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Exploring the potentials, barriers and option for support in the Nigeria renewable energy industry

Gbadebo Collins Adeyanju[1] · Oluyomi A. Osobajo[2] · Afolabi Otitoju[3] · Olushola Ajide[4]

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Abstract
Climate change remains a pivotal area and a persistent challenging issue for deliberation among the nations of the world. Most especially in a country like Nigeria, where fossil fuel remains a pivotal source of socio-economic development and well-being of the society. Transforming the Nigeria electricity sector into a source for reducing the country's carbon emission remains a significant challenge to policymakers, i.e. the Government. This is attributed to the fact that the nation's primary energy sources come from traditional biomass and fossil fuel such as coal, and natural oil and gas, which has contributed significantly to the level of carbon emissions. In this paper, we explored and identified the potentials, barriers and option for renewable energy in Nigeria. The findings of the review revealed that the Nigerian electricity sector is crucial to reducing the carbon emission generated in the country. Likewise, it is of no doubt that Nigeria is endowed with a different mix of renewable energy sources. Hence, exploring and developing these renewable energy sources will aid the effort of the government in reducing the country's input to the global carbon emission, instrumental to the socio-economic development of the country and improved well-being of the society at large. Also, policy recommendations to foster renewable energy development were identified.

Keywords Renewable energy development · Renewable energy sources · Climate change · Private sector · Nigeria

1 Introduction

Climate change remains a pivotal area and a persistent challenging issue for deliberation among the nations of the world in the twenty-first century. These changes have been attributed to the resultant effects of human activity and natural variability [1, 2]. Yet, the Inter-Governmental Panel on Climate Change (IPCC) observed that the ongoing discussion has focused on human activity as a significant cause of global warming. This has been linked to the resultant impacts of globalisation, which fosters increased industrialization in both developed and developing countries. Also, has further led to the release of greenhouse gases such as carbon dioxide (CO2), water vapour (H2O), methane (CH4), nitrous oxide (N2O) and ozone (O3) into the atmosphere [3, 4].

To find a workable solution to climate change challenges, different organisations such as the IPCC, and United Nation Framework Convention on Climate change are trying at identifying different strategies that could help combat the negative impacts of climate change globally [3]. Yet the emissions of greenhouse gases remain on the increase with the energy sector, contributing almost 72% of the global emissions as shown in Fig. 1.

✉ Gbadebo Collins Adeyanju, gbadebo.adeyanju@uni-erfurt.de | [1]Centre for Empirical Research in Economics and Behavioural Science (CEREB), University of Erfurt, Nordhauser Street 63, 99089 Erfurt, Germany. [2]Aberdeen Business School, Robert Gordon University, Aberdeen, Scotland, UK. [3]Africa Partners Initiative e.V. (API), Meyfartstr. 16, 99084 Erfurt, Germany. [4]Head of Partnership Development, FOL, Aberdeen, Scotland, UK.

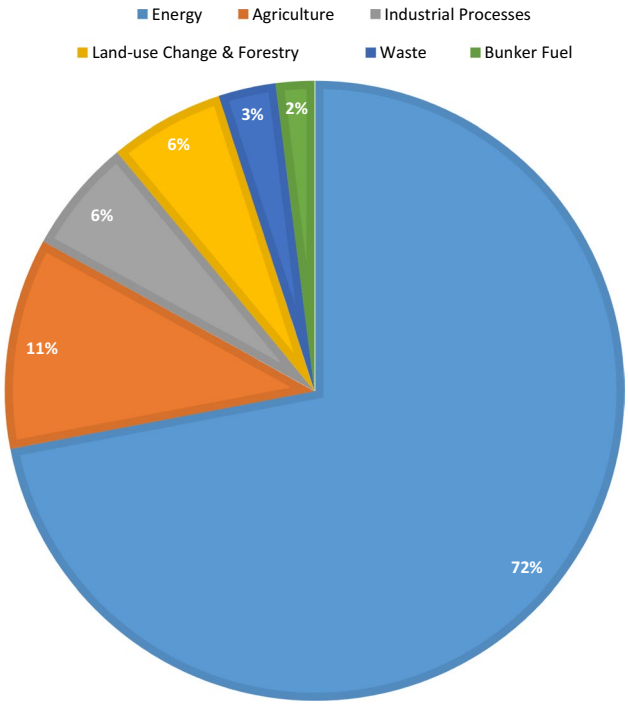

Fig. 1 Global greenhouse gas emissions by sector (Source: [5])

Scholars and researchers have argued that fossil fuel such as coal, and natural oil and gas are the main sources of energy and has contributed to CO2 emissions level significantly [6]. This has been linked to the increase in the demand for energy consumption in developed countries due to population growth, economic growth and urbanization [7]. Hence, an increase in environmental emission impacts (as shown in Fig. 2) has given rise to prolonged droughts, sea levels overflow, rising heat waves and crop damage [8]. This is consistent with numerous studies assertion that energy is a significant determinant driving global emissions [9]. Hence, renewable energy has been highlighted by researchers and scholars as a way of obtaining and improving environmental efficiency [10]. This is consistent with the International Energy Agency projection that the quota of renewables in primary energy use will rise from 13 to 18% by 2035. This is because renewable energy is classified second to electricity production due to increasing growth of bioenergy and hydropower.

