



Energy Security and Nigeria's Sustainable Development: SDG 2030 (7)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Over the years, affordable and sustainable energy has been regarded as the backbone of any country needed for the development of her social and economic sectors. Sustainable energy is vital to the production of goods and services, transport, agriculture, health as well as an instrument for politics, security, and diplomacy. Nigeria is regarded as one of the most populous countries in Africa and is blessed with rich and diverse energy resources. However, poor access to affordable and sustainable energy by a larger percentage of the population has become a norm in the past decades and this has constituted greatly to the poor economic and social development of the country. This paper provides a minireview of the different potentials of energy resources in the country, prospects, and challenges of achieving energy security in Nigeria by the year 2030 as detailed in the United Nations sustainable development goal (SDG: 2030). The paper also discussed recent efforts by the government of Nigeria in tackling the energy crisis bedeviling the country. Findings from the review showed that Nigeria is blessed with abundant energy resources. However, the government needs to be proactive in the implementation of some of the proposed actions such as having a clear policy direction on energy and inclusion of renewable energy sources into the energy mix and reduction in energy wastage in its stride towards meeting sustainable development goal (SDG: 7) by the year 2030.

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1. INTRODUCTION

It is a common knowledge that economy of a nation and its industrial development centered on its ability to develop clean, efficient, and sustainable energy systems. Adequate access to sustainable energy can be beneficial not only to the social and economic development of human lives but also provide opportunities for cities and human settlements to be inclusive, safe, resilient, less-polluting, and more sustainable to grow and perform [1]. However, access to clean, reliable, and affordable energy supply most especially in developing countries such as Nigeria has been a herculean task for both private and industrial sectors. Not only that it affects the living standard of individual and reduces the production capacities of industries, but also grossly responsible for the slow growth of the Gross Domestic Product (GDP) of developing countries. It is in the light of this that the United Nations in 2016 came together to agree on a common framework to tackle 17 major world issues by 2030 out of which access to affordable and efficient energy system was listed as SDG 7.

According to Shittu [2], Sustainable Development Goals (SDGs) can be referred to as proposed set of targets relating to future international development. They are set of goals and agenda that United Nations member states are expected to use in developing their policies and various programmes to arrest variants of problems and issues globally. In line with the above definitions, 17 integrated goals were put forward in the year 2015 towards having a better human society by the year 2030 (UNDP, 2015). In Nigeria, despite several effort put in place by subsequent governments in the past to provide affordable electricity to larger percentage of the populace, Nigeria remains one of the countries in Africa that has highest number of people with little or no access to electricity and thereby making it difficult for the country to achieve energy security [3].

The definition of energy security is variant, and it has different meanings across the globe. Its dimensionality cuts across political, military, technical and economic differences. Bieleck (2002) explained that the economy of energy security is primarily concerned about the macroeconomic impacts of high energy prices and the risk of economic losses as a result of inadequate energy supply. Nakicenovic et al [4]

also asserted that accessibility to energy usage is increasingly becoming one of the most vital ingredients for social and political development of a country thereby ensuring a giant stride in educational, agricultural and health sectors of the economy. Accessibility to adequate supply of energy is particularly very critical to both existing and budding local businesses in the process of developing vibrant economy in the member nations. Therefore, the United Nation ensures that accessibility to affordable and reliable power supply forms a key component in the universal indicator of sustainable development goals. Also, one of the sustainable development goals (SDG) targeted by the United Nations is to ensure that the percentage component of renewable energy in the global energy mix by 2030 increases substantially in order to improve energy efficiency.

The objectives of this paper include the reviewing of the existing energy potentials in Nigeria and issues relating to the energy security and its prospects in the country. Also, the roadmap to achieving the SDG (7) on energy and proposed actionable steps to be taken in achieving energy security in Nigeria by the year 2030 were also discussed.

