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RENEWABLE ENERGY IN NIGERIA - A REVIEW

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ABSTRACT

One of the most important resources of a nation is energy. The significance of energy definitely cannot be overemphasized as it is immensely utilized in our everyday activities as a very germane requirement for survival and robust lifestyle. The amount of energy availability and its usage in a country measures the level of industrialization. Several devices including machines, electronics, household electrical appliances and other domestic equipment and machines, industrial production and processing machines, streetlights for lighting, our vehicles all require energy in various form be it solar, hydro-electric, biogas, gasoline, diesel and the likes to function properly to optimum capacity. However, owing to the stupendous hike in fuel price, increase in electricity charges and the desire to limit the use of fossil fuels and reduce carbon emissions, there have been several human efforts on the pursuit for alternate means of power. This study is aimed at analyzing the range of renewable energy potentials in Nigeria, and how they can ultimately be used for national development.

Key words: Energy, Solar, Wind and Hydroelectric.

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1. INTRODUCTION

Nigeria is known to be the most populous country in the continent of Africa and one of the bonafide members of the United Nations. The achievement of clean energy as part of the seventeen Sustainable Development Goals is the responsibility of every member of the United Nations which Nigeria is a part of. (Giwa et al., 2017 and UN 2015) Lack of sufficient power from the available energy has been part of the causative factors affecting the economic growth of Nigeria. (Brimmo et al., 2017 and Ajayi 2009).

The rate of industrialization of a country is proportional to the amount of energy availability and its utilization. The demand for energy in Nigeria outweighs its supplies. Hence one can say that the level of industrialization in Nigeria demands catalytic force to foster its optimization. Nigeria operates under lower efficiency in the utilization of energy. With direct loss due to energy wasted not put into consideration, energy inefficiency or the underutilization of energy brings about the following drawback to the nation's advancement in Nigeria:

- The investment in certain energy chain supply infrastructure invariably differ in the demand of energy.
- The large level of energy consumption causes more environmental problems and
- As a result of excessive energy consumption in the nation the cost of production of goods is increased especially in the energy intensive companies and industries across Nigeria such as cement, iron and steel, refineries, etc., which in turn influenced the standard of living (Sambo, 2005).

In the course of this study, we considered the renewability aspect of energy resources classification, with concentration majorly on "renewable energy". Energy resources are classified into non-renewable energy resources and renewable. The different forms of resources for renewable energy include water (Hydro-energy), solar, wind, biomass, etc. while fossil fuel in the form of crude oil, natural gas and coal is an example of non-renewable forms of energy. (Oyedepo, 2014). The non-renewable energy resources are not always produced, grown or used on a sustainable scale of its consumption rate. This is because depletion with time may lead to extinction. Their consumption rate is much faster than it can be created. The utilization of energy without its regeneration will definitely leads to extinction which will in turn devastate the economic productivity. The dependency of fossil fuel, a form of nonrenewable energy resource, in Nigeria has skyrocket the cost of production and thus diminished the standard of living and economic growth, as its quantity and availability diminish each day. (Oyedepo, 2012). The knowledge of the importance of renewable energy resource can boast the nation's productivity. Nigeria as an energy resources nation, blessed immensely with diverse resources such as biomass, natural gas, wind crude oil, solar and coal still have an estimate of 60-70% of her population without access to electricity. (Osueke, 2011). 90% of energy supply in Nigeria depends majorly on fossil fuel. This explains the ineffectiveness and the inability of Nigeria to harness the diverse energy resources for adequate development of her nation. The understanding of renewable energy, its source, how and what they can be used for? its importance, how much energy could be generated from them (I.e. from the various types of renewable energy)? and what are the benefits of using each can change our orientation on the dependency on the depleting fossil fuels. This will thus launch the nation and her economy into lime light of industrial revolution.

In this paper, we attempt to explain what 'Renewable Energy ' is, a brief history on 'Renewable Energy', types and application and also it benefits to the national development of Nigeria.