Nigeria, known as the giant of Africa with a population of about 200 million people has the fastest striving population in Africa with an annual growth rate of 2.6% contribute 0.5 metric tons per capita of CO2 emission to the global emission in 2014. Even though Nigeria's contribution to CO2 emission is below the sub-Saharan average of 0.8 metric tons per capita, the country's fast population growth is accompanied by an equal growth in its CO2 emission rate. This is due

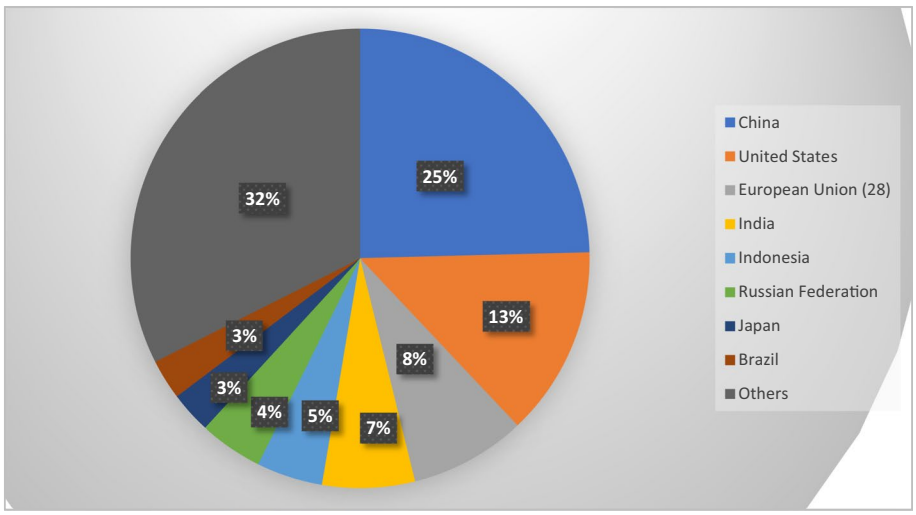

Fig. 2 Global greenhouse gas emissions by country (Source: [5])

to an increase in energy use, which calls for immediate attention to be given to sustainable ways of providing energy. Oyedepo [11] asserted that the lack of access to clean energy continues to be a significant challenge for Nigeria. This is because the country's socio-economic development is greatly influenced by power, i.e. energy. Energy Information Administration [12] asserted that about 39% of the Nigerian population lack access to electricity. Hence, most of the country's energy comes from coal, and natural oil and gas, which are fossil fuel sources of energy. This suggests that over 74 million people, which is more than one-third of the Nigerian population is a victim of the situation. This is consistent with the Nigeria Power Baseline Report claim that oil accounts for almost 57% of the Nigeria energy mix, followed by 36% of natural gas and 7% from hydroelectricity. As a result, other energy sources, such as renewable energies play a less significant role. Yet scholars and researchers have argued that Nigeria could meet its energy demands and have a higher chance at success using renewable energy sources [13, 14].

This paper aims to evaluate option available locally to Nigeria for a low-carbon development path by analysing the prospects for renewable energy markets. The paper follows this sequence to achieve the stated aim. Section 2 discusses Nigeria amid global climate change. Also, the section critique the impacts of climate change on Nigeria and the nation's contribution to the global climate change. Section 3 critiques the Nigerian electricity sector as a significant source of greenhouse gas emission and how the different reforms within the sector have failed in reducing the nation's greenhouse gas emissions. Section 4 identifies and discusses the significant barriers to renewable energy development in Nigeria. Section 5 explores and assesses the potential of promoting the private sector investment active participation in the Nigerian electricity sector. Section 6 discusses the need for further action and recommendations.

2 Nigeria amidst global climate change

The African continent is vulnerable to the impacts of climate change [15]. This is due to its high dependence on agriculture, ecosystem services and poverty. Brown, Chanakira, Chatiza, Dhliwayo, Dodman, Masiiwa, Muchadenyika, Mugabe and Zvigadza [16] added that the African continent is prom to a sharp increase in temperature and inter-annual variability of rainfall events due to climate change. These views are consistent with Muller, Waha, Bondeau and Heinke [17] assertion that countries within the African continent are projected to experience changing rainfall patterns, increasing temperatures, floods and droughts. Dube, Moyo, Ncube and Nyathi [18] concluded that African continent is most vulnerable to climate change due to its geographical positioning, dependency on agriculture, socio-economic gaps in governance, high rates of poverty, government financing, and growing population. However, climate change impacts on the African continent are not evenly distributed [19].

