



Renewable energy resources for distributed power generation in Nigeria: A review of the potential

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ABSTRACT

Fossil fuels-based conventional grid extension in developing countries from centralized power systems in urban centres to rural areas is usually capital intensive and in most cases not economically realistic. From a global perspective, more than a quarter of the human population experiences an energy crisis, especially those living in the rural areas of developing countries. Among these numerous victims of global energy shortage are the majority of people in sub-Saharan Africa, like Nigeria. More than 80% of Nigerians consistently rely on combustible biomass especially from forest wood and its charcoal derivatives for primary energy consumption amidst a serious shortage of access to modern energy sources. Nigeria has abundant renewable and non-renewable energy resources. While most attention is concentrated on tapping only the traditional bioenergy resources, other renewable energy resources are underexploited. This article reviews comprehensively the potential of four major kinds of renewable energy sources (biomass, solar, wind and hydro) in Nigeria. A total energy potential of 697.15 TJ is estimated from crop residue, 455.80 PJ from animal waste and 442 MW from municipal solid waste in Lagos metropolis alone. The solar radiation in the country ranges from 4 kW h/m² in the south to 7 kW h/m² in the north, which is sufficiently above the threshold average value of 2.3 kW h/m² required for the operation of simple domestic load especially in rural communities. Wind speed in the country varies from 1 m/s in the southern plain to 7.96 m/s far northwest in Katsina State between June and September. Unexploitable hydropower potential of 12,954.2 MW also exists as against the backdrop of 10,000 MW required to raise the socio-economic growth level and alleviate poverty in the country.

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1. Introduction

The objectives of harnessing renewable energy (RE) in developing countries are to focus on provision of sustainable energy to the economically subjugated fraction of the society, combat energy shortage, encourage the development of rural infrastructure and provide clean energy from the perspective of the Kyoto directive towards global decarbonization. This concept of RE has become a fast growing idea in the global power sector. The popularity of RE development can be directly allied to the growing trend of environmental concern and the rapidly depleting reserves of conventional energy resources due to the aggressive utilisation. These emergent concerns call for a viable alternative solution to the contemporary environmental challenges and the energy crisis scenario through sustainable means. There is increasing struggle in the developed and developing countries to make provision for essential services such as electricity to humanity through sustainable development. Sustainable development is a goal that many countries all over the world aspire to achieve [1] to preserve the environment and achieve economic and social development. Realistically, the developing countries of South Asia and sub-Saharan Africa (SSA) are well-known for their over-dependence on traditional energy sources due to poor technological access. However, to achieve sustainable development, there must be an adequate transition to the emerging energy technologies. Nigeria is the most populous country in Africa with over 160 million people but has very limited access to electricity compared to some countries even in SSA despite the presence of huge oil, gas and other energy resources.

Poor access to energy in the country obviously translates into increased poverty, poor economic performance, limited employment opportunity and complicated prospects for institutional development. The high growth rate of the population is an indication that the country's energy demand will continue to rise, similar to how the increase in global population and industrial transformation of the 20th century tremendously increased energy demand [2,3]. The energy crisis situation in Nigeria has considerably affected the public users of electricity. This phenomenon has undeniably compelled the majority of households in both rural and urban segments of the country to significantly depend on combustible RE sources especially for domestic heating and cooking. Fuel wood and charcoal are widespread energy sources commonly used in Nigeria and across SSA. Conventional biomass consumption has received little attention in the ongoing biofuel debate, because it is considered unsustainable and primitive [4]. Fig. 1 shows that more of the fuel consumed in Nigeria in 2007 is obtained from fuel wood and kerosene with fuel wood alone running to approximately 70%. Fuel wood is predominantly used by those without the potential to meet the expense of

commercial alternatives [5–23]. A share of electricity consumed was just 0.52% within the same time period. The diminishing access to electricity arising from inadequate supply has resulted in the depletion of the natural biodiversity, human health deterioration, continuous deforestation and land degradation through excessive cutting of trees for domestic energy consumption.

There are several other renewable energy resources (RES) in the country such as wind and solar, which are yet to be exploited. The Nigerian hydropower development is very limited compared to its exploitable potential. The development of solar energy is highly restricted to a few individual homes in urban cities and some public street lighting operations to augment power shortage from the public utility grid. Though there is vast research on the potential of wind power in Nigeria, its development has not attracted attention. This article critically reviews the current potential of RES in Nigeria as well as policy issues and challenges towards decentralized RE generation.

2. Nigerian power sector and its looming crisis

Nigeria is naturally endowed with diverse and sustainable renewable and non-renewable energy resources. The main RES in the country are biomass, wind, solar and hydro with different degrees of sustainable potential. A reserve crude oil deposit of as much as 36 billion barrels and natural gas 187.44 trillion cubic feet was estimated in 2005 (Table 1). Nigeria, being a key member of the Organization of Petroleum Exporting Countries (OPEC), is one of the major oil exporters in the world market today and is ranked the eighth largest producer [25,26].

Table 1
Nigerian energy reserve and capacity (2005) [27].

Source of energy	Estimated reserve
Crude oil	36.5 billion barrels
Natural gas	187.44 trillion cubic feet
Tar sands	30 billion barrels of oil equivalent
Coal and lignite	Over 40 billion tonnes
Large hydropower	11,235 MW
Small hydropower	3500 MW
Fuel wood	13,071,464 ha
Animal wastes	61 million tonnes/yr
Crop residues	83 million tonnes/yr
Solar radiation	3.5–7.5 kW h/m ² /day
Wind	2–4 m/s at 10 m height

Table 2
Energy generation (MW h) by power stations in Nigeria, 2007–2008 [4].

Power station	2007	(%) of total	2008	(%) of total
Kainji	2816,749.70	12.26	2,707,020.00	12.90
Jebba	2750,325.00	11.97	2,794,976.00	13.32
Shiroro	2230,768.00	9.71	2,089,460.00	9.96
Egbin	3636,680.52	15.83	4,528,451.09	21.58
AES	1552,586.28	6.76	1,846,704.40	8.80
Omotosho	147,541.60	0.64	491,324.90	2.34
Afam	1401,159.60	6.10	300,209.60	1.43
Okpai	3294,207.00	14.34	2,708,690.80	12.91
Sapele	490,290	2.13	728,977.00	3.47
Delta	2696,718.60	11.74	1,510,988.00	7.20
Ajaokuta	357,110.00	1.55	995,873.98	4.75
Geregu	1208,341.20	5.26	N/A	N/A
Omoku	348,583.54	1.52	211,752.37	1.01
Rivers	9,976.00	0.04	42,960.00	0.20
NESCO	37,092.16	0.16	23,390.82	0.11
Total	22,978,128.66	100.00	20,980,778.96	100.00

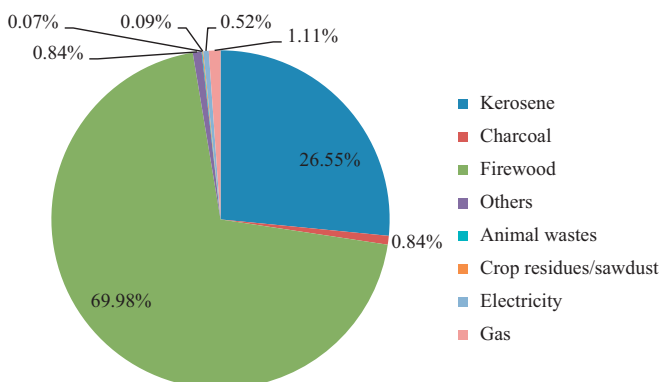


Fig. 1. Shares of energy consumption by source in Nigeria [24].

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