2. RENEWABLE ENERGY

Renewable source of energy is a form of energy from a source that does not get use up in supply when used. Renewable energy could be generally defined as a form of energy which is collected from available resources that are replenishable on the timescale of humanity, which include sunlight (solar), tides, wind, rain, geothermal heat, and waves. These are the energy sources that can be readily produced, regenerated or replenished rapidly through natural processes. Their availability is not affected by their consumption rate, hence cannot get exhausted in the nearest future. Though most of these renewable resources could be depleted via human indiscriminate consumption, but they can also be replenished thereby maintaining a steady flow. Some of this renewable energy relevant to Nigerian environment which could be easily tapped would be discussed later in this paper. Renewable energy is said to provide energy in some important areas such as water heating/cooling, air and transportation, electricity generation, and rural (off-grid) energy service.

3. BRIEF HISTORY

The industrial revolution led to the great yawn for energy as against our modest desire in the past energy. (Oboirien, 2018) We all before the revolution rely more on the sun and burnt wood, straw, among others, for the production of heat. The transportation system then was majorly driven by the power of the wind in our sails and the muscle of horses to reach our targeted destination. (Edomah, 2016) Animals were the main work force to do even what we couldn't do with man’s labor force. Wind and water were the instrument driving simple machines that could ground our grain and pumped water. Coal in 1880 was a source of energy for the powering of Steam engine which was attached to the first electric generator in the world. The first electric light which powered the New York Times was the Thomas Edison's plant and Wall Street. The First Hydroelectric plant was the invented went in Appleton, Wisconsin which uses fast-flowing rivers to turn wheels for the grinding of corn. Within a few years, Henry Ford then built small hydro plant the powering of his home in Michigan by the assistance of Edison

Petroleum which is now the main source of energy in Nigeria was discovered in the late 1800s. It then became the main source of valuable commodity for lighting across the continent. The processed oil in form of gasoline was became the main source of fuel for firing internal combustion engines (ICE). The rapid spread of electricity and low-cost automobile thus change the society's energy used. The size of power plants, coal plants and hydroelectric dams now become larger with increased in technology. Power lines are extending hundreds of miles between cities, thereby empowering the rural community with electricity.

The used of Gasoline grows unchecked as a result of the continuous energy demand. The capacity of Cars became larger and heavier between 1950s and 1960s. It was recorded that the average mileage of an American car was only 13.5 miles per gallon, and a gallon of gas cost less than a quarter. (Alamdari, 2012)

According to REN2l's report in 2016, renewable energy was about 19.2% of humans' global consumption of energy and over 23.7% to their electricity generation in 2014 and 2015, respectively. Traditional biomass in 8.9% ,4.2% of heat energy (i.e. modern geothermal, biomass, and solar heat), hydroelectricity in 3.9% and 2.2% of electricity from solar, geothermal, wind, and biomass were the division of the sum total of energy consumption. The total cost and investment on renewable energy across the globe amounted to above US$286 billion in the year 2015, with nations like the United States and China heavily investing in wind, hydro, solar and biofuels, hence an estimated value of over 7.7 million estimated number of jobs associated with renewable energy companies and industries, and solar photovoltaic being the recorded largest renewable employer.

Table 1 Energy in Nigeria (Source: IEA Key World Energy Statistics Statistics)

Year	Export (TWh)	Population (million)	Electricity (TWh)	Production (TWh)
2004	1,508	128.7	13.4	2,668
2007	1,445	148.0	20.3	2,695
2008	1,343	151.3	19.1	2,638
2009	1,419	154.7	18.6	2,660
2010	1,691	158.42	21.62	3,005
2012	1,607	162.47	24.45	2,988
2012R	1,625	168.83	26.22	3,160
2013	1,415	174.00	24.52	2,973

In Nigeria, to adopt any form of the renewable energy the questions below should be critically considered:

- How much of the energy is available in the country, and its source.
- What are the purposes that this energy be used for (what is the end-use of the energy).
- What could be the environmental impact of these technologies in terms of sustainability.
- How much it cost to develop the energy in terms of cost-effective.