Nigeria, like other countries in Africa, is vulnerable to climate change in areas such as agriculture, energy, health, biodiversity, land use and water resources [20]. Odjugo [21] added that Nigerian citizens, buildings and social infrastructures are vulnerability to climate change due to wind, rainstorm, flooding and erosion. This is consistent with Enete and Ezenwanji [22] assertion that Nigeria will felt the impacts of climate change more because of the continuous increase in the sea level along her 800-km long coast time, flooding and erosion disasters, land degradation and worsening desertification. Alawa, Asogwa and Ikelusi [23] stated further that the conventional farming practice among Nigerian farmers, which involves setting fire on agricultural lands and other residues contributes significantly to the CO2 emission and thus, increase climate change issues. Likewise, Agbola and Fayiga [24] claimed that emission of greenhouse gases from open burning, gas flaring, use of solid fossil fuel for cooking, vehicle emissions and deforestation are the major sources of climate change in Nigeria. This is consistent with Mbah, Ezeano and Saror [25] conclusion that bush burning, deforestation, burning of firewood for cooking, use of inorganic manure, overgrazing of farmland by livestock and increase in population, which leads to loss of farmland are the significant sources of climate change. Arguably, the potential impacts of climate change on Nigeria will affect the entire environmental, social and economic landscape.

Odekunle and Adejuwon [26] asserted that there had been a decline and persistent decrease in rainfall in Nigeria over the last few decades. This is consistent with Odjugo [21] claim that there is an increase in temperature and a reduction in the amount and duration of rainfall. Onuoha [27] added that climate change impacts on agriculture would be evidence through changes in water and land regimes to changes in the intensity and frequency of flooding, droughts, worsening soil conditions, water shortages, desertification, pest and disease outbreaks on livestock and crops. Arguably, one could conclude that climate change will have an impact on almost every facet of the Nigerian economy such as food production, health, water supply and energy.

The impacts of climate change are considered severe for agricultural production output. Against this background, scholars such as Onyenechere and Igbozurike [28] claimed that the reduction in agricultural production resulting in food

crises could be attributed to other factors such as lower yield. Anyoha, Nnadi, Chikaire, Echetama, Utazi and Ihenacho [29] argued that global climate change had intensified reduced productivity in agricultural production. For example, there has been variation in the planting seasons in Nigeria due to the inability of local farmers to predict rain incidence based on past statistics and observations. Likewise, prolong occurrence of drought is common in majority parts of the country. Hence, resulting in either too early or late crop planting and decreased water availability. Besides, a significant proportion of the Nigerian populace is endangered with poor and inadequate water supply. This is in line with Ohwo and Abotutu [30] assertion that less than 30% of the Nigerian population has direct access to potable water. Hence, Nigerians are at risk of water stress. This could be attributed to the escalated inconsistency in rainfall due to climate change resulting in a decrease in surface water resources and droughts in some part of the country.

Nigeria, like any other country in Africa, also contribute to the global greenhouse emission. Figure 3 present greenhouse gas emissions with Nigeria identified as the second most emitter of greenhouse gas emission in Africa. Nigeria is enriched with the abundance of fossil fuel-based energy utilisation and production, which is a significant contributor to global warming [31]. This is consistent with Cruz, Sequera, Molina, Picon, Pillich, Ghebreegziabhe and Bornstein [32] assertion that there is a link between fossil fuel energy utilisation or production and climate change. Shaaban and Petinrin [33] argued that because of continuous gas flaring due to oil and gas companies' activities and operations in the Niger Delta region, Nigeria had been rated the second highest producer of greenhouse gas emissions in Africa.

While fuel and energy generation sources such as firewood, gas, kerosene, charcoal and electricity are available at the disposal of the Nigeria populace, wood and charcoal fuel consumption are on the increase. This is consistent with Ogwumike, Ozughalu and Abiona [34] assertion that due to poverty and the rise in fuel prices such as liquefied petroleum gas and electricity, many households in Nigeria have reverted to the use of firewood and charcoal. Likewise, Ali and Victor [35] claimed that despite the significant shift in household energy use, many households (both in rural and urban areas) rely exclusively on charcoal as their primary source of cooking energy. This is consistent with the United Nations argument that charcoal is becoming a choice fuel for over 52% of the urban population. Oyedepo [11] concluded that both the urban and rural households (i.e. 86% and 42% respectively) largely depend on wood as an energy source with about 94% of them using a stove and/ or open fire without chimney despite its detrimental effect on land and forest degradation, human health and climate change. This is consistent with Egwuonwu and Nweke [36] argument that continuous fuelwood utilisation in Nigeria has given rise to environmental issues such as desertification, flooding and changes in the country's climate condition.

To combat the impact of climate change, Nigeria has expressed its commitment by joining the Kyoto Protocol, and the United Nations Framework Convention on Climate Change, in 2004 and 1994, respectively. In addition to being a signatory to the Paris Climate Agreement, Nigeria has implemented various clean development projects. Yet, fossil fuel and traditional biomass, which are the dominant source of carbon emission, remain the backbone of the nation's energy sector.

