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Renewable Energy Potentials Across North Eastern Nigeria: A Review

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Abstract: The increasing demand for energy has enhanced the usage and pursuit for whatsoever form of energy. Regrettably, some forms of energy have numerous negative impacts socially, economically and on our physical environment. In addition to that, Nigerian national grid could not provide enough power to the country. This necessitated the hunt for an energy source that is; environmentally friendly, economically viable and socially acceptable. Some of these renewable sources are practicable at individual stage while some require government intervention. North eastern Nigeria been one of the most populous geopolitical zones in Nigeria still believe and rely on hydroelectric power generated by government which is not sufficient. Others rely on petroleum generators which are not friendly (socially and environmentally) and are increasingly becoming costly. This paper highlights the renewable energy potentials of the region based on previous researches. The renewable energy sources reviewed are solar energy, Geothermal energy, Wind energy and Biomass. The advantages and potentials of these sources are discussed. This will help to awaken individuals to energy solutions that require no recurring cost and are environmentally friendly.

Keywords: Renewable Energy, Solar Energy, Geothermal Energy, Biomass, Wind Energy, North Eastern Nigeria

1. Introduction

The activities of humans and other creatures on earth is highly influenced by energy. Energy is what gives us the ability to perform various works. Energy is one of the most important factors that contribute to the development of any nation. Some of the fundamental forms of energy for domestic purposes include electrical, thermal, chemical and mechanical. Each of the mentioned forms of energy can be converted to another form. Thermal can give electrical, electrical can give thermal, mechanical can give electrical, electrical can give mechanical, chemical can give thermal and electrical.

The electrical energy used in north eastern Nigeria is mostly the one generated from hydroelectric power plants and little from petroleum (Diesel and petrol). The heat energy used is generated from burning woods, coal and little from hydrocarbon (cooking gas and kerosene). Each of the mentioned forms of energy in use has its problem.

Economic growth is the major determinant of the power of a nation. Economic growth can only be achieved when there is adequate supply of energy especially electrical energy. The result of economic growth brings about job creation, poverty eradication, security of food, material and soul. Without power, the reverse will be the case. We will get nothing withpoor energy supply apart from deprivation, poverty and

economic decline. Hence any serious nation is required to a matter of urgency pay attention to its economic growth by focusing on its energy potential, supply and exploration. Stable and sufficient power supply contributes to reduction of poverty, Socioeconomic development especially productivity, income growth, health and education.

Nigeria has one of the lowest consumption rates of electricity per capita in Africa [1]. Nigeria with over 170 million people produced around 4,000 MW of electricity whereas Brazil with a similar population generated 24 times as much that of Nigeria [2]. The increasing challenge in power sector makes it necessary to explore all available energy resources (especially sources of renewable energy) to plan a new energy future for Nigeria.

Renewable energy when explored will provide a long term solution to power problem due to its abundance, cost effectiveness (exploration and site setting may be expensive but there is no recurring cost) and importantly been a clean source of energy (less hazardous compared to fossil fuels) [22, 23].

Renewable energy sources in north eastern Nigeria include solar energy, Wind energy and thermal (Geothermal) energy, Biomass. Various studies have been carried out to view their potentials across the area. A review of the previous studies is given in this paper with the aim of harmonizing and figuring out a comprehensive report that with shade more light on the potential of the area.

The present study will contribute to add to the available data and information relating to renewable energy resources in Nigeria with a view to stimulate the government to immediately commence utilizing naturally available resources to generate power for her citizens.

Contributions of this kind are not much in the region. That is why been one of the most populous geopolitical zones in Nigeria still believe and rely on hydroelectric power generated by government which is not sufficient. Others rely on petroleum generators which are not environment friendly and are increasingly becoming costly.

2. The Study Area

The North east Nigeria is one of the six geopolitical zones of Nigeria. It represents the countries north east both geographically and politically. The region covers 1/3 of the country's landmass. The region has majorly two ecological regions namely; the semi- desert in the east and tropical savannah in the west. In terms of population, there are 26 million people which carries 12% of Nigerian population. There are 6 states in the region namely Adamawa, Bauchi, Gombe, Borno, Taraba and Yobe states. Bauchi and Maiduguri are the most populous cities [3].

The geology of the region consists of ancient (Precambrian) crystalline Basement complex rocks represented mainly by granitic and migmatitic rocks [4, 26].