4. FORMS OF RENEWABLE ENERGY AND ITS APPLICATION IN NIGERIA

4.1. Biomass Conversion

Biomass could be regarded as a form of renewable energy in the organic m state. A very good example is biological materials that are obtained from different living organisms, such as human waste, wood, and alcohol fuels etc. Wood energy, a form of Biomass, is derived from harvested wood and wood waste products. This energy is popularly known as Ghana source of power. Municipal waste, manufacturing waste and landfill gas can be used to generate waste energy. Biomass alcohol fuel or ethanol is obtained almost exclusively from corn. Sometime this year (2016) it was heard that the Ogun State government were looking into biomass conversion which is a positive move and a method to solve improper waste disposal in the state. If all states in Nigeria could develop its own source of power, and then the work load on the Kainji dam would reduce potential for failure. (Emetere, 2016)

4.2. Agricultural Residue and Municipal Solid Waste

Animal and human power makes up the bulk of the required energy for agricultural production. Agricultural products such as cornstalks or processing waste (rice husk, cassava peels, corn shells, palm kernel shell, etc) are all good sources of fuels. Wastes from animals such as poultry droppings, cow dung, and abattoir wastes are also available at specific sites. (Abila, 2014)

The energy from these products possesses a immense potential for sustainable energy generation in Nigeria especially for the northern areas of the country and most recently the south and west. If each state could adopt this method it could also be used to reduce the waste dumping on road sides as adequate method would be initiated in capturing this waste for the energy harnessing.

In Nigeria, the high density of population is a major factor causing the poor status of waste management (Suberu et al., 2013 and Ezeah et al., 2012)

As an outcome of the ineffective and non-thorough management of waste in the country, most wastes are indiscriminately dumped on landfills, virgin lands, into the sea or burnt. (Abila, 2014 and Kofoworola et al., 2007)

4.3. Solar Applications

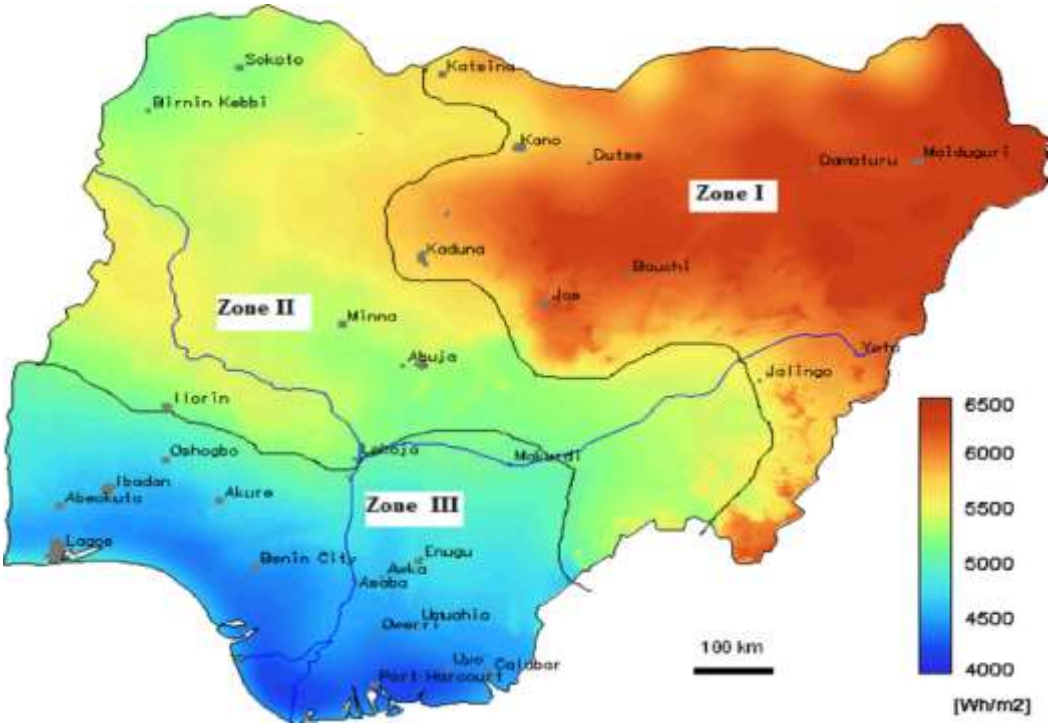

Figure 1 Nigerian Solar Map. (Adaramola, 2014)

The radiant rate of the sun's energy is about 3.8 x 1023 kW per second, this makes solar energy the most promising form of the renewable energy sources as it is potentially limitless. (Ohunakin et al., 2015) We have two basic forms of solar energy; the Photovoltaic (PV) which are commonly found on the roof top of your neighbour's house or houses close to you and the Concentrated Solar Power (CSP). Figure 1 shows the solar intensity distribution in Nigeria with a conspicuous demarcation between areas of high intensity, medium and low intensity. The CSP is an array of solar with large number of curved panels, they look like PVs but they use mirror system to draw in concentrated beam of sunlight.