3 The Nigerian electricity sector

Nigeria began generating electricity in 1896. However, Nigerian Electricity Supply Company, which was recognised as the first and formal utility corporation, became operational in 1929. By the year 2000, the National Electric Power Authority (NEPA), which is a solely owned by the state oversaw the generation, distribution and transmission of power, i.e. electric in Nigeria [37]. However, the Nigerian electricity sector experienced a reform in 2001 with the pronouncement of a new policy in support of the National Electric Power in the country. The policy's main objective is to establish an operational

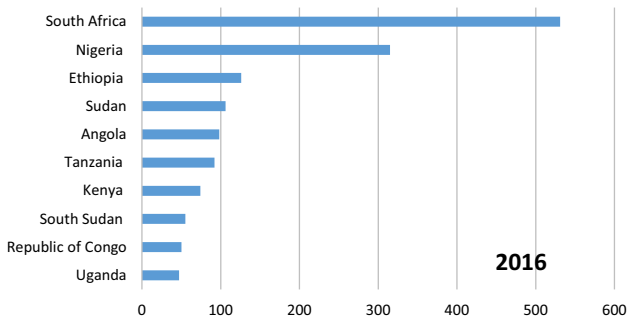

Fig. 3 Greenhouse gas emissions over 165 years (Source: [5])

and sustainable electricity market in the country [38], by relinquishing the management and ownership of the electricity sector to the private sector. This involves committing the sector assets and infrastructure into a private hand.

In line with the Electric Power Sector Reform (EPSR) Act, the Nigerian Electricity Regulatory Commission (NERC) was created in 2005 to oversee the activities and operations of the electricity industry as an independent body. Also, the Power Holding Company of Nigeria (PHCN), which is a transitional corporation, was established. The PHCN comprises of one transmission company, six generation companies and eleven distribution companies, which forms the eighteen successor companies [39]. Figure 4 presents the structure established under the EPSR Act.

Furthermore, in 2010, the Nigerian Bulk Electricity Trading Plc (NBET) was created as a reliable off-taker of electric power produced by generation companies. However, the Federal Government of Nigeria retained the ownership of the transmission company while all distribution and generation companies were privatised by 2013 [40]. The Transmission Company of Nigeria (TCN) does not only own the transmission but also operates the national transmission systems.

The main sources of energy used in electricity production in Nigeria are thermal and hydro, which are approximately 80% and 20% respectively. Other energy sources such as renewable energy sources (solar, wind and biomass) contribute less than 1% [41]. At 200.79 trillion cubic feet, Nigeria is categorised among the world ten largest gas reserves [12]. However, the TCN is operating at a very low capacity utilisation. The nation's estimated electricity demand of 17,520 Megawatt (MW) (including suppressed and latent demand) surpasses the 5,300 MW peak generation capability. Arguably, the country's electricity system is characterised by a huge gap between demand and supply. Ikpe and Torriti [42] concluded that the demand for electricity resulting from industrial development has grown and exceeded supply.

At presently, about 40.7% (i.e. seventy-six million people) of the populace, which is double of Canada population are not linked to the national power grid [43, 44]. Besides, about 90% of those connected to the national grid do not receive any power supply. Even though the total installed generation capacity is 12,522 MW, only 2519 MW reaches the final consumer as 7.4 and 27.7% of the generated capacity of 3,879 MW is lost during transmission and distribution, respectively. Yet, it is forecasted and estimated that the electricity demand for Nigeria will reach 21,000 MW by 2020. This has given rise to Nigerians self-generating their electricity, which is highly polluting and more expensive than the cost of grid-based power [45]. Table 1 presents the electricity supply source categories in Nigeria.

Emodi, Chaiechi and Beg [47] stated that the electricity demand is expected to rise significantly in the coming years. This is because electricity demand by household, which has the largest share of the electricity demand will increase because of growing urbanization and it is estimated to grow at a rate of 4.23% per annum. Also, the population growth is estimated to grow at a rate of 2.7% per annum, which is twice the global growth rate of 1.1%. Besides commercial and industrial demand is predicted to rise with projected gross domestic product rates trending between 4.50 and 7%.

