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Energy poverty and environmental sustainability in Nigeria: an exploratory assessment

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Abstract. Energy constitutes an indispensable catalyst for sustainable socio-economic development. The imperative of energy security is highlighted by the pervasive energy poverty that characterizes developing countries, especially Nigeria. Despite being a major oil producer and having four refineries, Nigeria imports 90 percent of its domestically needed refined petroleum products. Similarly, Nigeria requires about 98,000 megawatts (MW) to achieve national electricity security. However, its thermal and hydropower stations have a combined installed capacity of only 12,522MW but generate between 3,000MW and 4,000MW and sometimes less than 3,000MW. The electricity challenge is deepened by fluctuations. The implications of this suboptimal power generation include: only 40 percent of Nigeria's 193 million population have access to electricity, erratic nature of electricity supply and the long hours of power outages. Thus, Nigeria can be categorized as an energy poor country. The major goal of this paper is to assess the link between energy poverty and environmental sustainability given that households must take alternative steps to bridge energy gaps that impact them. It further evaluates the opportunities and barriers to energy security and holds that the untapped potentials, especially among renewable energy resources, hold the key to sustainable energy development to tackle energy poverty in Nigeria.

1. Introduction

Nigeria is not only the most populous black country but also the largest economy in sub-Saharan Africa. Additionally, it is well endowed with enormous resources, which it could harness to provide energy for its teeming population, but its energy situation is deplorable and presents a serious paradox. Nigeria is a major oil producer with enormous hydrocarbon reserves. It has four refineries with a total installed capacity to refine 445,000 barrels per day. It has the resources to even expand this refining capacity in order to achieve self-sufficiency in refined petroleum products. However, none of these refineries has ever refined up to 20 percent of its capacity resulting in the country importing about 90 percent of its required refined petroleum products [1,2]. This scenario has led to several distortions and contradictions in the economy of Nigeria ranging from high cost of these products, uncertainty in their availability, encouragement of corrupt practices due to subsidies, and unpredictability in supply often resulting in the unavailability of these products.

Similarly, Nigeria has the potential to harness its abundant renewable and non-renewable resources to generate electricity but its electricity situation is more than deplorable. Nigeria requires an estimated 98,000MW to achieve energy security. By energy security, we mean the minimization of a country's vulnerability to the various energy systems and the possession of the capacity to provide energy services within its jurisdiction [3,4]. Nigeria has an installed capacity to generate 12,522 megawatts (MW) of electricity from its existing thermal and hydropower stations. However, it has only managed to generate between 3,000MW and 4,000MW and most times much lower than this range. The result is

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that only 40 percent of Nigerian households have access to electricity with the rural areas having marginal access as only approximately 10 percent of rural households are connected to electricity [5].

All the foregoing indicators suggest energy insecurity which invariably underpins Nigeria's energy poverty. In other words, Nigeria's energy profile suggests that it is an energy poor country which also means that its people are energy poor. The goal of this paper is to assess the relationship between energy poverty and environmental sustainability, that is, whether energy poverty faced by households has led them to engage in certain practices that have constituted threats to the environment. Relying on the traditions of exploratory research design, the paper utilizes secondary data sourced from statistical reports, government publications and journals to examine and analyze the inter-linkages between domestic energy poverty and environmental sustainability. This is against the backdrop that households must evolve survival strategies to augment shortfalls in their energy needs whether it is because they are unavailable or because they lack the resources to procure them. The paper finds linkage between energy poverty and the depletion of forestry resources which invariably leads to the deepening of household poverty. It further reviews and evaluates the opportunities and barriers to energy security and holds that the country must seek for effective ways to exploit its untapped renewable and non-renewable energy potentials.

2. Potentials and Paradoxes: Nigeria's Energy Profile

Nigeria has abundant renewable and non-renewable energy resources that could be harnessed to meet its energy needs, both present and future. But despite these enormous ensembles of energy resources, Nigeria is an energy poor country as majority of its 193 million people both lack access to energy resources and also the financial capacity to pay for them in order to meet their household needs. Paradoxically, Nigeria possesses the capability to lift its teeming population out of energy poverty but a combination of factors including among others weak policy framework and policy summersaults, corruption and lack of vision undermine efforts to bridge the energy poverty gap between the country and global averages in energy production and consumption.

2.1. Renewable energy resources

The global emphasis on renewable energy is a product of established relationship between non-renewable energy sources and climate change. Thus, the key emphasis of the international community centers on gradual transition to renewable energy sources as a panacea to the climate change menace. In other words, the world is evolving, adopting and emphasizing renewable energy options as veritable means to achieving energy sustainability and by extension, environmental sustainability.

