in global climate change and massive environmental damage [5]. Many programs have already been initiated throughout the world in order to reduce GHG emission, which enhances mainly the utilization of renewable energy technologies [6]. The energy crisis, which has engulfed Nigeria for almost two decades, has been enormous and has largely contributed to the incidence of poverty by paralyzing industrial and commercial activities during this period [7]. Conversely, a lack of access to energy contributes to poverty and deprivation and can contribute to the economic decline. Energy and poverty reduction are not only closely connected with each other, but also with the socioeconomic development, which involves productivity, income growth, education, and health [8].

An estimated 60-70% of the Nigerian population does not have access to electricity. Energy demand in Nigeria is dominated by fuelwood and women and children are the most affected in the energy crisis.

The country has huge renewable energy (Solar, biogas, wind, hydro etc.) potentials because of its geophysical condition. Ikuponisi [9] estimated the technical potential of solar energy in Nigeria with a 5% device conversion efficiency

put at  $15.0 \times 10^{14}$  kJ of useful energy annually. This theoretical potential represents more energy striking the earth's surface in one and a half hours (480 EJ) than worldwide energy consumption in the year 2001 from all sources combined (430 EJ) [10].

Chiemaka and Chineke [11] show that Nigeria receives abundant solar energy that can be usefully harnessed with an annual average daily solar radiation of about 5.25 kW h/m<sup>2</sup>/day. The sun is the most readily and widely available renewable energy source capable of meeting the energy needs of whole world.

The general objective of this paper focuses on the review of present energy situation of the nation in a view to exploring strong mechanism of improving energy supply by moving towards clean, reliable and sustainable energy provision. This is expected to reduce greenhouse gases and increase wealth creation through the supply of energy to the teeming urban and rural population for economic development and growth

### **Overview of Nigeria and global energy situation**

As a country's population grows and its economy expands its demand for electrical energy multiplies. If this demand is not met adequately a shortage in supply occurs. This shortage can assume crisis proportions [13]. According to Seccp [14] electric power as a major component in the requirements for effective industrialization and development is grossly inadequate in Nigeria. The Nigerian economy can be disaggregated into industry, transport, commercial, household, and agricultural sectors, with the household sector dominating energy consumption [15]. The energy consuming activities in the house-hold sector still remain mainly cooking, lighting, and operations of electrical appliances (i.e., non-substitutable electricity). It is still pertinent to note that our energy consumption is projected to grow geometrically while our ability to sustain our growth through energy generation, transmission and distribution continues to dwindle [16; 17; 18; 19]. Among the renewable sources, large hydropower all over the world plays an important role (approximately 80%) and contributes around 20% of the total energy generation [17]. But the use of hydropower is no longer increasing due to environmental limits throughout the world [18]. Hydropower is the largest (17%) renewable resource used for electricity generation. More than 150 countries are producing hydroelectricity by constructing dams [17; 18; 19]. Nepal, India and China have a huge potential in hydropower generation. Among them, Nepal and India have economically exploitable hydropower potential of 84,000 MW and 34,000 MW respectively [20;21] Moreover, China has already installed a massive hydroelectric project known as Three Gorges Dam with an installed capacity of 18,000 MW and also plans to install larger plants in the near future [22]. Many developed countries including some developing countries are adopting large scale investment in Renewable Energy Technologies [RETs] since the global reserve of non-renewable sources like petroleum, gas, coal etc. gets reduced. Global renewable energy (wind power, solar hot water, geothermal heating, and off-grid solar PV capacity) increased at a rate of 15-30 percent annually during the period 2002-2006 [17]. UN predicts that 50% of the world's population now live in cities and this figure will be 60% in 2030. Over 75% of energy consumption is directly related to cities and per capita energy consumption is increasing fast in many cities especially in the developing countries [23]. Grid-connected solar photovoltaic(PV) is a growing technology in developed nations ( Japan, Germany, United States) of the world[22]. The average annual growth of PV market over the last 15 years is 30 percent. Table 1 shows World Energy generation, supply, consumption and CO<sub>2</sub> increasing trend from 1973 to 2006. Nigeria's primary energy consumption was about 108 Mtoe in 2011[13]. Most of the energy comes from traditional biomass and waste, which account for 83% of total primary consumption. The rest is from fossil fuels (16%) and hydropower (1% ) [7]. Nigeria has oil reserves of about 35 billion barrels ( $5.6 \times 10^9$  m<sup>3</sup>) and gas reserves of about 5 trillion cubic metres, ranking 10th and 9th in the world, respectively. Global production in 2009 reached 29 billion barrels ( $4.6 \times 10^9$  m<sup>3</sup>) of oil and 3 trillion cubic meters of natural gas [1]. The energy capacity in table 2 shows that Nigeria has strong energy potentials to meet the present and future energy demands, but the sector has not been fully developed as a result of weak energy policies, lack of political will and deep corruption. If the energy resources from the sun (Solar radiation) and wind are properly harnessed and developed at 50% capacity; this will be sufficient to meet the energy demand in the country by 100% especially in the northern extract of the country.