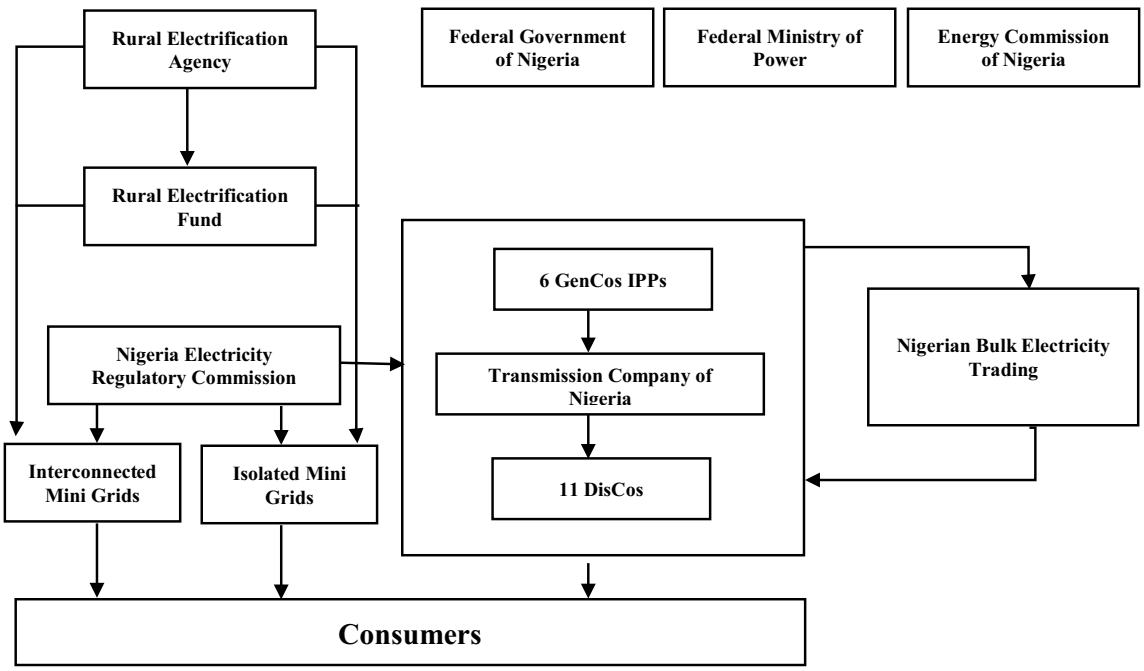

Fig. 4 Nigerian Electricity Sector Structure (Source: Authors')

Table 1 Source categories of electricity supply in Nigeria (Source: [46])

Source of Supply	Description
Grid-supply	Power grid generation
Off-grid A: backup	It is used when grid-supply power is not available
Off-grid B: full time ≥ 1 MW	This requires government registration. This category of the power supply is used full time. Although, the source gives room for grid access, which generates equal to or greater than 1 MW
Off-grid C: full time < 1 MW	This source of supply is free of government registration. Also, it is used full time. Although the source only gives room for grid access, which generates less than 1 MW
Off-grid D: no grid access	This source focuses mainly on rural power generation and lacks access to the grid

To meet this challenge, the Nigerian Government released the Power Sector Recovery Plan (PSRP) 2017–2021. The recovery plan seeks to transfer the management and ownership of the government wholly-owned power sector to private hands through policy and regulatory actions, financial, governance and operation. The recovery plan objectives are:

1. Restoring the Nigerian Power Sector's financial viability.
2. Meeting growing demand by improving power supply reliability.
3. Promoting transparency by strengthening the Nigerian Power Sector's institutional framework.
4. Encouraging and implementing investors' confidence through the implementation of transparent and sustainable policies within the sector.
5. Establishing a contract-based electricity market.

In the medium to long-term, the government, through policy intervention, seek to increase and improve access to electricity by implementing off-grid and renewable energy solutions and creating frameworks for the off-grid development plan. Even though the Nigerian electricity sector contribution to greenhouse emission is small compared with the oil and gas sector, an electricity supply is likely to experience rapid growth due to increase in energy demand, economic growth and improvement in living standards.

4 Barriers to renewable energy development in Nigeria

Nigeria, as a nation has only been able to make little progress in the deployment of renewable energy sources just like other countries in Sub-Saharan Africa [14, 31].

4.1 Reliance on fossil fuel

Nigeria economy depends largely on the oil and gas industry [48]. Hence, oil and gas remain the backbone for its power sector. After the Middle East countries, Nigeria is recognised as one of the leading oil and gas exporting nations in the world due to its relative abundance in oil and gas products. However, the low cost of petroleum fuels remains a significant barrier to deploying alternative sources of energy. This is because fossil fuels (i.e. natural oil and gas) source of electricity generation is relatively cheap. Hence, it remains a threat to renewable sources of electricity generation. In the same manner, Aliyu, Modu and Tan [49] concluded that the availability of local subsidy in petroleum fuels contributes to the barrier of renewable development as a source of electricity generation in Nigeria. This suggests that renewable energy sources of electricity generation will remain expensive and unaffordable if subsidies on fossil fuel power generation persist.

4.2 Infrastructure and high investment cost

Even though renewable energy sources are now more affordable in developed countries globally, the initial investment involved in renewable energy installation in developing countries remains a major barrier to its development [50]. This is consistent with Ogunmodimu and Okoroigwu [51] assertion that the high initial cost involved in the installation of

renewable energy technology remains a primary barrier in Nigeria. Oyedepo et al. [41] added that infrastructure constraints, which cut across the sector value chain, i.e. generation, distribution and transmission, remains a major challenge.