2. BRIEF OVERVIEW OF ENERGY GENERATION AND DISTRIBUTION IN NIGERIA

Nigeria operates a centralized energy system where communities and individuals are connected to a common energy sources, mainly thermal and hydro power plants. Many poor communities live without electricity because of cost implication and other factors. Nigeria is blessed with enormous energy resources that can be harnessed to address the shortage of energy that are currently faced by both private and public sectors. These resources are broadly divided into renewable energy which consist of energy from solar, wind, biomass and hydro and nonrenewable energy resources made up of energy from crude oil, natural gas and coal. The energy resources are discussed in the following subsection.

2.1 Renewable Energy Resources in Nigeria

Renewable Energy (RE) resources are different types of energies that are obtained naturally from the environment and include energy obtainable

from solar, biomass, wind, hydropower, geothermal. Nigeria is endowed with abundant renewable energy resources which provide her with immense capacity to develop an effective national energy plan. The introduction of renewable energy resources into the nation's energy mix can have great implications on its energy budget [5]. However, the integration of the vast potential of renewable energy most especially energy from solar, wind and geothermal has not been achieved over the years [6].

As stated by Ezugwu [7], Nigeria is a country that is highly endowed with large rivers and some few natural falls while small rivers and streams can also be found in each of the eight hydrological basins in the country. Some of these rivers maintain minimum discharges all the year round and the potentials accruable to hydropower currently accounts for about 29 % of the total electrical power supply. Ijeoma (2012) confirmed that around 20% of the technically exploitable hydropower potential of the country which was conservatively estimated at 11,000 MW is currently being tapped and deployed to the National grid.

In terms of solar energy potentials, Nigeria has abundant solar power with incidence of around 1831.06 kWhr covering a total land area of 923768 km² [6]. The country also has an annual average sunshine of about 6.25 hr ranging from 3.5 hr at the coastal region to around 9.0 hr at the Northern part of the country. It has also been estimated that the Northern part demonstrated the strongest potential for solar electricity with highest yearly average daily global irradiance of 6.22 kWh/m² per day at horizontal and

6.4 kWh/m² at optimal inclined angle of 16° [8]. The solar radiation reduces towards the central part of the country having a maximum value of 2,186 kWh/m²/year annual average solar energy in zone 1 and a minimum value 1,822 kWh/m²/year in zone 3. The full detail of zonal distribution of solar energy in Nigeria is presented in Table 1.

The potentiality of wind for energy generation in Nigeria has been examined by various researchers [9,10,11]. The Northern part of the country has the highest wind potential and the mean wind regimes in the area hovers in the range of 4.0 to 8.6 m/s. In the southern part, the wind regime is found between 2.0 and 4.13 m/s with the exception of the coastal regions/offshore operating at 10 m above the ground [12]. The range of the exploitable wind energy in the Northern part of the country was estimated to be between 8 to 97 mWh/year [13]. The level of wind power development is still low in the country with the few available wind fields limited to 5 and 0.7 kWh located in the Sayya Gidam and Danjawa respectively in the north [6,14]. Table 2 provides information on the different zones in Nigeria and the annual average of solar energy intensity (Kwh/m²/year).

Biomass energy resources which include firewood, tree trunk, animals and human waste, organic wastes from household industries are in large quantity in the country. Currently, Nigeria can boast of about 144 million tons of biomass resources on a yearly basis. The vast majority of rural dwellers used this source of energy for cooking, heating and lightning and it contributes about 37 % of total energy demand mostly needed by these groups of people living in the villages.