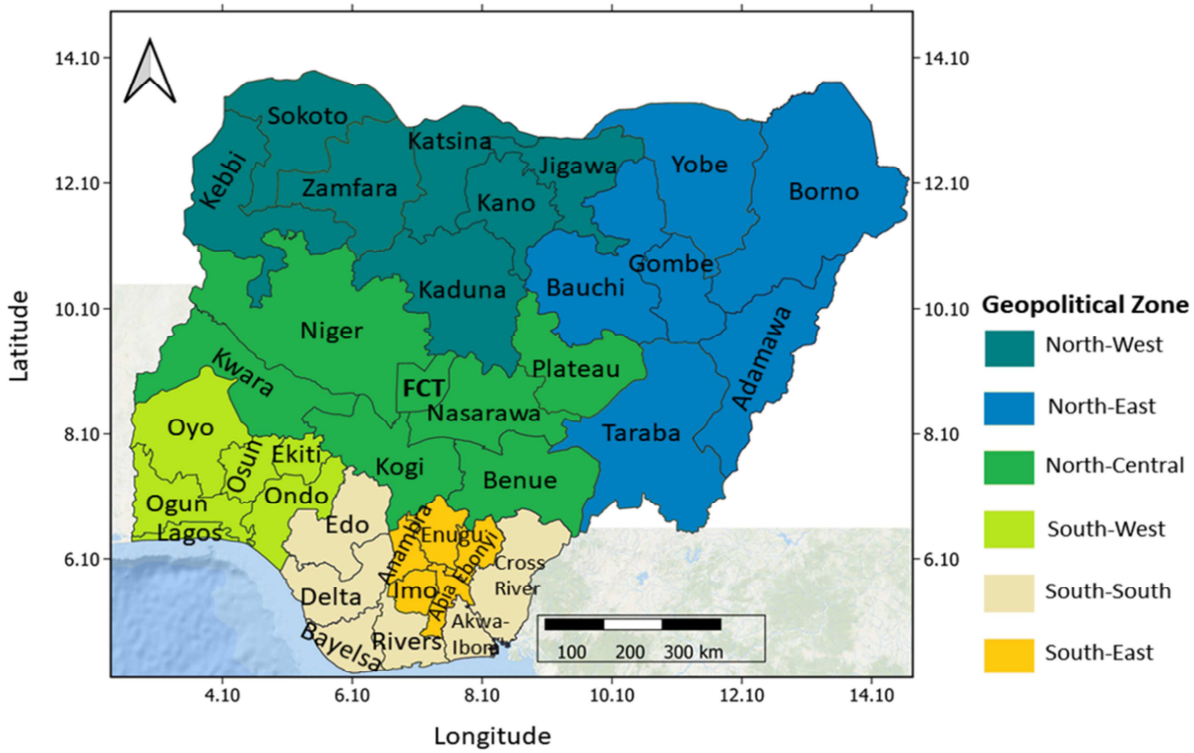

Figure 1. *Nigerian map showing the study area [4].*

3. Geothermal Energy

Geothermal energy is the energy driven from the utility of heat energy in the interior of the earth. The earth's heat engine is driven by cooling of the crust and heating of the lower crust and mantle by thermal decay of radioactive isotopes, thus the deeper below the surface, the hotter the

temperature is. geothermal energy is a clean and sustainable source of energy beneath the surface of about 3982°C, super-hot gas and molten are constantly being replenished [5]. Studies have been carried out across the study area most of which appraised the geothermal energy potential in the north-eastern Nigeria.

Abraham *et al* (2015), appraised the average geothermal gradient of the region around Wikki Warm Spring (WWS) located in Bauchi state using aeromagnetic data of the upper Benue trough was found to be 54.11°C/ 100 K. The result predicted the area as a viable geothermal region [5].

Lawal et al (2018) found the average heat flow in thermally normal continental region as 60m/Wm^2 which is the minimum value for considerable generation of geothermal energy. The values in excess of 80 m/Wm^2 – 100 m/Wm^2 are allied to anomalous geothermal surroundings. The study concluded that the study area can generally be considered as a thermally normal region. The study further recommended northeastern part of the study area with values in excess of 80 m/Wm^2 for further investigation [3].

Okolie et al (2019) reviewed the geothermal energy of the region. The study and subsequent discussions lead to the recommendations of maximising the use of the numerous resources to optimise the process of harvesting Geothermal Renewable Energy. If the Geothermal Energy plans and policies are appropriately instigated, professionals are given free hands to make Geothermal Energy decision, energy crises will become history in Nigeria [6].

Udochukwu (2019) studied the aeromagnetic data of the region. The geothermal gradient indicated that the high heat flow and geothermal gradient in Monguno region of the northeastern Nigeria suggested the presence of geothermal energy in the area [7].

In 2020, interpretation of aeromagnetic dataset over Ruwan Zafi, Adamawa State and environs, Northeastern Nigeria, was carried out in order to map out places with the potentials for application of geothermal energy for electricity generation and geothermal direct heating. Geothermal gradient range between 33.79 and 69.01°C/km and the associated mantle heat flow varies from about 84.48 to 172.53 mW/m^2. The geothermal gradient greater than 48.11°C/km and heat flow greater than 120.26 mW/m^2 in these areas reflect high potentials of the ccurrences of geothermal resources in those places.