Nigeria is blessed with abundant renewable energy resources. By renewable energy, we refer to all energy sources that are permanently available or renew themselves within a short frame of time. Nigeria is endowed with rivers, waterfalls, dams and river basins from which it could generate hydropower, adequate sunshine across the country for solar energy, strong wind for wind energy, adequately endowed environment with diverse biological mass to develop biomass energy and coastal corridor to generate wave and tidal energy. However, the challenge that Nigeria currently faces is suboptimal development of these energy sources due, largely in part, to inchoate policies and weak incentives to attract investors to the sector [6].

2.1.1. Hydropower energy: this is the major renewable energy source for the generation of electricity in Nigeria. This is mainly as a result of several large rivers, waterfalls, dams and river basins in the country. However, the major water sources that account for Nigeria's rich hydropower potentials are rivers Niger and Benue as well as the Lake Chad basin [7]. Despite the centrality of hydropower and its potential high capacity to generate Nigeria's electricity needs, it is grossly underexploited. This is in great contrast with the picture at the global arena.

Previous estimates of the potentials of Nigeria's seven out of eleven river basins, namely Chad, Cross River, Sokoto, Hadejia-Jama're, River Niger, Upper Benue, Lower Benue, showed a combined small-scale hydropower (SHP) capacity of about 734.2MW [8], but current adjusted estimates of river

basins in Nigeria indicate a potential energy output of 3,500MW [9]. Notwithstanding this huge potential, Nigeria's installed capacity for SHP is approximately 45MW, which means that it has only developed about 1.3 per cent of its SHP potentials [10]. In the same vein, the total estimate of Nigeria's hydropower potential is about 14,750MW but, until recently, it only generated about 15 percent of this capacity or 1,930MW [11]. As at 2017, the total percentage contribution of Nigeria's hydropower stations (Jebba, Kainji and Shiroro) to the country's energy mix rose to 26 per cent [12]. This was essentially the result of the US$100 million maintenance, repairs and investment undertaken by the African Development Bank (AfDB) [7].

Nigeria has projected expansion in the contribution of hydropower to its energy mix as its economy grows towards being among the world's 20 largest economies by 2020. Thus, it is envisioned that hydropower's contribution (both large and small) would rise from 2,030MW in the short run to 6,664MW in the medium-run and ultimately 67,000 MW in the long-run [7, 11]. Efforts appear to be at various stages to strengthen the capacity of several existing hydropower plants, including the 30MW Gurara 1, the 10MW Tiga, 10MW Oyan, the 8MW Challawa and the 6MW Ikere plants as well as construct new ones like the 700MW Zungeru and the 40MW Kashimbila hydropower stations [7]. While these efforts will contribute in alleviating Nigeria's energy poverty, the commitment for their full completion remains to be seen.

2.1.2. Solar energy*:* the potential to develop solar energy due to the vast supply of sunshine all year round is very high in Nigeria. Solar energy involves the conversion of sunlight into electricity through photovoltaic or concentrated solar power systems. The prospects of solar energy to boost Nigeria's energy production and thus eliminate energy poverty lies in a combination of factors, namely, its capacity to deliver the country's annual energy requirements in just an hour; its status as a clean energy source, free of pollutants and greenhouse gases; and its non-susceptibility to geo-political constraints and conflicts [13].

Although solar resources are readily available around world, the amount available to each region differs. The same applies to Nigeria as it has various climatic regions. Thus, despite its location on the equator with attendant advantage of being placed within a high sunshine belt with fairly well-distributed solar radiation, there are still variations across the country. Osueke, Uzendu and Ogbonna [14] have pointed out that the amount of solar energy that is available in any geographical location is indicative of the measure of solar irradiance that falls on that location. The solar potential of Nigeria is very high. This implies that all the regions of the country have viable potentials for solar energy production, but in terms of hierarchizing solar energy potentials, the northern region has more potential than the southern region. Figure 1 below shows the radiation range of different parts of Nigeria.

