WHAT IS THE POTENTIAL OF RENEWABLE ENERGY SOURCES IN ADDRESSING SECURITY OF ENERGY SUPPLY CONCERN? THE CASE OF NIGERIA

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Abstract:

Nigeria is largely dependent on Oil as the major source of Energy and basis for Government Revenue, this has accentuates its Vulnerability to the repercussion of the imminent Oil depletion. Hence this paper examined individually the potentials of the five (5) major Renewable Energy Sources (Hydro, Wind, Solar, Biomass and Geothermal) and discussed their viable roles as alternative Energy Sources in tackling the Security of Energy Supply concern in the country. From the discussion it was observed that Nigeria has great potentials of Renewable Energy Sources but not effectively utilized, therefore, there is need for an urgent and necessary actions to develop and provide a level playing ground for Renewable Energy Sources to adequately served as a clean alternative Energy sources in the country.

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LIST OF ABBREVIATIONS

Small Hydro Power	(SHP)
Renewable Energies	(REs)
Renewable Energy	(RE)
World Summit on Sustainable Development	(WSSD)
River Basin Authorities	(R.B.A)
Mega Watts	(MW)
Kilo Watts	(KW)
Known Geothermal Resource Areas	(KGRAs)

1. INTRODUCTION:

1.1 BACKGROUND OF THE STUDY:

Renewable Energy (RE) for more than three decades has been one of the most debated and interesting issue due to over consumption, environmental consequences and decline in supply of fossil fuels. This is because Renewable Energies (REs) are considered to be substitutes of fossil fuels and can help mitigate the difficulties presumed to happen when the fossil fuels especially Oil became exhausted. Renewable Energy Sources are receiving a lot of favourable attention with a view to discover its potentials across the countries and subsequently developed its Technology before the scourge of Oil Scarcity reaps the world. Renewable Energy sources can also complement the fossil fuels to accommodate the overwhelming economic expansion in the world, as Thomas, B. J.,(2009) mentioned, "If the world economy expands to meet the aspirations of countries around the globe, energy demand is likely to increase even if strenuous efforts are made to increase the efficiency of energy use. Given adequate support, Renewable Energy Sources can meet much of the growing demand at prices lower than those usually forecast for conventional energy".

Renewable Energy Resources involve the harnessing of natural Energy flows (e.g. Sunlight, Wind, Waves, Falling Water, Ocean Currents and Tides). [1] Unlike fossil fuels, which are exhaustible, renewable energy sources regenerate and can be sustained indefinitely. The five renewable sources used most often are: Solar, Wind, Geothermal, Hydropower, and Biomass. The use of renewable energy is not new. More than Century ago, wood, which is one form of biomass, was the dominant supplier of our energy needs. As the use of coal, petroleum, and natural gas expanded, the World became less reliant on wood as an energy source. Today, we are looking again at renewable sources to find new ways to use them to address the Security of Energy Concern. Security of Energy refers to Reliable, Adequate and Affordable Energy Supply. After the world Summit on Sustainable Development (WSSD) in 2002, most countries intensified efforts in Promoting Renewable Energy Resources in their respective constituencies. [2]

[1] Holdren, J.P., et al, (1980), "Environmental aspects of Renewable Energy Sources" Annual Review Energy 5, 241-291.

[2] One Sky-Canadian Institute of Sustainable Living, (2004);"Status of Renewable Energy In Nigeria" Background Brief for Energetic Solutions, an International Conference on making Renewable Energy a reality, Abuja.

Renewable Energy Sources are clean and environmentally friendly unlike fossil fuels. John, T., and Anthony, D. W., (2006) stated that "Harmful emissions can be classified as chemical (as from fossil fuel and nuclear power plant), physical (including acoustic noise and radioactivity) and Biological (including pathogens); such pollution from energy generation is overwhelming as a result of using 'brown' fuels, fossil and nuclear. In contrast, renewable energy is always extracted from flows of energy already compatible with the environment". Renewable Energy Sources are almost evenly distributed un-like Fossil Fuels, REs can be found almost everywhere, though its abundance and fluctuation varies from one country to another. The highest Scientific and Practical Potentials of Renewable Energy Resources globally have been forecasted to be around $7.04x10^4$ and $3.36x10^4$TWhe per annum respectively by the year 2030.[3]

1.2 Research Question:

Understanding the fact that RE is the only solution or substitute to Oil (though some argue that some of the Fossil Fuels like Coal and Natural Gas may dominate in Future), it is reasonable all countries to ask themselves, What is the Potential of RE Sources within their territories in addressing Security of Energy Supply concern? This paper answers this question with reference only to Nigeria.