Dopamu (2021) carried out regional estimation of geothermal resources of part of the study area (entire Benue Trough, Nigeria) using high resolution aeromagnetic data. The study identified part of Adamawa state as a geothermal zone with a mean geothermal gradient of 26.0°C/km, and average curie-point depth of 23.2 km [8].

4. Wind Energy

The kinetic energy of Wind is a good source of clean energy. Wind exists freely because it is naturally occurring and hence sustainable. The usage of Wind energy is expanding continuously, and will play an imperative role in the future electricity generation. In Nigeria, Wind energy is among the cleanest sources of Renewable energy and is very abundant. Despite its abundance and advantages due to environmental friendliness, it is still least utilized [9].

According to Omorogiuwa Eseosa and Uchechikwu (2019) less than 3.5m/s Wind speed is not sufficient for power generation. Wasiu Olalekan Idris et al. in 2020 investigated the status of the development of Wind energy in Nigeria and appropriately recommended the application and development Wind energy [10].

Andrzej Tywoniuk and Zbigniew Skorupka in 2018 presented energy global demand in terms of Wind power plant efficiency [11].

Researches like that of Kunya and Ahmed (2022) identified smaller wind turbines to have more efficiency than bigger ones when converting wind energy specially in low wind period, [12], this indicated increasing interest on wind energy generation by researchers.

Studies have indicated that northeastern Nigeria have high energy potential when we come to discuss Wind energy. A study by Richard in 2022 reported that Maiduguri, Baga and Gamboru in Borno state and Kumagunnam in Yobe stae which fall in North eastern Nigeria possess high Wind energy potential. Moreover, the Wind speed of Kumagunnam and Gamboru is high around January to march [9].

5. Solar Energy

Solar energy is the energy derived from the sun. The sun is blessed with both heat and light which are both good sources of energy. Solar energy continuously motivates all life systems on earth. Consequently, what influences many phenomena including Wind and air movements which cause Changes in earth's weather and climate is solar energy. Solar energy is yet to be sufficiently employed as energy source in Nigeria even with its abundance Nationwide [27]. In addition to the positive aspects of using sunlight, the photovoltaic system is more efficient, has no critical size and indeed size can be matched to load with little loss in efficiency, can be physically located near the load and are environmentally benign in operation. It is thus one of the most attractive future technologies [27].

Richard and Omorogiuwa (2022) performed a comparative research on solar energy potentials across Nigerian six geo-political zones. The annual electricity that can be generated for Gumel of North-West is found to be 338,463MWh, while Maiduguri, Kumagunnam, Gamboru and Baga of North-East had 158,445MWh, 343,964MWh, 300,927MWh and 317,968MWh respectively. Pankshin and Biu of North-Central had 149,665MWh and 318,416MWh. South-West, South-East and South-South recorded 128,349MWh, 252,174MWh and 230,209MWh. The North-Eastern part of the country is more favourable according to their findings. [13].

Ayigun (2022) accessed the MTN Lumos box solar energy as an alternate electrical power source in Mubi Adamawa State, North Eastern Nigeria. He concluded that the Lumos

box is a good alternative electrical power source to houses, and business places [14].

Ohakwere-Eze *et al.* (2022) provided a preview of the influence of solar energy in a formal setting; to show how solar energy can be the best alternative way of tackling problem of power failure in one of the North Eastern University; to reduce to the barest minimum the power challenges facing the school [24].

6. Biomass

Plants and animal wastes make up Nigeria's biomass assets. Crop production as well as population are continously increasing in the country especially in the North eastern part of the country. Crops as like maize, sorghum, sugarcane, and barley are good sources of biofuels. One of their advantage is that they don't compete for water supplies, property, and crop plant manures the way biodiesel and bioethanol do [25].

These biomasses can be used as feedstocks to produce biofuel in order to complement the energy obtained from other sources [15]. North Eastern part of the country is rich in some of these crops that can be used as biofuels as shown in figure 2. The region is also rich in animal waste because of animal rearing activities that takes place in the area. According to [25], "1kg of animal waste can generate up to 0.03 m^3 of biogas". This reveals the potential of the region in producing biofuel.