According to Osueke (2011), the average daily sunshine in Nigeria is about 6.25hrs which range between 3.5hrs at the coastal areas and 9.0hrs at the far northern boundary with an average annual solar daily radiation of 5.25KW/m2 per day and 7.0KW/m2 per day at the coastal and northern area respectively. The energy radiation from the sun is about 4.85×1012kwh of energy per day in Nigeria. Nigeria is thus positioned within a high sunshine belt and has abundant solar energy potentials. Sambo (2009) stated that the average solar radiation receives by Nigeria is about 19.8MJm-2day-1. On the average, sunshine hours are analytically estimated at 6hrs per day. The underutilization of this abundant energy has laid much dependency of the economic driving force on a standby. If this energy can be harnessed into PVs or CSP in our homes and industries, the country's dependence on hydro and fuel would be reduced and put into other research program. (Ohunakin et al., 2014)

4.4. Wind Energy Technology

The atmospheric pressure difference due to the disparity in temperature is the cause of wind. This process is catalyzed by the sun. The sun produced uneven heating effect on the earth at

different temperature and at different times and at different places. This uneven distribution of heat thus creates warm air in form of wind which rises and while cooler air descends to occupy the void and generate wind which in the movement of air. Wind power system utilizes benefits of the power of wind in their functionality. Wind energy resource is available everywhere on the earth without restriction, both on the sea and land. Due to the absent of topography to act as wind breaker near the sea, the levels of wind energy at sea than the land. Hence greater energy potential is obtained in riverine environment. (Oyedepo, 2012).

According to figure 2, there are some certain states of the federal republic of Nigeria have wind in abundance and some in a little magnitude. The wind energy potential, the annual wind speed in Nigeria cities ranges from 2.32mis for Port Harcourt to 3.89mis for Sokoto, with maximum extractable unit power per unit relative area of 4.51 and 21.97 watts for every square meter of the blade area, respectively. (Shaaban et al., 2014). The energy per unit area is respectively accounted for as 168.63 and 1,556.35 kWh for every square meter of the blade area when the wind speed greater than 3m/s is considered in duration. (Sambo, 1987 and 2005). There are factors which affect the choice of site for the setting up of wind power system. The effectiveness of any wind powered is determined by the relative consistency of wind flow rate. Hence barriers such as hills, structures or trees should be cleared off the vicinity. (Osunmuyiwa et al., 2017) There barriers interfere with the rotors of the power system thereby limiting its efficiency. It is much advisable to place the rotors on top towers to overcome any wind drag and harness advantage of the available stronger up. Other factor is temperature; the speed of wind varies with temperature season, and time of day (Osueke, 2011). The energy generated is most times not consumed at the instant of production; and also, as a result inconsistency in the wind flow rate, the wind power system requires the help of batteries for energy storage. This thus makes the energy available when needed. The wind energy resource is a great limitless source of energy that can serve as alternative form of power to the country by investing much interest and finance in it, most especially in the riverine part in Nigeria.