Renewable energy technology requires huge start-up capital compared to other conventional energy alternatives, although, despite that, it is the most-cost effective, in terms of operational and maintenance costs [52]. In a country where ease of doing business according to World Bank doing business Index 2020, ranks 131, such capital as a foreign direct investment would be minimal. At the same time, renewable energy technology businesses face the problem of restricted access to capital, in the absence of specialised funds for renewable energy investment.

4.3 Insecurity and vandalism

Insecurity and frequent act of vandalism represent a deterrent to successful business operations and management in Nigeria [53]. For example, the Northern and Eastern Nigeria has respectively been the territory for insurgent activities of Boko Haram and militants. Their actions in the last decade have resulted in untold infrastructural destruction. This current situation transforms into a high-risk investment for both local and foreign companies to invest in renewable energy technology or installation that can be easily vandalised or destroyed [51]. Furthermore, the fear of people being put out of business due to accepting a renewable source of energy constitutes a social barrier [54]. This makes it impossible or limits the thinking of people in accepting the change.

4.4 Data aggregation

Poor access to accurate and timely data or information on renewable energy has been a major barrier for effective policy and decision making in Nigeria [54]. For example, it is difficult to ascertain the total wattage number of solar PV installations operational across the country. This is consistent with Sen and Ganguly [50] assertion that there is a lack of reliable data without which the generated output is likely impossible to be calculated. The absence of data recording stations constitutes a major barrier to the development of renewable energy, such as solar energy in Nigeria. Arguably, a lack of access to relevant data and inaccurate statistics remain a major barrier for renewable energy development in Nigeria.

4.5 Political barrier

At present, the government of Nigeria lacks the political will to formulate standards and regulatory framework and provide incentives that will enable it to make a significant change and/or improvement in the nation's energy usage from conventional to renewable energy sources. This view suggests that the Nigerian government is not doing enough at making the transition from the use of conventional energy to renewable energy. This is in line with Akuru et al. [54] assertion that the implementation and achievement of 100% renewable energy is highly hindered by political will. Likewise, Abdullahi, Suresh, Renukappa and Oloke [55] added that the current barriers to implementing the roadmaps for renewable energy are neither economic nor technical, but political. Elum and Momodu [31] concluded that political obstacles constitute a significant roadblock to the implementation of successful renewable energy policies in Nigeria.

4.6 Policy barrier

The enforcement of inconsistent policies and rules reinforces earlier identified barriers. Even though multilateral initiatives involving Power Africa, the World Bank, Nigerian private sector and Nigerian government and private sector are ongoing at addressing key issues and challenges within the power sector, the efforts are insufficient and slow-paced [56]. For example, several projects aimed at expanding hydro and thermal sources have been introduced by the government. Also, the government has availed intervention facilities to DisCos and GenCos to ease their financial commitment and constraints. But despite that, government investments are low compared to existing targets and deficits. Amigun, Sigamoney and von Blottnitz [57] stated that a major barrier militating against renewable energy development is the lack of appropriate and inconsistency in policy implementations. Hence, Oyedepo et al. [41] argued that more responsive and effective policies are required to promote renewable energy technologies (RETs) in Nigeria. Elum and Momodu [31] concluded that to achieve different renewable energy development initiatives, objectives of the Nigerian energy policies such as mobilising private resources at the grassroots or community levels must materialise.

Beside the stated barriers to renewable energy development in Nigeria, the country's power sector (i.e. power generation, transmission and distribution) until 2013 was solely managed and controlled by the Nigerian government without

any participation from the private sector. Even though the Nigerian power sector is now privatised, it is operated more like a monopoly venture compared to most countries in Europe and South Africa where the participation of private investors is encouraged through the provision of attractive feed-in-tariff programmes [58]. For example, the South African renewable energy independent power producer procurement programme gives room for independent investors and manufacturers to play key roles in energy generation. However, potential private investors in Nigeria are confronted with non-attractive feed-in-tariff and energy policies [41, 53]. These views suggest that the promotion of active private participation in the generation, transmission and distribution of renewable energy in Nigeria can provide a solution to the electricity supply challenge of the country.

5 Fostering private-sector participation in Nigeria renewable energy development

Considering the nation's endowment in renewable energy resources, it represents a profitable market for the Nigeria electricity industry because there are sufficient potential and possibility for the private sector involvement in the industry. Yet, investors (i.e. the private sector) are not guaranteed about their investment and participation. Williams and Ghanadan [59] asserted that private sector involvement in the electricity sector would drive choices and improvement that are likely impossible to achieve through public monopoly. Likewise, Aslani, Naaranoja and Zakeri [60] asserted that it is imperative to encourage the support and contribution of the private sector to use renewable energy resources economically reasonable in developing economies. This is consistent with Williams, Jaramillo, Taneja and Ustun [61] argument that private sector participation in electrification projects could result in both an improvement in managerial and technical performance as well as an increase in capital investment availability. These views suggest that there is increasing attention given to encouraging private sector participation in the electricity sector. Eshun and Amoako-Tuffour [62] argued further that private sector involvement is essential in developing efficient power sources for sustainability in emerging economies. Hence, Shakeel, Takala and Shakeel [63] concluded that developing countries should engage and involve the private sector to attain their vision of increased electricity generation through renewable energy sources.