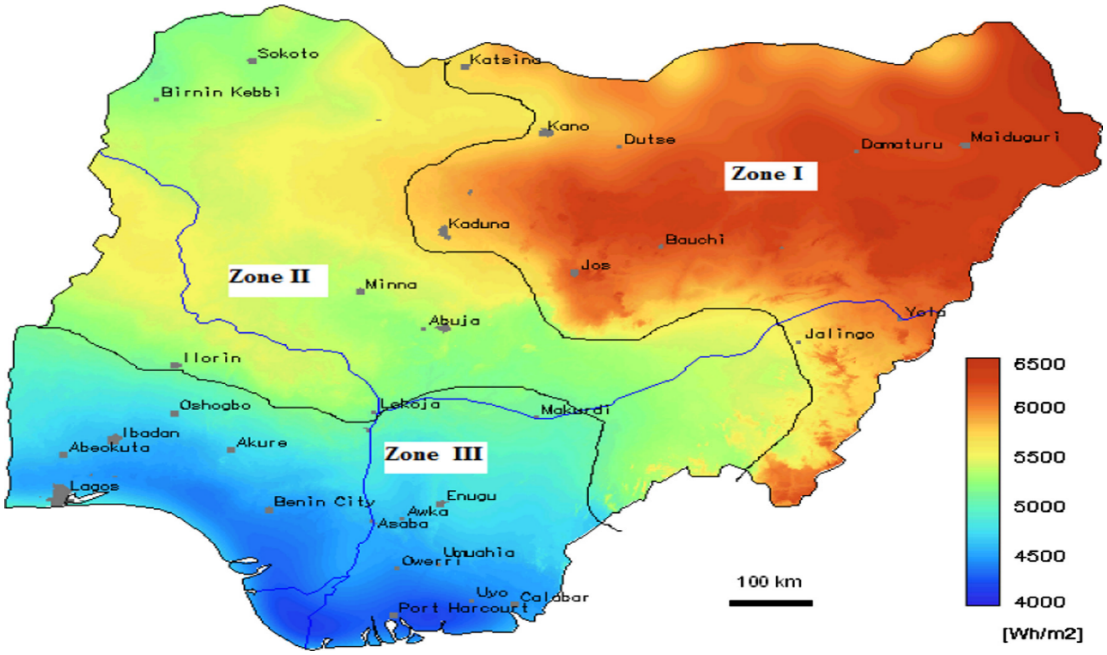

Figure 1: Map of Nigeria showing solar radiation zones [13]

Nigeria's sunshine profile is quite impressive. The sunshine radiates about 17,459,215.2 million megajoule (MJ) of solar energy per day on Nigeria. When this is broken down, it shows that the average daily solar radiation varies from around 12.6 MJ/m2/day (equivalent to 3.5 kWh/m2/day) in the coastal region to about 25.2 MJ/m2/day (equivalent of 7.0 kWh/m2/day) in the northern region [6, 11]. What this implies is that Nigeria has utilizable solar energy to lift its population out of energy poverty and ensure energy security.

Scholars have painted various scenarios to demonstrate the viability of solar energy in Nigeria. Maren, Agontu and Mangai [8] contend that the country could generate electricity that is equivalent to 4.66 million barrels of oil per day from 1 percent of its surface area if solar energy appliances with just 5 percent efficiency are used. In the same vein, Shaaban and Petinrin [11] project that if only 0.1 percent of the estimated 17,459,215.2 million MJ/day of solar energy that falls within the country's territory were to be harnessed at an efficiency of 1 percent, Nigeria's total energy demand would be met. In spite of the potentials painted by the foregoing scenarios, solar energy is yet to be included in the country's energy mix.

2.1.3. Wind energy: the wind is another untapped energy resource. Currently, the wind does not contribute to Nigeria's energy mix. In fact, the only large-scale harnessing of wind energy is a 10MW facility that is currently under construction in Katsina State. And yet every part of Nigeria has varying wind speed and strength that can be harnessed for various purposes, especially to generate power. According to estimates by scholars, the variation in the annual average wind speed at 10 meters heights could range from approximately 2 m/s in the coastal regions to approximately 4 m/s in the northern region with a peak wind speed recorded in the months of April through August for most sites and at 50m, the range is 2 - 8 m/s. There are both small and large modern wind turbines that can be customized and localized to generate electricity for utilities and other small energy needs [15].

Essentially, wind energy is produced by channeling the wind towards the blades of windmills or wind turbines, which in turn rotates them and drives electrical generators to produce power [15, 16]. Several studies have characterized wind speed and pattern in various parts of the country with a positive verdict on the viability of wind as a source of power generation [16-21]. However, studies also showed that across locations and even within a very close proximity, there is a wide variation in wind speed [22]. The variations in wind speed is normal around the globe. What is required based on

the various conflicting data generated by scholars on wind speed from different parts of the country is, as Brimmo et al. [22]) have argued, to create a platform to validate all available data in order to ensure minimum error in mathematical models to predict wind speed.

Wind energy is very important if Nigeria must meet its target of clean energy as well as attain energy security. A major step towards actualizing it is to develop a clear policy direction in this regard, which of course will deal with the challenges of low financing, lack of awareness and attraction of investors who will encourage the development of appropriate technical capacities and wind technologies.