1.3 Significance of the Study:

Nigeria as an energy resource rich country and so much rely on oil revenue as the major source of Government Income, still is endowed with abundant REs like Solar, Hydro, Wind, Biomass, Biogas etc. Nigeria also is growing fast in terms of population and demand for energy especially clean Energy. All these coupled with the commitment of the country to tackle the issue of global warming and mitigate the imminent energy scarcities and difficulties make it imperative to explore and developed the available REs in the country, this cannot be achieved until the country had identified the potentials of its RE Sources in addressing the Energy Security Issues, and that is why this paper is written to expose those potentials in order to serve as a conception of

[3] Swisher, J., et al, (1993); "Long-term Strategies for Mitigating Global Warming" Renewable Energy Potential, Energy8(5), 437-459.

knowledge and also as policy recommendation which will help in designing an effective policy framework for the Energy Sector.

1.4 Methodology:

The paper took each RE Source and discussed its potentials in Nigeria. Each source is treated individually, its potentiality is assessed, and level of its utilization and challenges were also discussed using some empirical Literatures. The paper is divided into chapters, chapter one (the current chapter) contains the Introduction where the general background of the study and its significance are highlighted. Chapter two discussed the potentials of various RE sources (individually) in addressing the Energy Security in the country. Chapter three is the conclusion which was followed by Bibliography.

1.5 Limitations:

The Author appreciate the need to expatiate the Technical aspect and requirements in developing the RE sources but due to particular academic restrictions guiding the overall word limit, the content of this work is restricted to theoretical information that provide basis for critical analysis. Moreover, only the most important and common Sources were discussed.

1.6 Findings:

From the discussion of the Paper, it was found that Nigeria has huge potentials of RE Sources, which could be developed effectively to address the issue of Energy Security of Supply. Renewable energy is considered a viable solution to the energy challenges in Nigeria especially in the rural areas of the country and to the restrictions posed by the rising cost of conventional or traditional energy. There is need for a holistic change in the Nigerian Energy Sector, which call for development of effective and feasible policies toward this change. In addition to that, everybody has to pitch-in and Private Investment has to be provided with the level playing ground to complement the government efforts.

2. Potentials of Renewable Energy Sources in Addressing Security of Energy Supply concern in Nigeria:

2.1 Hydro:

Nigeria is blessed in many areas with Rivers, stream and run-off waters of depth ranges from about 1 metre to 25 metres which are suitable for small scale hydro scheme. Small Hydro power (SHP) is a renewable and environmentally friendly Energy Source that can help supplement or substitute other Energy Sources used in Generating Power. It can play a substantial role in making life better for rural and Semi-urban dwellers as well as in the development of cottage industries in Nigeria.

Aliyu and Elegba (1990) indicated that the country is at least reasonably endowed with large Rivers and some few natural falls. The Rivers Niger and Benue with several tributaries constitute the Nigerian River system which offers some potential Renewable Source of Energy for Economically viable Large Hydropower development. In addition several scores of small rivers and streams also exist within the present split of the country into eleven River Basin Authorities (R.B.A), as shown in the following Table. Some of which maintain minimum discharge all the year round.[4] Development of these Rivers into Energy will add immensely to the total power produced at the national grid, and help reduced usage of fossil fuel in power generation. Similarly, it will add to the capacity reserve in case of any supply shortage from gas or any other source of generating electricity.

Table 1: Identified small Hydro Potentials in surveyed states in Nigeria (2004)

S/NO.	STATE	RIVER BASIN	TOTAL SITES	POTENTIAL CAPACITY (MW)
1	Sokoto Katsina	Sokoto-Rima	22	30.6
2	Niger	Sokoto-Rima	11	8.0

[4] Aliyu, U. O., And Elegba, S. B., (1990), "Prospects for Small Hydro Development for Rural Applications in Nigeria" Nigerian Journal for Renewable Energy. Volume 1.

3	Kaduna	Niger	30	117.6
4	Kwara	Niger	19	59.2
5	Kano	Niger	12	38.8
6	Borno	Hadeja-Jama'are	28	46.2
7	Bauchi	Chad	29	20.8
8	Gongola	Upper-Benue	20	42.6
9	Plateau	Upper-Benue	38	162.7
10	Benue	Lower-Benue	32	110.4
11	Cross River	Lower-Benue Cross River	19 18	69.2 28.1

Source: National Energy Commission of Nigeria.[5]

Aliyu and Elegba are of the view that from the classifications of Various Hydro Schemes, the small, mini and micro Hydro Scheme are of specific interest for the task of meeting part of the Energy Requirement of some rural communities as well for the overall Energy Security in the country.