Table 1. Zonal distribution of solar energy in Nigeria [6]

Zones	Annual average of global solar radiation (kWh/m ² /day)	Sunshine duration (h/day)	Annual average of solar energy (kWh/m ² /year)	States
Zone 1	5.7 - 6.5	6	2,186	Borno, Yobe, Jigawa, Kano, Bauchi, Gombe, Adamawa, Plateau and Katsina
Zone 2	5.0 - 5.7	5.5	2,006	Sokoto, Zamfara, Kebbi, Niger, FCT(abuja, Nassarawa, Taraba, Kwara, some section of Plateau, Benue and Katsina
Zone 3	<5.0	5	1,822	Lagos, Oyo, Osun, Ekiti, Kogi, Benue, Rivers, Delta, Imo, Anambra, Abia, Enugu, Edo, Ondo, Bayelsa, Akwa - Ibom, Cross rivers, Ebonyi

Table 2. Different renewable energy resources in Nigeria and their potentials. (Source: FMEnv, 2012)

Resources	Potential	Remark
Large hydropower	11 .250 MW	1900 MW exploited
Small hydropower	3 .500 MW	64.2 MW exploited
Solar	4.0 kWh/m ² /day to 6.5 kWh/m ² /day	15 MW dispersed solar PV installations
Wind	2-4 m/s m 10 m height mainland	Electronic Wind Information System (WIS) Available; 10MW wind farm in Katsina in progress
Biomass (non fossil organic matter)	Municipal waste, fuel wood	18.5 million tonnes produced in 2005 and now estimated at 0.5Kg/capita/day - 43.4 million tonnes/yr firewood consumption
	Animal Waste	245 million assorted animals in 2001
	-Agric residue	91.4 million tonnes/yr produced -
	-energy crops	28.2 million hectares of arable land; 8.5 % cultivated

The estimated energy accruable from different sources of biomass as at 2011 was 816 MJ and till present, the energy is still used in it crude form. Table 2 presents a comprehensive list of different energy resources in Nigeria and their potentials.

2.2 Non-Renewable Energy Resources in Nigeria

Several energy resources are available in Nigeria in abundant proportions. The non-renewable energy comprises of energy derived from fossil fuels such as coal, crude oil, natural gas and nuclear power. The estimated reserve for coal in Nigeria is put at 27 Billion tons as of 2011 [6] and most of the coal deposit could be found from the cretaceous Anambra basin and extend to Dekina in the northern part of the basin [15]. The coal mining sites are unevenly distributed around the countries each with various production capacities, type and depth of the coal. As reported by Osueke and Ezugwu [15], the production capacities of major mining sites in Nigeria can be boosted after full privatization and rehabilitation such that Onyeama and Okpara can attain a production capacity of 150,000-400,000 tonnes/year, Owukpa (2500 tonnes/year) and Okaba (15,000-300,000 tonnes/year).

Nigeria is also ranked as the world's sixth largest reserve of crude oil and has an estimated oil reserve of 36.2 billion barrels and Natural gas reserve is about 187 trillion-cubit feet. The oil and gas reserves are mainly found and located along the Niger Delta, Gulf of Guinea, and Bight of

Bonny [16]. Natural gas is another fossil fuel that is trapped underground in reservoirs. It is mostly made up of methane and is cheaper than crude oil. Nigeria's gas reserves are currently estimated at 182 TCF (trillion cubic feet) as of January 2006 with a projected growth rate of over 70 % by 2025 [17]. The capacity makes the country the seventh largest natural gas reserve holder in the world and the largest in Africa. The vast majority of natural gas found in Nigeria is associated, which means that that it occurs in crude oil reserves as free gas. Due to the infrastructural deficits in many of the oil fields in Nigeria for the direct production of the associated natural gas, gas flaring is employed which accounted for about 43 % of the annual gas production capacity in the country [6].

3. ENERGY SECURITY: PROSPECTS AND CHALLENGES IN THE CURRENT AND FUTURE SETTINGS

Energy Security can be described as the availability of energy resources that are diverse, much available to the populace, sustainable in terms of quantities, easily affordable in prices and is environmentally friendly [18]. For economic buoyancy, social and political development of a country such as Nigeria, it is indispensable to have an efficient and sustainable energy sector that will be affordable and available to the larger percentage of the populace. As part of his recommendation, Bello [19] advised the federal government of Nigeria to incorporate the design and development of an integrated renewable energy planning and

investment that will promote investment in research, market development and regulation of renewable energy resource as path to sustainable growth of the country.