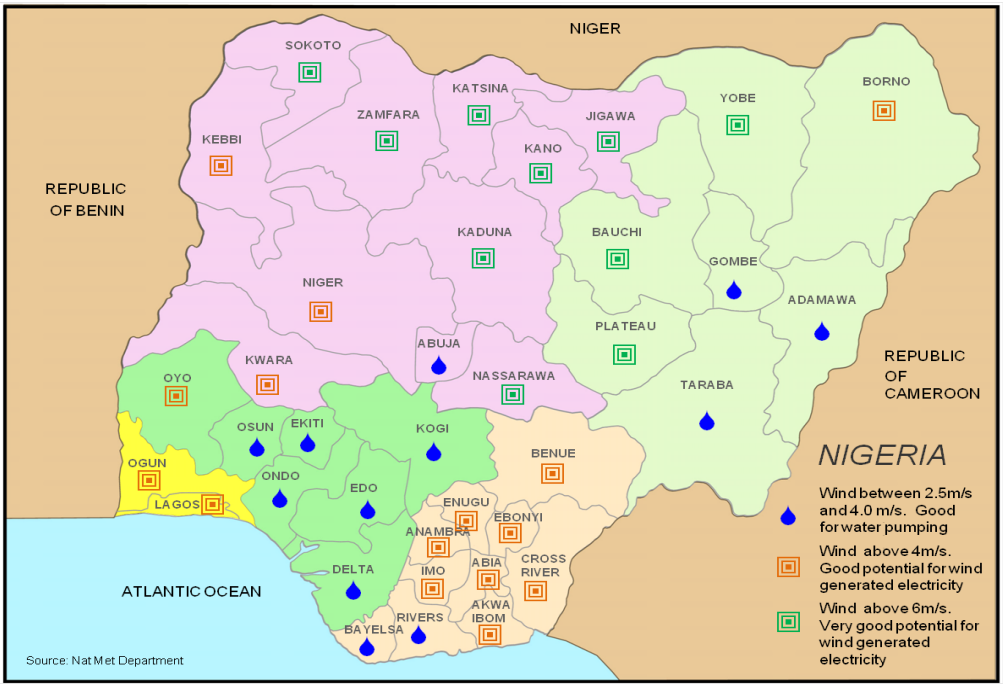

Figure 2: Wind strength across the country
(Source: http://www.neenigeria.com/Nigeria_wind_NEW.png)

2.1.4. Biomass energy: this is the oldest source of energy ever used by mankind. Its attraction lies in its abundance, cheapness and accessibility. Biomass energy is generated directly or indirectly from biological sources ranging from plants, algae, micro-organisms to animals. Thus, Nigeria has abundant biomass resources from which biomass energy could be generated. These biomass resources include: grasses and shrubs, water hyacinth, agricultural residues, livestock manure and animal wastes, urban refuse and industrial wastes. Generally, both food and non-food biomass could be converted into biofuels and they may either be solid, gas or in liquid forms [20]. Biomass is converted into electric power through several methods. These methods range from direct combustion, gasification, pyrolysis, fermentation of wet wastes to anaerobic digestion.

The various biomass conversion methods are specifically suitable for different biomass resources. In other words, different types of biomass require different forms of processes based on the type of energy that is being targeted to be produced. For instance, woody biomass, namely pellets, sawdust and wood chips as well as other categories of wastes like household refuse, dry organic wastes, industrial and agricultural wastes are combusted or gasified to generate electricity [23]. Similarly, both anaerobic digesters and pyrolysis are used to convert wheat straw residues, corn stover, and special fast growing trees into biogas, bio-oil or biofuel. Wet wastes such as those from animals and humans are also converted into energy through anaerobic digesters [15].

Nigeria has a great potential to generate bio-energy as a result of the availability of biomass resources. Although available data do not appear to converge, anecdotal evidence based on Nigeria's

population and the volume of domestic and industrial refuse generated by households and industries respectively, which often overwhelm waste management authorities across the country, it could safely be said that Nigeria can generate the necessary biomass resources to generate electric power. While Shaaban and Petinrin [11] assert that Nigeria can obtain 200 million tonnes of dry biomass from forage grasses and shrubs to generate energy, Aliyu, Dada & Adam [20] aver that Nigeria generates about 227,500 tonnes of animal waste on daily basis, which could potentially produce about 6.8 million m^3 of biogas per day. This is based on the calculation that a kilogramme of fresh animal waste yields about 0.03 m^3 of biogas [24].