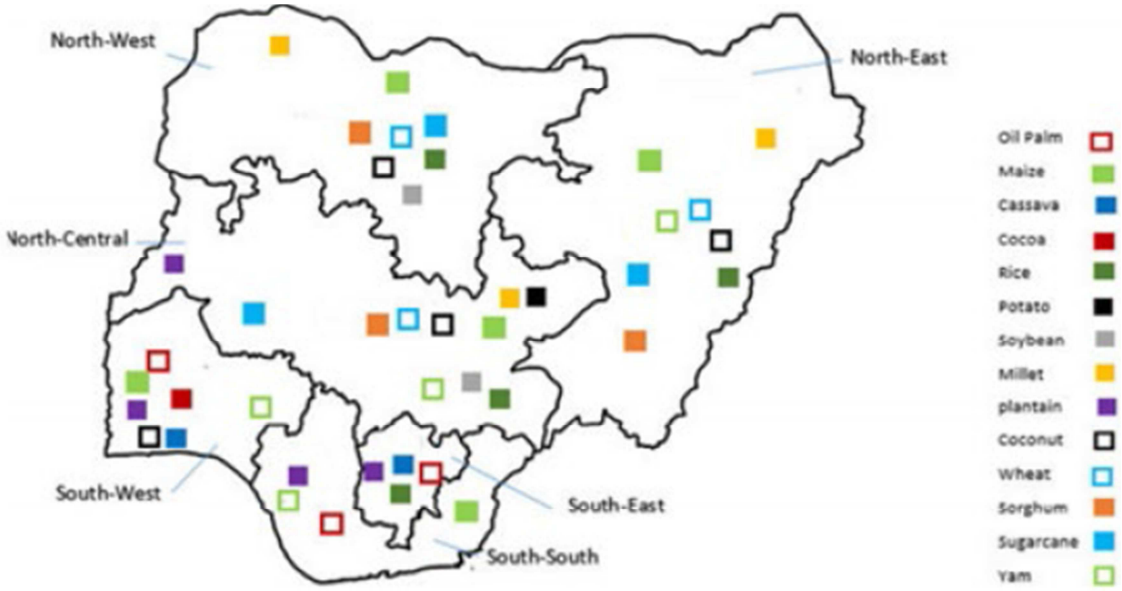

Figure 2. *Agricultural crops cultivated in different regions in Nigeria (Okafor et al. 2022).*

Biofuel production in Nigeria will help to facilitate agricultural development, boost economic activities in the rural areas, encourage the development in the rural areas which will reduce social problems especially in North east were boko haram issues have affected severely.

According to Edeh (2023) It is necessary for Nigerian government to implement and expand the biofuel policy completely as a panacea to the energy-to-feed crises [16].

So many researchers have viewed the potential of Bioenergy in Nigeria [17-19, 16].

Dankawu et al (2022) analysed cow dung and poultry waste to compare their biogas productivity. They concluded that biogas produced from cow dung will contribute more in relieving the growing price of cooking gas and it will also reduce over dependence on firewood that causes deforestation [20].

Ukpanyang and Terrados-Cepeda (2022) Selected some Nigerian cities which include Bauchi state (a north eastern state) to study their potential in production of biofuels. They provided awareness that utility of biomass waste will provide alternative energy source for road users. According to their research, Bauchi with approximately 279,183 Stock of Vehicles has 0.14 Billion kg CO_2 Emissions from Diesel and 0.84 Billion kg CO_2 Emissions from Gasoline. They proposed a gasification model with a post-treatment water–gas shift reaction and absorption process of CO_2 for hydrogen production. The production of hydrogen was maximized at 900°C and 0.8 for the gasification temperature and steam-to-biomass ratio. The produced hydrogen gas is compressed and stored under high pressures of around 700 bar.

According to the finding, 3.21 Billion Liters of Hydrogen Gas was Produced to replaced 0.54 Billion Liters of Diesel and avoided CO_2 Emissions to convert 1.46 Billion kg Diesel Consumption.

In addition to hydrogen utilization in transportation sectors, it can be used to produce ammonia, a crucial feedstock for manufacturing fertilizers in industries. It can also be used to produce methanol and steel. It also provides electricity to the grid or off-grid using fuel cells [21].

Biomass burners are now available for cooking using wood shavings and sawdust as fuels. The use of biomass as a source of energy is presently restricted to heat applications as a fuel for drying of agricultural produce and cooking food.

The animal dung and the dead plants are also used as a source of cooking gas. Implementation of biofuels will reduce the rate of wood burning that influences deforestation which increases toxic gases like CO and CO_2 that in return destroys ozone layer to cause global warming. In addition to that, it also reduces cost.

7. Conclusion

The increasing energy demand has amplified the search for whatever form of energy. Some forms of energy are actually not environmentally, socially and economically friendly. Renewable energies reviewed and discussed in this paper; Solar, Wind, geothermal and Biomass are found to be of high potential in the study area. Considering the energy requirement, current position and renewable energy potentials of the area, we concluded that: the existing energy supply in the area is below its demand, there are opportunities for incredible energy generation from different sources for the nation at both individual and Governmental level.

Competing Interest

The Authors declare that there is no competing interest.

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