From the preceding, it is evident that involving the private sector represents a means through which the Nigerian government can tap or access capital available in the private sector [64] to meet its key objectives of providing electricity to rural households. Also, because private sector involvement in the electricity sector is now a global trend [65], arguably, a collaboration between the private sector and government could be a driver for promoting the Nigerian electricity industry.

5.1 National Renewable Energy and Energy Efficiency Policy (NREEEP)

The Federal Executive Council of Nigeria in 2015 approved the NREEEP as published by the Federal Ministry of Power (FMP). The NREEEP further expand on the Energy Policy 2003, which touches on all forms of energy (fossil and non-fossil) and sets out the government's renewable energy vision, goals and objectives. The document also stipulates that the National Energy Policy 2003 lack an all-encompassing and coherent framework that can drive the growth of the country's renewable energy sector. Because of this, calls for integrated energy efficiency and renewable energy policy, which will drive the sector by promoting the deployment and development of renewable energy technologies while limiting or eradicating conflicts among different stakeholders in the future.

The NREEEP, therefore, sets a target of 23,000 MW renewable energy contribution to final energy generation from all sources by the year 2030. It also defined renewable energy as energy derived through sources whose utilization does not result in the depletion of the earth's resources. These include energy technologies and sources such as solar energy, biomass, wind, hydro, tide, geothermal and wave energy, which have minimal environmental impacts. To achieve the 23 Gigawatt (GW) target by 2030, the document encourages the deployment of both large- and small-scale renewable energy generation, thus emphasise off-grid and on-grid mini-grids generation respectively. To further strengthen the Government's commitment to creating a level playing field to all investors in the sector, the policy provides entrepreneurs with appropriate motivations and incentives. This is to facilitate adequate investment returns from renewable energy sources and power generation.

Furthermore, financing facilities in support of domestic investments in off-grid and remote areas is encouraged. This includes a 5 year tax holiday for energy-efficient equipment, renewable energy equipment and accessories manufacturers. Also, this is extended to provide a 5 year tax holiday on all dividend incomes made from domestic investments in renewable energy sources. To promote the effective and efficient performance of the incentives introduced as it relates

to exports and imports, it was recommended that the Ministry in charge of finance at the federal level establish a special task force to oversee the energy efficiency and renewable energy subsectors within the Customs Service. The Task Force will be responsible for fast-tracking screening activities as it concerns renewable energy and energy efficiency components coming into and out of Nigeria. Also, it will be responsible for streamlining the cumbersome process inherent in importing of renewable energy equipment (e.g. solar panels and storage batteries) into the country.

The policy recommends that national energy efficiency and renewable energy action plan be developed along with an integrated resource plan be designed to elaborate further the targets set in the document and specify the tasks of key private and public sector players. This process as stipulated in the policy should align with the Economic Community of West African States (ECOWAS) strategies for energy efficiency and renewable energy. Since the process started in 2015, only the NREEEP has been developed. Still, the process of revising the policy within the 12 months stated in the document has been prolonged.

5.2 Renewable Energy Feed-in Tariff (REFIT)

The Federal Government of Nigeria approved the REFIT in November 2015 and became active 3 months after, i.e. in February 2016. The provision of the REFIT supersedes the Multi-Year Tariff Order (MYTO) II (2012–2017), which provides the rates shown in Table 2 for renewable energy technologies.

The REFIT aimed to stimulate investment in the electricity sector by utilising the untapped renewable energy potential of the country. Tariff levels are guaranteed for 20 years and are technology-specific. This may change due to varying costs and digression; however, the prevailing tariff at the time a power purchase agreement (PPA) is signed remain fixed throughout the life of the contract. The REFIT is reviewed every 3 years to account for changes in technology. Still, adjustment and changes apply only to new PPAs, thus allowing investors time to plan investment on a long-term basis.

REFIT target was to have a total of 2000 MW generation capacity from biomass, wind, small hydro and solar energy. The REFIT tariff is calculated using the Levelized Cost of electricity and long-run marginal cost methodology. This method gives room for the project operating cost and cost of capital to be recovered over the period of the power purchase agreement.

5.3 Mitigation scenarios

To reduce the country's overdependence on hydrocarbons by meeting the projected growth in demand for electrical power by 2035 without a similar expansion in greenhouse gas emissions, the Nigerian government has identified different mitigating scenarios that will further promote sustainable development in the sector.