The use of firewood or fuel wood is also an aspect of biomass energy. As a result of energy poverty, it is estimated that more than 70 percent of the people in the rural areas depend on fuel wood and associated charcoal for their household energy needs [25]. What this indicates is that although fuel wood is critically important to many poor households since it contributes to their energy provision, it also hurts the environment by putting pressure on forest resources and contributing to deforestation and degradation [26. Notwithstanding that the global charcoal trade in 2015 amounted to 2.6 million tonnes and Nigeria was ranked alongside Indonesia, Myanmar, Namibia, and Poland as a top charcoal-exporting country [26], the current energy policy of Nigeria deemphasizes the use of fuel wood for energy [25, 27].

2.1.5. Geothermal energy: Nigeria has the resources through which it can derive geothermal energy. Across the Northern and Southern regions, there are major river basins, river alluviums, deltaic sediments, sandstones and basalt deposits that signpost potential geothermal resources for energy generation[22]. Thus, the geology of Nigeria indicates the viability of generating thermal energy considering the availability of such geothermal resources as lavas, hot springs, geysers, fumaroles, volcanoes and mud pots [28]. According to Brimmo et al [22], "geothermal energy is derived from heat generated by Earth's formation, and subsequent radioactive decay of the earth's minerals. This heat is driven from the core to surrounding rocks which superheats ground water, pressurizing it to the surface." The current situation with geothermal energy is that it is uncommon and not in the forefront of energy mix being seriously considered for electricity generation in Nigeria.

2.1.6. Wave and tidal energy: Nigeria's massive coastline of 853 kilometers provides prospects for the harnessing of energy from the wave and tides of the ocean. Wave and tidal energy is derived from the oceans and seas. As Amoo [29] has explained, "tides are caused by the gravitational pull of the moon and the sun on the rotating earth. The associated motion of these bodies leads the surfaces of the oceans to be raised and lowered periodically, according to some interacting cycles." Thus, wave and tidal energy could be seen as a form of hydropower that depends on the conversion of the rising and falling of the ocean and sea levels to generate electricity. Waves are prominent in the oceanic areas of Nigeria and thus could be harnessed to produce electricity. However, this is not the case as wave and tidal energy is yet to be exploited at all in Nigeria [27, 29]. Thus, what is required is to mainstream wave and tidal energy into Nigeria's prospective scheme of low-carbon, clean energy and environmentally-friendly energy mix as well as initiate dedicated research in this sector.

2.2. Non-renewable energy resources

Nigeria is rich in non-renewable energy resources, which mainly consist of hydrocarbons. Not only is Nigeria richly endowed, it is classified as a major oil producing country. Thus, hydrocarbons occupy a very important place in its economic development. Except for the period between 2004 and 2009 when rebellion which was orchestrated by the Niger Delta militants disrupted oil production activities, Nigeria's oil production outputs average between 2.1 and 2.5 million barrels per day [30]. Additionally, in terms of the outlay of oil production activities, Nigeria had cumulatively produced some 75.9 billion barrels of crude oil between 1960 and 2016 [31].

Notwithstanding this volume of crude oil production, the proven reserves of Nigeria's crude oil stock was estimated at 37.453 billion barrels in 2016, thus placing it on the 11th position among oil

producing countries [31]. Furthermore, the Nigerian government projects to expand the volume of proven oil reserves to 40 billion barrels by 2020 [32]. Nigeria is also enormously endowed with natural gas. Its enormous natural gas holdings in terms of proven reserves which were 5,475.2 billion standard cubic meters as at 2016 placed it among the top 10 in the world [31]. In addition to these enormous reserves, the cumulative marketed natural gas between 1970 and 2016 was put at 88,312.4 million standard cubic meters [31]. Nigeria's thermal stations which have total installed capacity of 10,142MW depend on natural gas to power them. However, the thermal stations barely meet the target as they operate at less than 25 percent of installed capacity. A major challenge often cited as being responsible for poor electric power generation is shortfall in gas supply as a result of either mechanical fault or sabotage [33].

Nigeria also has significant deposits of high quality lignite coals. Coal deposits are found mainly in the Anambra basin and the Benue trough with some minor deposits in the stretch of the Bida and Sokoto basins [34]. Coal was the first conventional energy resource that was discovered and utilized in Nigeria. Coal reserves are estimated at 2.8 billion tonnes in 17 identified coalfields with proven reserves of 639 million tonnes [6,35]. Although coal contributed to the economic development of Nigeria from the time it was discovered in Enugu, Nigeria in 1909 to the 1960s, it has since been abandoned. In other words, Nigeria's coal resources have remained unexploited following their abandonment. Before its abandonment, coal production in Nigeria peaked at 790,030 tonnes in 1956 and about 70 percent of this amount went into the country's energy generation [6].