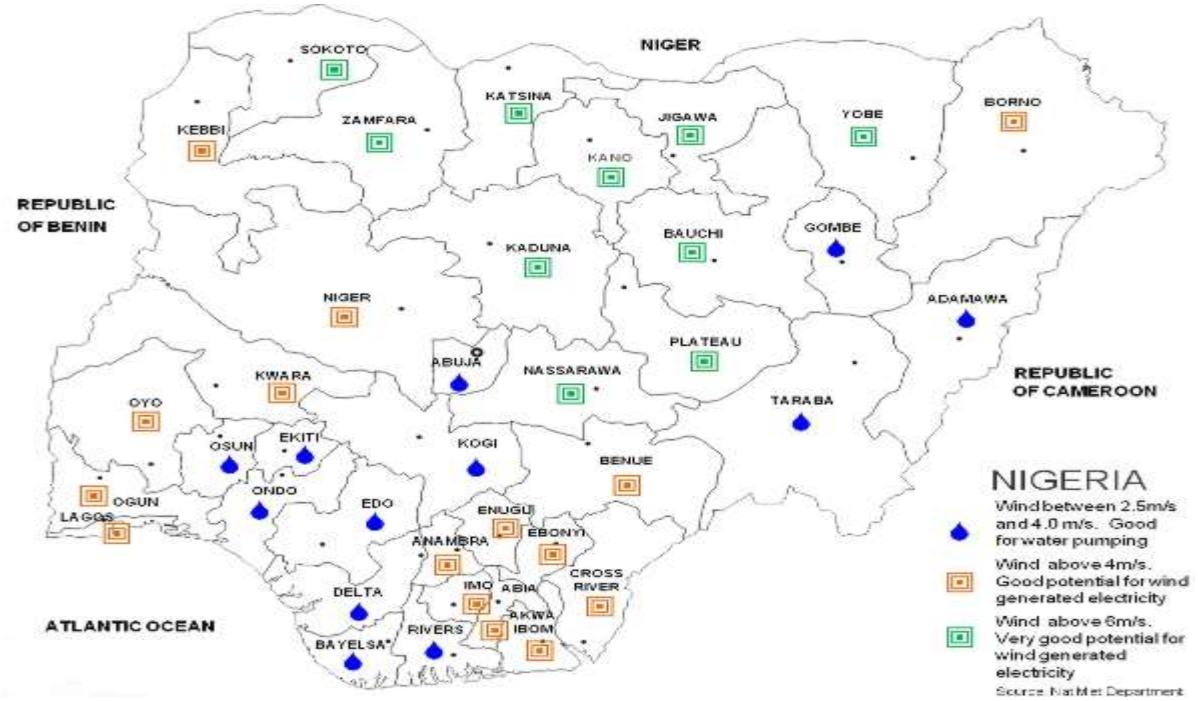

Figure 2 Wind Potential Mapping of Nigeria

(Source: http://www.neenigeria.com/html/wind_energy.html)

4.5. Hydro Power

Hydro energy is one of the largest forms of renewable energy. Nigeria is a country with rivers, waterfalls and streams; this simply means that there is a high potential for hydro power. Hydro power has been in Nigeria for a long time and still is the country's main source of power. (Akuru et al., 2017) Report carried out in twelve states and four (4) river basins reveals that over 278 unexploited Small Hydropower (SHP) sites with total potentials of 734.3 MW were located in Nigeria. However, SHP potential site is virtually in all parts of Nigeria with an average estimated capacity of about 3,500 MW. The energy harnessed for the Kainji darn is 760MW on a minimum as shown in table 2 and 960MW on the maximum, if the energy potential of 3,500MW as shown in table 3 could be harnessed then the power/electricity shortage in the country would be resolved. (Adom et al., 2017)

Table 2 List of Power Stations in Nigeria (Source; https://infoguidenigeria.com/power-stations-nigeria).

Stations	Capacity	Year Completed/ Commissioned	Location
Kainji Hydro Power	760MW	1968	Niger State
Jebba Hydro Power	576.8MW	1985	Niger State
Shiroro Hydro Power	600MW	1990	Niger State
Egbin Thermal Power	1320MW	1986	Lagos State
Sapele Gas-Fired Steam Turbine	1020MW	1981	Delta State
Afam Power Station	977MW	2002	River State
Transcorp-Ughelli Gas Turbine	972MW	1990	Delta State
Geregu Gas Turbine	414MW	2007	Kogi State
Papalanto Gas Turbine	335MW	2007	Ogun State
Omotosho Gas Turbine	335MW	2006	Ondo State
Kwale Okpai Gas Turbine (ipp)	480MW	2005	Delta State
Afam vi Power Station (ipp)	642MW	2010	Rivers State
Ibom Gas Turbine (ipp)	190MW	2009	Akwa Ibom State
Aes Barge Gas Turbine (ipp)	270MW	2001	Lagos State
Omoku Gas Turbine (ipp)	136MW	2005	Rivers State
Aba Gas Turbine (ipp)	140MW	2012	Abia State
Geregu ii Gas Turbine (nipp)	434MW	2012	Kogi State
Sapele Gas Turbine	450MW	2012	Delta State
Alaoji Gas Turbine	1074MW	2015	Abia State
Calabar Gas Turbine (nipp)	561MW		Rivers State
Gbarain Power Station (nipp)	225MW		Bayelsa State
Egbema Gas Turbine (nipp)	338MW	2013	Imo State
Ihovbor Gas Turbine (nipp)	450MW	2013	Benin State
Omoku ii Gas Turbine (nipp)	225MW		Rivers State
Omotosho ii Gas Turbine (nipp)	450MW	2012	Ondo State
Olorunsogo ii Gas Turbine (nipp)	675MW		Ogun State