However, as pointed out by Dike [20], state of energy mix in Nigeria is heavily dependent on crude oil for energy generation and this has slowed down the development of other alternative forms of energy. Several efforts made by successful government to bail Nigeria out of energy crisis has not yielded the desire results as more inhabitants mostly the rural dwellers have little or no access to electricity and many interior villages are yet to be connected to the national grid.

Based on official statistics, the number of Nigerians with little or no access to electricity supply stood at about 77 million while more than 80 % of those that have direct access still back up their energy supply through the usage of firewood and petrol or diesel fueled generators [21,22]. According to the study conducted by Amiesa et al. [23], energy insecurity has a direct and negative impact on all sectors of the economy. Presently, there is a sharp decline in economic activities trends in some states of the country with high energy insecurity and this was reflected in the state's internally generated revenue. Another implication of energy insecurity is that Nigeria might become an importer of crude oil between 2030 and 2035 as the country economy, industrial activities and population grows [24].

Unhealthy political opposition, saboteurs, and activities of terrorists in several part of the country are other agents frustrating the development of energy sector in Nigeria. Also, the domination of oil and gas downstream sectors by cartels that manipulate the prices through artificial supply restriction cannot be overruled as a clog to the wheel of energy development in Nigeria [18]. In the work of Okeke et al., [25], the elitist dimension to energy insecurity were discussed. Based on their findings, one of the critical challenges to energy security in Nigeria is the lack of clarity in policy objectives and strategies which hardly galvanize the citizenry into actions.

Despite all these travails, Elum and Mjimba [26] opined that Nigeria as a country has recognized and analyzed its potential in a variety of renewable energy sources for possible exploitation to diversify its energy mix. However,

the existing policies of the federal government are not favourable in driving the renewable energy development projects. Ajayi and Ajanaku [27] reiterated that Nigeria receives a huge amount of solar radiation and is blessed with abundant wind energy resources, large deposits of fossil fuel, as well as enormous hydro-power resources. Yet, out of all the listed potentials, the wind and solar energy have not received expected patronage in terms of exploitation while about 80 % of hydropower remains untapped.

4. NIGERIA ROADMAP TO ACHIEVING SDG 2030 (7) AND PROPOSED WAY FORWARD

The Sustainable Development Goals (Table 3) also known as the 'Global Goals', refers to the roadmap developed by the United Nations to among other things reduce inequality among the gender, mitigate the effect of climate change on natural resources and end poverty among the member countries. At present, the world is facing critical environmental, economic, and social issues and this has prompted the development of the 17 goals and 169 specific targets to address these challenges among the United Nations by the year 2030 [28]. However, as laudable as the sustainable development goals are, clear guidance on policy framework, massive financial investment and capacity building have been identified by Jaiyesimi [29] and Muhammad, et. al [30] as important key factors for its successful implementation most specifically in Africa. Goal 7 of SDG addresses the issue of energy security in member nations and is to ensure access to affordable, reliable, sustainable, and modern energy for all. In essence, every country is expected to put up a system of targets and indicators to allow monitoring the steps toward the achievement of the SDGs [31].

Nigeria road map to achieving the SDGs is designed to focus on six thematic areas namely: policies, data management, institutions, partnership, communications, and finance. The implementation of these policies which was designed to be carried out in three phases is geo- political zone dependent and based on the pressing need of each zone at a point in time [33]. In order to achieve the objectives of SDG n.7 and address the energy insecurity in the country, a few actions and measures were put in place by the federal government of Nigeria. For example, in 2015, a new policy on renewable energy was developed and approved by the

Federal Executive Council of Nigeria in one of its meetings. One of the key objectives of the developed policy was to increase the percentage contribution of solar energy to the total energy mix and ensure a minimum electricity contribution of 3 % by 2020 and 6 % by 2030 respectively ([34]. This policy was to complement an existing policy on energy 'National Energy Policy' (NEP) drafted by Energy Commission of Nigeria in 2003 and revised in 2018. The NEP has a target to increase electricity generation to 30 GW in 2030 and increase the contribution of coal by 30 % to the national energy mix by 2030 [35].