### **Demand and consumption of energy in Nigeria**

Nigeria is endowed with convectional and renewable energy potentials. Despite the huge energy resources, the country is very far from meeting the energy demand of her populace. The sudden increase in population of Nigeria put high pressure on energy demand for socio-economic development. Population is a major driver of energy demand but its most important determinant is the level of economic activity and its structure measured by total Gross Domestic Product (GDP) alongside with its shares by various sectors and sub-sectors of the economy [24]. Global statistics shows that Africa continent has the lowest energy consumption due to its low industrialized level [1]. It has often been stated that if the developing world were to follow the energy profligate example set by some industrialised nations, the global impact would be devastating [25]. The developing nations accuse the industrialised nations of destroying the environment by over-consumption, while the industrialised nations accuse the developing nations of destroying the environment by overpopulation [25]. The African continent accounts for 3% of world energy consumption, the lowest per capita modern energy consumption in the world. In terms of biomass energy consumption, the African continent has the highest share in

the world; 59% of total energy consumed is biomass [26]. There is considerable variation in energy consumption among the different regions and countries in Africa (Table 3). Sub-Sahara Africa continues to rely heavily on biomass and traditional energy sources. This over reliance on traditional energy sources leads to low level of energy efficiency, deforestation and biodiversity loss, greater health hazard due to indoor air pollution and reduced capacity to mitigate climate change [27; 28].

At present, the nominal electricity generating capacity in Nigeria is less than 6000MW and the actual capacity is about half of the installed capacity. Energy demand is dominated by fuel wood; household consume about 95% of fuel wood [29]. Fig.1 shows the energy consumption in Nigeria in 2011. Nigeria is the 7<sup>th</sup> country in terms of proven reserve of natural gas in the world which was estimated to last for over 100 years. Fig.2 shows the natural gas production for 20 years (1992 – 2012) with the highest production of 73,019 mmscm achieved in 2012 [31]. Fig.1 shows the statistics of gas produced, consumed and exported in Nigeria [37].

Nigeria is the largest oil producer in Africa, the world’s eighth largest exporter of crude oil and a member of the Organization of the Petroleum Exporting Countries (OPEC) since 1971 [1]. Nigeria had about 37.2 billion barrels of proven oil reserves as at January, 2011[30; 33; 35]. The total production as at 2010, including lease condensates, natural gas liquids and refinery gain, was averaged slightly above 2.46 million bbl/day. The petroleum and natural gas sector accounted for about 19.39% of the nation’s GDP in 2009. The sector also contributed over 95 and 70% of export earnings and total government revenue, respectively [31; 36; 37]. The situation has changed. Petroleum sector can no longer support the economy as reported in 2009. There is drastic decline in the crude oil demand by mostly the developed world and this brought crude price to an average of \$38 per barrel in 2015 as against \$ 140 per barrel in 2007, 2009, 2011 and earlier 2012. The reduction in crude demand does not only affect Nigeria, but all the oil producing Nations across the globe; this as a result of withdrawal of the developed countries from the use of fossil and concentrating more on the application of clean, renewable and sustainable energy [41; 42; 43]. United States of America (USA) demand for Nigeria crude oil dropped drastically with over 75% in 2015 as it is shown in Fig.4

Table 1: Comparison of World Energy related Data (1973 and 2006)

Category	Year-1973	Year-2006	Percentage Growth(1973-2006)
Primary energy supply	6,115Mtoe	11,741Mtoe	92.00
Final energy consumption	4,672Mtoe	8,804Mtoe	73.03
Electricity generation	6,116TWh	18,930TWh	209.52
Electricity consumption	439Mtoe	1,347Mtoe	206.83
CO <sub>2</sub> emission	15,640Mtoe	28,503Mtoe	79.05

Source: International Energy Agency [47].