Beside the current efforts of developing some Hydro potentials by the Government (Mambilla Project, with expected generation capacity of 2,600MW daily) there are other Hydro Power potentials which have been observed to be Technically viable for electricity generation. These include: Ikom-7300MW, Lokoja-1,050MW, Zangeru-450MW, Makurdi-1,062MW, Onitsha-1,050MW, Guraram-300MW and Dadinkowa 39MW. Outside the large scale Hydro Potential, some scale Hydro Potential has also been identified, while the small scale Hydro Potential is estimated at 3, 500MW, Nigeria has a huge potential in untapped Hydro Power generation but tapping into it is going to cost a huge sum of money.[6]

Right now, Nigeria has only three Hydro Power stations at Kainji, Jebba, and Shiroro. However, the life span of the Kainji and Shiroro dams is already threatened as Niger Republic is already

[5] Official Website of National Energy Commission, (2009), www.energy.gov.ng: News: Hydro Potential of Nigeria.
[6] Martin, A., (2008), "Harnessing Nigeria's Hydro Power Potentials" Business Day News online; Tuesday, 16 December.

building a dam on the River Niger, this will drastically reduce inflow into the Kainji Lake. There is also an urgent need to develop more Hydro Capacity, but this could be done effectively only through Public-Private Sector Partnership, due to high initial cost. Similarly, uncertainty or fluctuation of inflow of dams due to seasonality and natural dryness could lead to un-reliability of Hydro Power Source. Long time taken before Hydro Power Plants could be developed may also discourage Investment on Hydro Power. But Hydro holds great potentials of contributing to the Energy Supply of the country.

2.2 Wind:

In an attempt to discover Wind Energy Potential in the country, several sites like Enugu, Jos, Ikeja, Abuja, Warri, Sokoto and Calabar which all differ in natural conditions and having different Wind Characteristics were used to show their various wind Speed and it was discovered that the Annual Wind mean speed at a height of 10m above the ground ranges between 2.3m/s to 3..4m/s for sites along the Coastal areas and 3.0m/s to 3.9m/s for high land areas and semi-arid regions. From this analysis, the monthly average Wind Power can be as high as 50.1W/$m^{2.}$ Small Wind Energy conversion systems for pumping water, irrigation and small Agricultural Industries are recommended for small communities living in isolated areas around the selected sites.[7]

It was discovered that the Wind Turbine can generate up to 97MWh per year in Sokoto, a site in a high Wind speed regions. Therefore, using Wind Energy Conversion Systems for electric Power generation and supply in Nigeria-especially around the Sokoto axis will be cost effective and Energy saving. Similarly, after analysis of wind potential of a Town near Jos, it was discovered that the maximum Power intensity which could be extracted from the wind in the area was found to be 14.23W/m^2 out of the estimated available Wind Power intensity of 24.00W/m^2. The amount of Energy density available in the Wind has also been estimated to be 1126.28KWh/year. These results suggest that Heipany, a Town in Jos is an ideal Location for constructing Windmills.[8]

The use of Wind Power for the supply of Electricity broadens the Energy base and reduces environmental Pollution. It is particularly practical if it can be made economically competitive with conventional Energy Sources. The use of Wind Energy will also be suitable for rural farming

[7] Ogbonnaya, I. O., et al. (2003), " Prospect of Wind Energy in Nigeria" an academic Article, University of Nigeria Nsukka, Nigeria

[8] Ezeugwu, D. U., (2004), "Wind Energy Prospect in Developing Economy" B.Eng. Thesis, Department of Electrical Engineering, University of Nigeria, Nsukka.

companies that require lighting and some limited supply of electricity which will be costly to get due to the location of farms. Several researches have shown that in areas with annual mean of Wind speeds of 3.5m/s-4.0m/s or greater, Wind Power system can usually deliver electricity or pump water at costs lower than Photovoltaic, diesels, or grid-extension.[9]

"By using Metrological data collected from some selected weather statistics in Nigeria, analysis of such data shows that Wind Power prospects is high" Ogbonnaya, I. O. et al. (2003). It is understood that coastal and hilly areas are excellent sites for Wind Power development, therefore, all the Excellent sites such as Jos and Sokoto should have a Wind Plant for the generation of electricity which should be integrated with the existing national grid to subdue the probable Energy crisis in the future. However, the development of Wind to power needs a careful consideration as William, H. K, (2005) mentioned in his book "Having someone tell you there is plenty of wind is just not going to work. A wind turbine is a big investment and a careful site study should be conducted before you commit your dollars and time".