Coal played an important role in Nigeria's early quest for industrialization before it was displaced by the combination of crude oil, which was discovered in commercial quantity in the country and the global evolution from coal-powered to oil-powered industrialization. According to Odesola, Samuel and Olugasa [36], coal production facilitated the expansion and consolidation of such firms as the defunct National Electric Power Authority (NEPA), the Nigerian Cement Factory, the Nigerian Railway Corporation (NRC), and other industrial ventures. The major interrelated reasons for the abandonment of coal by Nigeria included: its diminishing lucrativeness due to oil, the modernization processes by those firms which had hitherto relied on coal for their operations, dwindling export profile due to declining global demands and the effects of the Nigerian civil war [6,36].

But coal is still relevant in augmenting global energy needs as exemplified by its contemporary resurgence in terms of usage despite concerns about climate change. It was estimated that 6.6 billion tonnes of coals were consumed worldwide in 2012 especially to augment shortfalls in energy requirements [37]. The strongest demand for coal as well as its biggest market is Asia as countries like Japan, Chinese Taipei and Korea use it to supplement their energy requirements to generate electricity and steel production due to the shortfall of natural energy resources [37]. In addition to electricity generation and steel production, coal has many important uses, especially in the manufacture of cement and as a liquid fuel. Furthermore, the high quality of Nigerian coal, due to its low sulphur and ash content as well as low thermoplastic properties, makes it ideal for "boiler fuel, production of high calorific gas, domestic heating, briquettes, formed coke and the manufacture of a wide range of chemicals including waxes, resins, adhesives and dyes".

The paradox of Nigeria's coal sector is that the country imports coal even with its abundance and high quality as it is mostly lignite and sub-bituminous. This is despite the announced intention of the Nigerian government to generate 30 percent of its electricity from coal [38-39]. There appears to be efforts in this regard going by the various coal electricity projects that have been flagged off in Nigeria since 2013 which target to generate and supply coal-derived electricity of 4,800 MW [6] but as at now, coal is yet to make contributions to Nigeria's energy mix. The total result of this effort remains to be seen as some of the projects expected to be completed in 2015 are still on-going.

3. Linking Environmental Degradation to Energy Insecurity and Energy Poverty

Nigeria has several energy resources to guarantee energy security. Like the concepts that have the term "security" attached to them, energy security is multidimensional and highly context-dependent as it is variously interpreted in terms of the perceptions of different stakeholders [40]. The term "energy

security" has metamorphosed over time to acquire a wider meaning. It has transformed from preoccupation with uninterrupted or stable supply of, and access to, oil to encompass a wider range of issues relating to energy policy problems such as providing equitable access to modern energy, issues of pollution and environmental degradation, energy efficiency and mitigation of climate change [40-43].

Although Månsson, Johansson and Nilsson [40] have noted the difficulty of a single definition that could offer an acceptable interpretation of energy security due to differences in perspectives and priorities, this paper is inclined to conceptualize energy security in terms of having "access to clean, reliable and affordable energy services for cooking, heating, lighting, communications and other productive uses" (cited in [44]). Therefore at the epicenter of energy security are the considerations about whether energy resources are available in the required quantities and if so, whether they are accessible in terms of easy procurement; whether they are affordable, which is concerned with their cost and ease of payment by various segments of the society; and the consideration of acceptability, which is preoccupied with the question of whether or not these energy resources are harming the environment or indeed contributing to environmental sustainability [41]. Energy security, therefore, underpins the formulation of energy policy strategies. Energy security plays some roles in the economies of countries considering the centrality of energy resources in driving contemporary global development. Thus, there is a link between energy insecurity and energy poverty.

Nigeria possesses real potentials to ensure energy security on account of its endowments. In other words, it can produce more than enough energy from diverse energy sources, with the exception of nuclear sources, to meet national energy requirements. Paradoxically, despite Nigeria's endowments with energy resources, it is confronted with energy poverty such that majority of its population lacks access to modern sources of energy. Energy poverty manifests differently in various regions of the world but it essentially depicts energy vulnerability and deprivation arising from non-availability of energy resources or the inability of people to access adequate energy for their needs due to unsustainable costs. Non-availability of energy resources has a tendency to affect affordability by households. Thus, energy poverty results from unsustainable increase in the costs of energy in the face of stagnation in the average income of households [45] or national incapacity to produce energy resources in such magnitude as to satisfy the needs of the population. The non-availability and expansionary trend in energy costs without commensurate increase in household incomes have increased household expenditure on energy thus deepening the dilemma of households, particularly those with lower incomes.