Table 2: Nigeria’s energy reserves/capacity December 2005

Resource type	Reserves	Reserves (BTOE)	Reserves (*10 <sup>^7</sup> )
Crude oil	36.2 billion barrels	4.896	20.499
Natural gas	166 trillion SCF <sup>a</sup>	4.465	18.694
Coal and Lignite	2.7 billion tonnes	1.885	7.879
Tar sands	31 billion barrels	4.216	17.652
Of oil equivalent			
Subtotal fossil		15.459	64.724
Hydro-power, large scale	11,000MW		0.0341/Year
Hydropower	3,250MW		0.0101/Year
Fuel Wood	13,091,464La		
Animal Waste	61 million tonnes/Year		
Crop residue	83 million tonnes/Year		
Solar radiation	3.5 to 7.0 KWh/m <sup>2</sup> /day		
Wind	2 to 4 m/s (annual average at 10m in height)		

<sup>a</sup>SCF, standard cubic feet, <sup>b</sup>forest land estimate for 1981, <sup>c</sup>BTOE, Billion tonnes of oil equivalent, Adapted from ECN[40].

Table 3. Energy consumption by type in % in 2001

Region/Country	Biomass	Petroleum	Electricity	Gas
North Africa	4.1	61.5	15.1	1.3
Sub-Sahara Africa	81.2	14.5	2.9	0.5
South Africa	16.5	29.3	25.9	26.8

Source: [27;28].

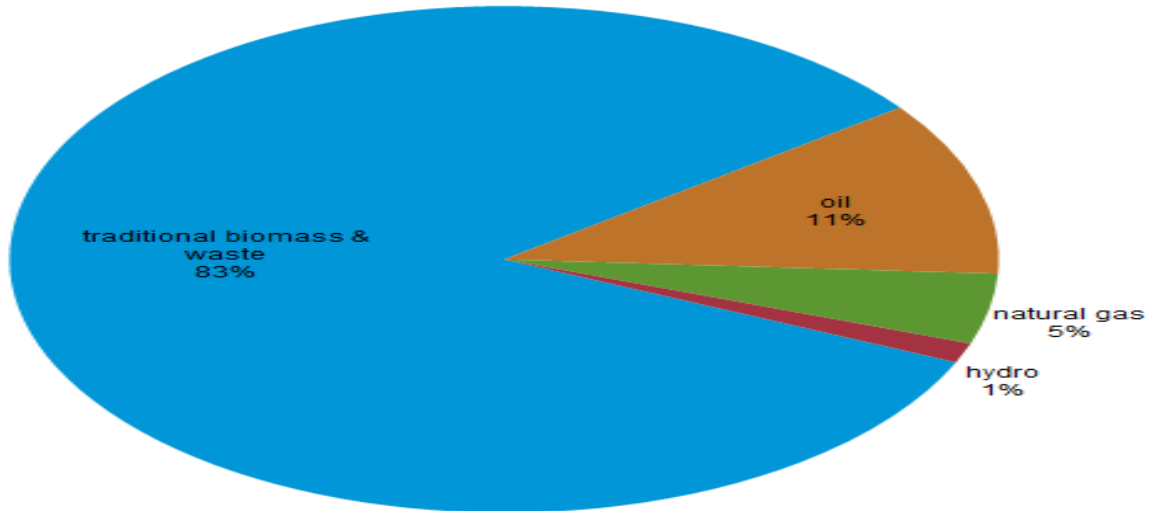


Figure 1: Total primary energy consumption in Nigeria, 2011[49]