As energy is considered an important factor of production and its acute shortage of energy may have detrimental effects on the industrial and commercial development in the country, the recent commitment of the federal government of Nigeria on the strengthening of effort to diversify economy through the completion of Ajaokuta – Kaduna – Kano gas project (AKK) gas pipeline project is a booster to energy security and the achievement of the sustainable development goal (SDG) 2030 [36].

Incorporation of renewable energy resources such as solar, wind, biomass, and hydro into the energy mix of the country has been advocated by many researchers [7,25,18]. Implementation of this request will be more beneficial and improve the chance of the country towards achieving sustainable development goal on energy affordability by 2030. As advised by Borok et al[18], the Federal Government of Nigeria should as a matter of urgency encourage the establishment of a Renewable Energy units in technological Universities and research institutions that will be saddled with the responsibility of conducting research and development in renewable energy technology thereby increasing its benefits and create a technical culture in Nigeria.

Also, overhauling the existing energy infrastructures by both the generating and transmitting companies in Nigeria is very critical to energy security in the country. The continuous use of outdated and obsolete equipment by energy companies may constitute energy shortage, scarcity, and reduction in performance. The need to curb incessant wastage of energy by both individuals and public sectors cannot be overemphasized as this unchecked attitude contributes its quota to energy insecurity in the country. Consequently, the reduction of waste is

a huge source of energy savings and requires actions from both individuals and industrial sectors. Additionally, it is also crucial that the populace is sensitized on the need to consume less energy by improving and modernizing energy infrastructure such as smart grid solutions, and smart cities and replacing old devices by energy efficient solutions, such as replacing traditional light bulbs by LEDs.

The 2019 Africa SDG Index and Dashboards Report prepared by Karoubi et al., [37] was a call for action by African nations and was targeted at encouraging African nations in meeting the SDGs. The report, which was also prepared to ensure timely and high-quality data on SDG indicators, focuses on the efforts that African governments are taking to incorporate the SDGs into their national strategies, budgets, public engagements, and coordination among branches of government.

Several indicators were used to compare the level of performance of each African country in their bid to meeting the SDGs by the year 2030. Among the indicators adopted in the report, access to clean fuels and technology for cooking, consumer affordability of electricity, access to electricity and the renewable energy share in the total final energy consumption were used to monitor the progress of Goal 7 of SDG which addresses the issue of energy security in member nations. As shown in Fig. 1, Nigeria performed comparatively well when compared with six other African nations in the consumer affordability of electricity and in the percentage of people with access to electricity. However, its performance in the number of people that have access to clean fuel and technology was not good enough when compared with Kenya and South Africa. Therefore, coordinated effort by relevant government agencies is needed for better understanding on what it will take the country to reach the SDGs while the Federal Government has to be more committed in providing necessary financial resources to meet the goals by 2030.

5. LESSONS FROM SELECTED COUNTRIES IN AFRICA

Nigeria effort to attain energy security can be boosted by learning from what is being done differently in other African countries and producing positive results. In Kenya, as part of the preparation of the government to achieving sustainable development goals in energy

accessibility, 61% of the total power generation is expected to come from RE sources. Kenya is also embarking on the construction of the largest wind farm (Lake Turkana Wind Power Consortium) with an install capacity of about 3000 MW. This addition of this to the national grid is expected to save the country about \$200 million on importation of fuel. Majority of Kenya's electricity is from geothermal which has 636 MW installed capacity presently and is aiming at 5,530 MW or 26 % of the total capacity by 2030. Accessibility of Kenyans to sustainable energy was also improved through the involvement of private sectors that worked in conjunction with the central government in assisting off grid communities to leap from using unreliable nonrenewable energy to affordable and sustainable practices [38].