The different circumstances of developed and developing countries underpin their divergent thresholds benchmarking energy poverty. For instance, although there is a wide distinction at the country level in the European Union about the benchmarks for energy poverty, they oscillate around struggling to achieve adequate warmth by households; inability to promptly pay utility bills; incommensurate energy bills in relation to household incomes and general negative effects on people's health and well-being due to insufficient energy services in the home or inadequate access to energy resources [45, 46]. Specifically, the UK has benchmarked fuel poverty through its low income high cost (LIHC) indicator. Within the framework of this indicator, a household is classified as fuel poor if it is operating a "relatively energy inefficient home, and stands to be left in relative income poverty as a result of paying fuel bills assuming they heat their home to the recommended regime" [47]. Notwithstanding the nuanced benchmarking of energy poverty, it generally denotes both non-availability and a lack of financial capacity to afford the type of energy which households require for normal functionality.

In Nigeria, energy poverty encompasses non-availability of energy resources in the diversity necessary for households to sufficiently make choices, financial constraints to access energy services, and general unavailability of modern energy resources that are clean, safe to the environment and support economic and human development in terms of meeting the basic needs of households and economic activities in the productive sector. A major sustaining factor of energy poverty in Nigeria is lack of diversification. Thus, national energy development has traditionally depended on Nigeria's oil

sector to power domestic energy needs. This has thrown up a host of prominent challenges like resource constraints, inadequate generation and distribution of energy and environmental pollution with serious implications for human security, national development and environmental sustainability [48].

4. The Implications of Energy Poverty on Environmental sustainability

It may be difficult to sustain a green environment in the face of energy poverty as households must find alternative energy sources to meet shortfalls in their domestic requirements. And most times these alternatives have negative impacts on the environment. Nigerians are grossly energy poor on many fronts, especially in the provision of both refined petroleum products and electricity. Thus, households have evolved survival strategies that undermine environmental sustainability. For instance, only about 40 percent of Nigeria's 193 million people have access to electricity [27].

Nigeria is a major oil producer and exporter as well as a member of OPEC. Despite OPEC's quotas to deal with market fundamentals in the international oil market, Nigeria's oil production outputs have averaged between 2.1 million barrels per day. However, in extreme cases of sabotage and vandalization of oil production pipelines, the outputs record declines [48]. Despite Nigeria's status as an oil producer, it is unable to satisfy domestic demand for refined petroleum products. As a result of its incapacity to domestically refine sufficient quantities of petroleum products to satisfy the populace, Nigeria imports these products. For a long time now, Nigeria has been subsidizing the importation of refined petroleum products by up to US$ 3.85 billion yearly [49].

Nigeria operates four refineries whose combined nameplate capacity is 445,000bpd, yet the country imports more than 90 percent of refined petroleum products needed for domestic usage. *Table 1* below shows a 5-year capacity utilization of the four refineries. The nature of the underperformance of these refineries is underscored by the level of their capacity utilization. Since 2014, none of them has produced up to 20 percent of its nameplate capacity [50] with the effect that Nigeria is now a net-importer of refined petroleum products (*See Table 2 below*). Notwithstanding the subsidies on refined petroleum products, it is generally believed that these petroleum products are priced out of the reach of the average citizen.

Table 1: 5-Year Capacity Utilization of Refineries (%)

Refinery	Total Installed Nameplate Capacity	2012	2013	2014	2015	2016
Kaduna Refining & Petrochemical Co. Ltd	**110,000bpsd***	**29.12**	**29.33**	**9.24**	**2.98**	**9.24**
Port-Harcourt Refining Co. Ltd**	**210,000bpsd**	**11.95**	**9.18**	**17.28**	**4.66**	**17.28**
Warri Refining & Petrochemical Co. Ltd	**125,000bpsd**	**27.88**	**35.99**	**12.03**	**7.07**	**12.03**

Source: NNPC 2016, 20**. *bpsd:** barrels per stream day. **PHRC Ltd is made up of two refineries: The first refinery nameplate capacity of 60,000bpsd commissioned in 1965 and the second refinery with an installed capacity of 150,000 bpsd commissioned in 1989.