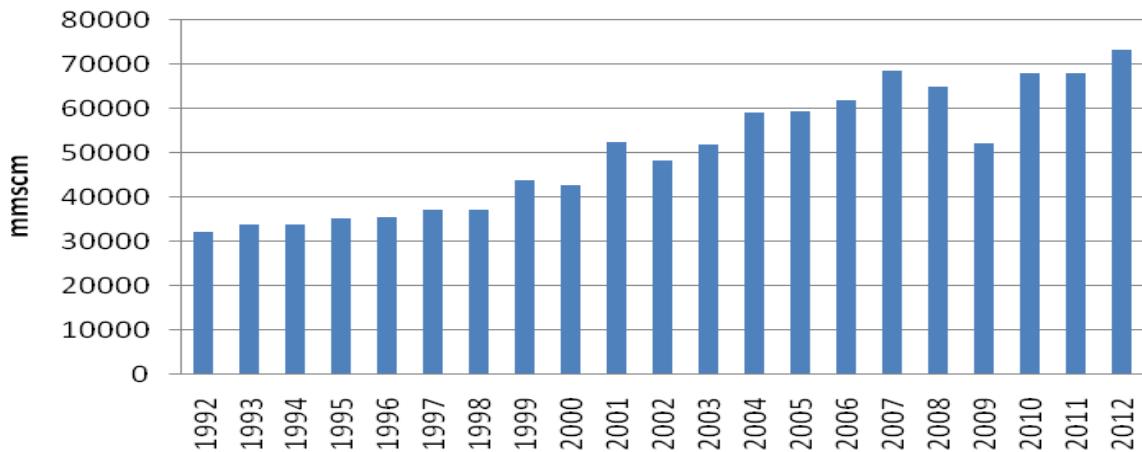


Figure 2: Gas Production in Nigeria [37]

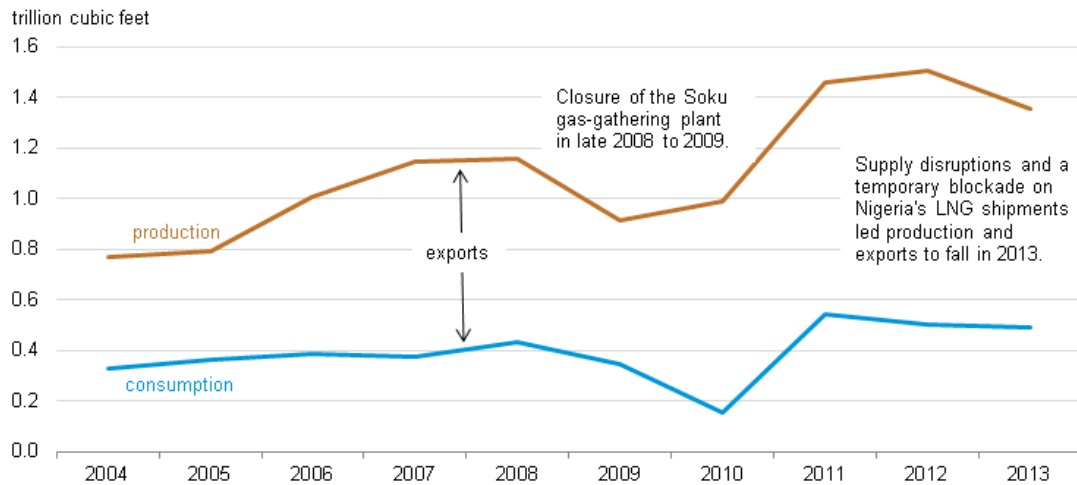


Figure 3 Nigeria's dry gas production and consumption [43]