2.3 SOLAR:

Nigeria lies within a high sunshine belt and thus has enormous solar energy potentials. The mean annual average of total solar radiation varies from about 3.5 kWhm–2day-1 in the coastal latitudes to about 7kWhm–2day-1 along the semi arid areas in the far North. On the average, the country receives solar radiation at the level of about 19.8MJm –2day-1. Average sunshine hours are estimated at 6hrs per day. Solar radiation is fairly well distributed. The minimum average is about 3.55 kWhm–2day-1 in Katsina (North-West) in January and 3.4 kWhm–2day-1 for Calabar (South-South) in August and the maximum average is 8.0 kWhm–2day-1 for Nguru (North-East) in May. Given an average solar radiation level of about 5.5 kWhm–2day-1, and the prevailing efficiencies of commercial solar-electric generators, then if solar collectors or modules were used to cover 1% of Nigeria's land area of 923,773km2, it is possible to generate 1850x103 GWh of solar electricity per year. This is over one hundred times the current grid electricity consumption level in the country. [10]

[9] Pourk, V., (2002), "Assimilating Wind" IEE Review, pp. 1-9.
[10] Sambo, S. A., (2009), "Strategic Developments in Renewable Energy in Nigeria" journal of International Association for Energy Economics.

Solar thermal applications, for which technologies are already developed in Nigeria, include: solar cooking, solar water heating for industries, hospitals and households, solar evaporative cooling, solar crop drying, solar incubators and solar chick brooding.[11]

Solar electricity in Nigeria may be used for power supply to remote villages and locations not connected to the national grid. It may also be used to generate power for feeding into the national grid. Other areas of application of solar electricity in the country include low and medium power application such as: water pumping, village electrification, rural clinic and schools power supply, vaccine refrigeration, traffic lighting and lighting of road signs, etc. This will help tremendously in tackling Energy supply concern in the country.

2.4 Biomass:

"The biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal waste arising from forestry, agricultural, municipal and industrial activities, as well as, Aquatic biomass" (Garba and Bashir, 2002). It was also defined as "energy derivable from sources of plant origin such as trees, grasses, and agricultural crops and their derivatives, as well as animal wastes" (Sambo, S. A. 2009). The biomass resources of the nation have been estimated to be about 8×10^{2} M.J. Plant biomass can be utilised as fuel for small-scale industries. It could also be fermented by anaerobic bacteria to produce a very versatile and cheap Fuel Gas i.e biogass.[12]

As an energy resource, biomass may be used as solid fuel, or converted via a variety of technologies to liquid or gaseous forms for the generation of electric power, heat or fuel for motive power. Biomass resources are considered renewable as they are naturally occurring and when properly managed, may be harvested without significant depletion. Biomass resources available in the country include: fuel wood, agricultural waste and crop residue, sawdust and wood shavings, animal dung/poultry droppings, industrial effluents/municipal solid waste. [13] If

[11] Energy Commission of Nigeria, (1998), "World Solar Programme, 1996 – 2005", Projects of the Government of Nigeria": Project Documents, ECN Abuja.
[12] Garba, B., and Bashir, A. M., (2002), " Managing Energy Resources in Nigeria": Studies on Energy Consumption Pattern in Selected Rural Areas in Sokoto State. Nigerian Journal of Renewable Energy, Vol. 10 Nos. 1&2, pp. 97-107
[13] Supra Note 11, at 16.

these Biomass resources could be enhanced in terms of its production, development and conversion to Energy, it will help tremendously in addressing the issue of Security of Energy Supply in the country, and it will also reduce the environmental pollution, because fuel made from Biomass could be environmentally friendly.

The availability of biomass resources follows the same pattern as the nation's vegetation. The rain forest in the south generates the highest quantity of woody biomass due to the rainy weather associated to the area while the guinea savannah vegetation of the north central region generates more crop residues than the Sudan and Sahel savannah zones, because the soil of the area is strong and very fertile, the Agricultural crops are harvested only once in a year. Industrial effluent such as sugar cane molasses is located with the processes with which they are associated. Municipal wastes are generated in the high-density urban areas.[14] Table 2 shows the estimated biomass resources in Nigeria. Fuelwood has the highest Energy Value, it is highlighted below:

Resource Quantity	**Energy Value**	**(million tonnes)**
		('000 MJ)
Fuelwood	39.1	531.0
Agro-waste	11.244	147.7
Saw Dust	1.8	31.433
Municipal Solid Waste	4.075	-

Table 2: Biomass Resources and the Estimated Quantities in Nigeria.