South Africa has implemented comprehensive sets of strategies, policies and plans within the key sectors to improve energy generation and reduces the emission of Green House Gases (GHG). For example, the country is currently investing in varieties of technology to bridge the gap of energy deficiencies in communities that have little or no access to electricity. Also, there is ongoing development of 9.6 MW Medupi and Kusile coal fire power plants. At the same time,

the country has started construction work on a pumped - storage scheme that builds flexibility into the South African system and connects the renewable energy independent [39].

In the case of Rwanda, the government has taken important steps by effectively domesticating the agenda of SDG through integrating the targets to be achieved into the medium-term development strategy and the National Strategy for Transformation, NST 1 (2017-2024). The coordination of the implementation of the strategies are to be carried out by the Ministry of Finance and Economic Planning is mandated to coordinate SDGs while supports are expected from multi-stakeholder structure which encompasses players such as development partners, civil society, private sector, citizens among others. In the energy sector, Rwanda has increased the proportion of population with access to electricity from 26.9% in 2016 to 46.7% in 2018. The country has equally implemented various strategies in ensuring that the proportion of population with primary reliance on clean fuels and technology improved from a low value of 0.7% in 2013 to around 1.2% in 2017. Renewable energy share in the total final electricity generation has also been increased to 53% in 2018 [40].

Table 3. Summary of Sustainable Development Goals [32]

SDG		SDG	
1	No poverty	10	Reduce inequality
2	Zero hunger	11	Sustainable cities and communities
3	Good Health and well being	12	Responsible consumption and production
4	Quality Education	13	Climate action
5	Gender Equality	14	Life under water
6	Clean water and sanitation	15	Life on Land
7	Affordable and clean energy	16	Peace, Justice and Strong Institution
8	Decent work and economic growth	17	Partnership for the goals

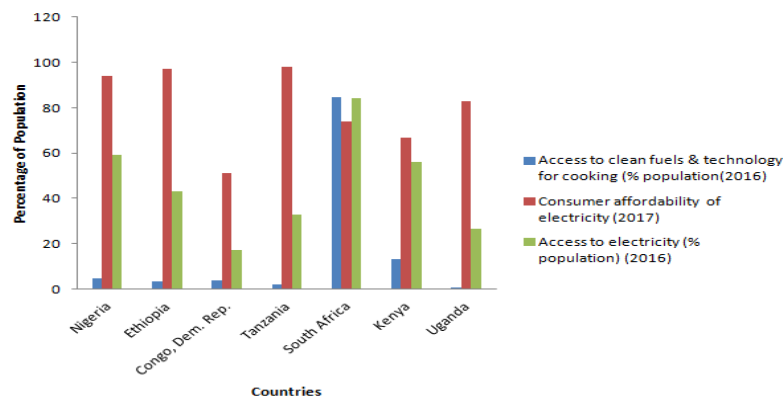


Fig. 1. Performance indicator for SDG: 7 for selected African Countries [37]

6. CONCLUSION

This paper discussed various energy potentials in Nigeria and the prospects and challenges of energy security in the country. Even though Nigeria is blessed with abundant energy potentials, its citizens are energy poor as accessibility to affordable and sustainable energy by common man in the past decades has not been achieved by successive governments. However, for the country to achieve goal 7 of the SDG by 2030, there is need for a paradigm shift in policy implementation, serious financial commitment from the federal government and development of other energy sectors to form greater part of energy mix.

Nigeria's energy mix is still dominated by oil and gas, with little contribution from hydropower, solar and other renewable sources of energy. Therefore, an inclusion of renewable energy in the energy mix will improve the chances of the country in meeting its energy security target by 2030 while also ensuring a more sustainable economic development and enhance poverty reduction.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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