Table 2: Importation/Consumption Profile of Refined Petroleum Products, 2014-2017 (In Litres)

Product	Description	2014	2015	2016	2017
Premium Motor Spirit (PMS)	Imported	18,572,793,515	18,794,323,749	18,660,108,114	17,313,512,018
	Distributed/ Consumed	17,591,021,628	17,779,846,057	17,382,007,474	18,335,739,889
	ADC*	48,194,580	48,711,907	47,491,824	50,234,904
Automotive	Imported	3,483,665,839	3,875,483,242	4,665,966,344	4,277,630,139

Gas Oil (AGO)	Distributed/ Consumed	3,314,583,036	3,249,662,707	3,896,774,724	4,748,102,354
	ADC*	9,081,049	8,903,185	10,646,925	13,008,500
Household	Imported	2,939,640,169	1,824,619,750	548,651,307	340,333,700
Kerosene (HHK)	Distributed/ Consumed	2,956,144,224	1,714,053,716	951,571,008	944,390,851
	ADC*	8,099,025	4,696,038	2,599,921	2,587,372

Source NBS, 2018; *ADC: Average Daily Consumption

In the electricity sector, Nigeria's total installed electricity capacity is 12,522MW consisting of 10, 142MW from thermal sources and 2,380MW from hydropower sources. Despite the gross inadequacy of this installed power generation capacity, the actual output has never been anywhere near that mark. As a matter of fact, power generation has normally hovered between 3,000 and 4,000MW, and on some occasions even less. If this is juxtaposed with the projected national demand of 98,000MW to achieve energy security, then it shows how energy poor Nigerians are. This also explains why only about 40 percent of Nigerians have access to power supply and the high incidence of power outages. The implication is that those without access to energy find alternative sources of energy with implications for the environment.

The Nigerian environment is rich due to the diversity of forests and wildlife. It is estimated that Nigeria's forests support wildlife consisting of at least 899 species of birds, 154 reptiles, 53 amphibians, 274 mammals and 4,715 species of higher plants. Besides timber and fuel wood, there are abundant non-timber forest products (NTFPs) ranging from medicines, pharmaceuticals, bio-chemicals, aromatics and toxins, food and forage, fiber to ornamentals which also constitute means of livelihood to households, especially in the rural areas [51]. However, Nigeria has been losing its forest resources at a pace this is unsustainable. For instance, between 1990 and 2005 it lost nearly 80 percent of its old-growth forests which was unprecedented. It was qualified as the highest rate of deforestation of natural forest in the world during that period. In a similar vein, FAO sources indicated that while Nigeria's forest cover was 17.5 million hectares in 1990, it declined to 13.5 million hectares in 2000 (cited in [51]). The implication of this depletion is that Nigeria recorded a forest cover loss of 2.6 percent or approximately 400,000 hectares per annum. At this rate of consumption of forestry resources, experts have warned that Nigeria might not have forests by 2047 [52]. Recently, the Nigerian Conservation Foundation estimated that the country had lost about 96 per cent of its original forest[53]. It is imperative that the Nigerian government boosts other energy sources, in terms of availability and affordability, as a countermeasure to the continued use of fuel wood as a source of energy. However, this problem could be solved by converting the ubiquitous mountains of refuse across Nigeria into much-needed energy. An example can be found in Ethiopia where Africa's first waste-to-energy plant has been installed to incinerate 1,400 tons of waste per day. According to Mourdoukoutas [54], the Ethiopia Reppie thermal plant has capacity to handle and convert 80 percent of Addis Ababa's waste into electricity and thus provide 30 percent of the energy needs of its about 3 million inhabitants.

5. Conclusion

The relevance of energy in the matrix of national development is already established. Energy availability and consumption per capita constitute an index to evaluate the quality of life and development of a country or region. Nigeria is an energy poor country even though it has the resources to ensure reasonable energy sufficiency. A major reason for Nigeria's seeming energy poverty is its sole reliance on non-renewable energy sources and non-utilization of its abundantly available renewable resources.

Undoubtedly, Nigeria needs to boost its energy generation considering the huge gap between what it needs (about 98,000MW) and what it is currently producing (between 3,000MW and 4,000MW). The impact of energy poverty is felt on the environment both directly and indirectly. Nigeria's forestry resources are being lost at a very fast rate. Not only are trees lost through logging for use as fuel wood as well as for other purposes but also non-timber forest products (NTFPs). All these have negative implications for the environment, economic activities and the people, including health challenges due the effect of inefficient combustion of solid fuels (The Secretary-General's Advisory Group on Energy and Climate Change, 2010). Currently, all the various sources of renewable energy are not exploited by Nigeria. In other words, renewable energy does not play any role in Nigeria's energy mix. Sustainable energy must necessarily rely on a multiplicity of energy sources.

Therefore, this paper recommends that Nigeria scales up its quest for energy security by expanding its energy mix to include renewable energy. Thus, what it needs to do is to pursue the implementation of its renewable energy master plan (REMP), attract investors in the various areas of renewable energy development, invest in further research for evidence-based data and evolve plans to develop domestic capacity to drive the entire process.

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