Source: Sambo, S. A. (2009);

2.5 **Geothermal:**

Geothermal energy is the natural heat from the earth's interior stored in rocks and water within the earth's crust. The main source of this energy is the constant flow of heat from the earth's interior to the surface. This heat creates the molten rock, or magma, beneath the surface crust.

[14] Report of the Inter-Ministerial Committee on Combating Deforestation and Desertification, August 2000.

Volcanoes, geysers and fumaroles are the visible evidence of the great reservoir of heat, which lies within and beneath the earth's crust. The

Magma heats the surrounding rock structures and when underground water comes into contact with this heat, geothermal fluid is formed. This energy can be extracted by drilling wells to tap concentrations of Steam at high pressures and at depths shallow enough to be economically justifiable. The steam is then led by pipes to drive electricity-generating turbines.[15] Geothermal power exploitation has numerous advantages over other energy sources. Among the benefits of geothermal power are the near zero emissions and the little space required for geothermal power development compared to other energy sources such as coal fired plants.

The widespread rate of geothermal manifestations in Nigeria is considerable because the wide applicability and relative ease of exploitation of geothermal energy is of vital importance to an industrializing nation like Nigeria, it's also important in substituting the dominant fuel which is speculated to decline in future. There are two Known Geothermal Resource Areas (KGRAs) in Nigeria: the Ikogosi Warm Springs of Ondo State and the Wikki Warm Springs of Bauchi State. These areas if developed effectively will provide a sufficient energy to large number of the country's population. Within sedimentary areas, high geothermal gradient trends are identified in the Lagos sub-basin, the Okitipupa ridge, the Auchi-Agbede area of the Benin flank/hinge line, and the Abakaliki anticlinorium. Geothermal gradients indicate that steam would be encountered at a depth of about 6,000 ft (1,800 m) in the Lagos and Auchi-Agbede areas, and at about 4,250 ft (1,300 m) in the Abakaliki area. [16] Therefore, developing these potential geothermal areas, will add to the Nigerian Energy Supply.

[15] Stephen, K., (2003), "Renewable Energy Development" Workshop for African Energy Experts on Operationalizing the NEPAD; Operationalizing the NEPAD Energy Initiative, Novotel, Dakar, Senegal

[16] Olufemi, O. B., (1984), "High-Potential Geothermal Energy Resource Areas of Nigeria and Their Geologic and Geophysical Assessment". *AAPG Bulletin* Volume 68.

3. Conclusion:

Do Renewable Energy Sources possess some prospects to contribute in tackling the Security of Energy Supply worry in Nigeria? This is the question that this paper answered, and it was found that Renewable Energy Sources like Hydro, Wind, Solar, Biomass and Geothermal hold a positive, viable and significant potentials and roles to play in addressing the Security of Energy Supply concern in the country. The paper discussed each Renewable Energy Source and examined its potentiality in addressing the Energy Challenges in the country.

It was observed that Nigeria has abundant RE Sources in all parts of the country but not utilized due to over dependence on Crude Oil, which the government rely heavily as the major Energy Source and basis for its revenue. This exposes the country's vulnerability to Energy Difficulties and Scarcities in future if the presumed depletion of Fossil Fuels especially Oil prove to be real. Subsequently, the country needs to embark on necessary and immediate actions (policy and practical actions) to develop its Renewable Energy Potentials in order to mitigate the imminent negative consequences of Oil depletion. Private investment in Renewable Energy Development should be encouraged through enlightenment of the prospective investors nationally and internationally on the benefits of investing on REs, providing soft Loans to the investors due to the huge initial cost in the development of some of the RE Sources and providing the necessary level playing ground both in the Law and Practice for the investment. Similarly, efforts shall be made to encourage the growing of some of the Renewable Energy Sources, especially Biomass which is the most traditionally utilized Source which has not been replaced in the same quantity as it has been consumed.

Potentials of other Modern Alternative Energy in the country especially nuclear need to be studied, another source which Nigeria has the potential to develop as an alternative Energy source is the Associated Gas which has been flared over the years. An extensive research need to be undertaken on how to effectively develop and utilize them.

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