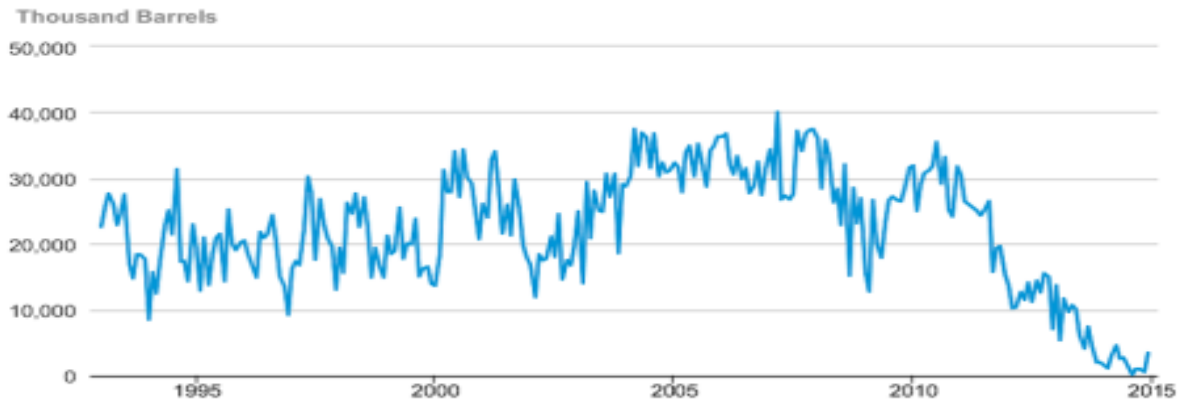


Figure 4. U.S Imports from Nigeria of Crude Oil [44]

### Renewable energy

Reduction of global greenhouse gas emission to seize global warming requires minimizing the use of fossil fuels [32; 43; 44]. The oil and gas energy sector is also the single largest source of greenhouse gas emissions, especially from gas flaring in the Niger Delta region of Nigeria [45]. To achieve this, a large scale use of renewable energies must be made over the globe for production of electrical and thermal energy [32]. World resources of oil, gas, and coal are limited and there is a global concern about this [33]. Renewable energy penetration in Nigeria is still in its nascent stage, the only source of renewable energy in the country is hydro-power and biomass; wind and solar energy have only been deployed in minuscule amount. Solar energy in Nigeria is majorly used in urban areas for street lighting, while in rural areas it is used for irrigation project and water pumping. The country has a target in 2007 to produce 7% of its 2025 energy needs from renewable with solar and hydro as the major priority [46]. Energy development is the effort to provide sufficient primary energy sources and secondary energy forms to fulfil civilization's needs [34]. It involves both installation of established technologies and research and development to create new energy-related technologies.

### Renewable energy and its applications in Nigeria

Renewable energy is energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, air and water heating/cooling, motor fuels, and rural (off-grid) energy services. Renewable energy is one of the means of tackling the global challenges of climate change [35]. Nigeria faces serious energy crisis due to declining electricity generation from domestic power plants which are basically dilapidated, obsolete, and unreliable and in an appalling state of disrepair, reflecting the poor maintenance culture in the country and gross inefficiency of the public utility provider [36]. The recent rapid rise in the growth of solar PV and wind based power generation capacity is not only to gradually replace the conventional power supply system but also to meet the obligations of global climate protection. The developing countries (China, India, and Bangladesh) which are still struggling to produce enough power for their growing industrialization as well as other sectors are focusing on power supplement from the alternative sources [7]. Nigeria has an enormous potential in solar energy, and therefore the installations of small and large-photovoltaic systems can help to reduce its current share of greenhouse gas emission to sustainable level. One family using a typical solar home system can save yearly 290 litres of kerosene by using solar lighting technology and can prevent the emission of 0.76 ton CO<sub>2</sub> per year [46].

### Conclusion

General analysis of energy system in Nigeria shows that the supply of energy is far below what is needed for normal world average consumption of primary energy of 7 kWh per day per person. The situation is further compounded by sudden population increase and socio-economic development. The main energy supply is fossil fuel which is not only depleting but unhealthy. Nigeria has exploited hydropower and commenced the exploiting solar energy, but has not exploited wind energy, bioenergy and geothermal energy despite abundance these renewable resources in Nigeria. Renewable energy is considered a viable solution to the energy challenges of Nigeria especially in the rural areas of the country and to the restrictions posed by the rising cost of conventional or traditional energy. In order to ensure the sustainability of energy supply and socio-economic development of Nigeria, the government has to design, develop and implement strong instrumental policies of renewable energy and energy efficiency system and create strong mechanism with the developed world of dramatically rising installed capacities of renewable energy in the areas of research and human development.

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