Table 3 Energy Potentials in Nigeria. (Source:

Resources	Potentials	Authors
Small Hydropower	3,500 MW	(Shaaban et al., 2014)
Large Hydropower	11,250 MW	(Shaaban et al., 2014)
	11,235 MW	(Aliyu et al., 2015)
Wind	2 - 4 m/s @ 10m height (main land)	(Shaaban et al., 2014)
Solar Radiation	3.5 – 7.0 or 7.5 kWh/m^2/day	(Shaaban et al., 2014)
Municipal Solid Waste	17451000 tonnes per day	(Scarlat 2015)
	7329000 tonnes per day	(Scarlat 2015)
Animal Waste	211 million assorted animals (285.065 million tons/yr of production)	(Aliyu et al., 2015)
	61 million tonnes/yr	
Energy crops and Agric Residue	28.2 (30% of total land) Million hectares of arable land	
Crop Residue	83 million tons/yr	(Aliyu et al., 2015)
Fuel Wood	11million hectares of forest and wood land	
Wave and tidal energy	150,000 TJ	(Aliyu et al., 2015)
	1759.6 toe/yr	(Aliyu et al., 2015)

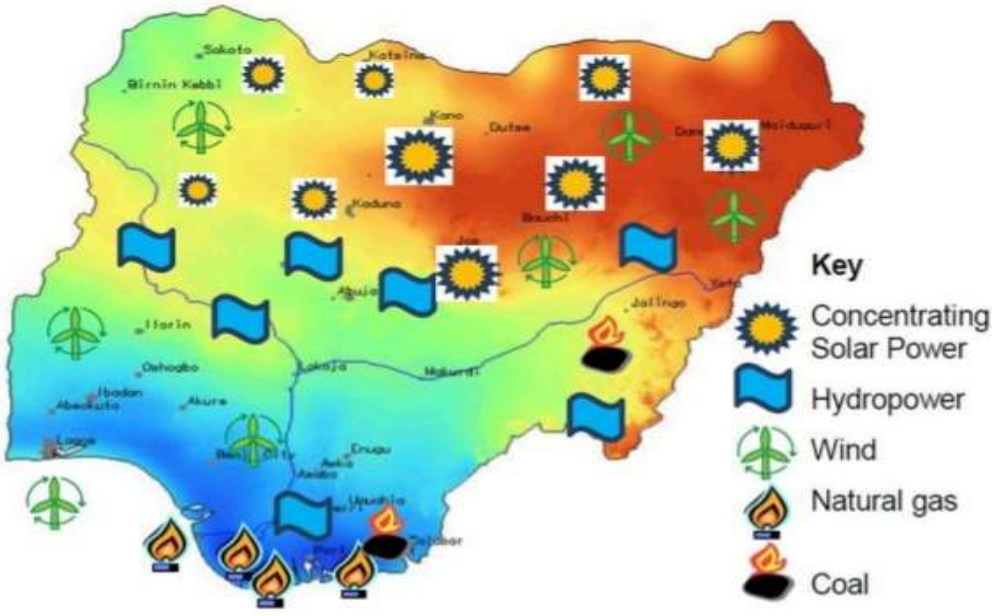

Figure 3 Energy mapping in Nigeria. (Source: Wikipedia)

5. CONCLUSIONS

The map in figure 3 clearly presents various energy potentials in Nigeria with the particular states of the six geopolitical zones that has relative peculiarities with the energy potentials that Nigeria is blessed with and its magnitude. It has also been rightly proven by various literatures that the utilized energy that is been converted to useful power for human consumption is outrightly insufficient alongside a reduction is certain efficiencies as its output does not commensurate to the respective populations of each state and the entire country at large as shown in table 1. Upon the abundance of diverse sources of energy in Nigeria, these potentials have not been relatively harnessed and an effective realization of this will require

enacting of workable strategies and policies to catalyze the attainment of the possible outcomes of a nation with robust, economically affordable, and reliable energy for her citizens.

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