5.3.1 Reducing grid transmission and distribution losses

An increase in grid-connection will result in a comparable growth of transmission capacity. Hence, the policy objective of reducing transmission and distribution losses. In 2009, the distribution and transmission loss in the grid were averaged at 20 per cent and projected to reduce to 12 per cent and 8 per cent after 2025 and 2035 respectively in line with international best practice as shown in Table 3. Hence, the government has made a significant investment in grid transmission and distribution based on different reference scenarios for 2009 to 2035. The different scenario options assume that $92.5 million fixed costs will be required for improvements. It is therefore envisaged that the Nigerian electricity sector could achieve a low-carbon economy comparable to that of other developing countries in the next two decades.

Table 2 The MYTO2 FiTs—MWh (N/MWh) (Source: [66])

Year	PV (ground mounted)	Onshore wind	Biomass	Small hydro (< 30 MW)
2012	67.917	24.543	27.426	23.561
2013	73.000	26.512	29.623	24.433
2014	79.116	28.641	32.000	27.456
2015	85.401	30.943	34.572	29.643
2016	92.192	33.433	37.357	32.006

Table 3 Planned reduction in Nigerian electricity transmission and distribution losses per cent of generation (Source: [67])

Year	2010	2015	2020	2025	2035
Low carbon scenario	20	19	15	12	8
Reference	20	19	16	13	12

5.3.2 Promoting low-carbon generation mix

This mitigating scenario is aimed at achieving a more diverse and optimal renewable portfolio of technologies for the Nigerian economy. Table 4 contrast the different technology mix defined in the reference scenario and low-carbon scenario for the electricity sector.

Table 4 shows that a more diverse portfolio of technologies is obtainable using the low-carbon scenario when compared with the reference scenario. These scenarios are intended as demonstration projects to appraise the economic and technical feasibility while promoting the potential use of renewable energy sources in Nigeria. The grid-connected technologies (i.e. photovoltaic, wind, concentrated solar power and biomass power) added 100 MW each in 2015. The off-grid capacity is presently intended for replacement and backup of erratic grid power. An essential characteristic of the low-carbon scenario is that it supports energy sources diversification across the county's national territory.

5.3.3 Promoting energy efficiency

This plan aims to explore energy efficiency avenues in different sectors of the economy that could result in potential energy savings. Some of the proposed programs in support of this mitigation plan are:

1. Prohibiting the manufacturing and sales of inefficient incandescent lights.
2. Encouraging the production and sales of light-emitting diodes and compact fluorescent lamps.
3. Setting and regulating efficiency standards for electrical appliances such as air-conditioning and refrigerators.
4. Educating people on the need to purchase efficient and cost-saving equipment by promoting clear labelling of equipment.

Table 4 Generation capacity mix in the reference and low-carbon scenarios (Source: [68])

Grid Connected Technologies	Base	Reference scenario			Low-carbon scenario		
	2010	2015	2025	2035	2015	2025	2035
Grid Connected Technologies							
Gas single cycle	6.5	18.2	30.2	51.8	16.7	15.8	15.6
Gas combined cycle	1.1	1.7	4.8	20.7	1.7	11.4	36.6
Coal subcritical	0.0	0.0	3.3	10.0	0.0	0.0	0.0
Coal carbon capture	0.0	0.0	0.0	0.0	0.0	2.0	5.0
Hydropower	1.9	2.0	7.2	7.2	2.0	8.2	11.2
Biomass power	0.0	0.0	0.0	0.0	0.3	1.0	2.0
Concentrated solar power	0.0	0.0	0.0	0.0	0.1	1.7	10.0
Nuclear	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Solar photovoltaics	0.0	0.0	0.0	0.0	0.1	1.7	10.0
Wind turbine	0.0	0.0	0.0	0.0	0.2	2.9	10.0
Off-grid Connected Technologies							
Gasoline generator	1.3	2.6	4.9	6.3	2.5	2.9	4.2
Diesel generator	3.1	4.6	9.6	18.8	4.4	7.0	6.2
Gas turbine	0.0	1.3	7.0	12.6	1.2	2.9	5.2
Small hydro	0.0	0.0	0.0	0.0	0.0	1.5	3.6
Solar photovoltaics	0.0	0.0	0.0	0.0	0.1	5.9	16.3
Hybrid PV-wind-diesel	0.0	0.0	0.0	0.0	0.1	2.9	11.4
Total	13.9	30.4	67.8	128.3	29.3	67.7	147.5

Table 5 Renewable energy sources linked to the region of potential (Sources: [33, 69, 70])

Renewable sources	Region
Biomass	Northern, Southern and Western
Wind	Northern and Western
Hydropower	Northern, Southern and Western
Solar Energy	Northern

5. Replacing fuel-based lightings such as candles and kerosene lanterns with more energy-efficient lamps.
6. Encourage the use of more energy-efficient industrial equipment such as electric chillers, motors and heaters.
7. Promote the use of solar lights, that integrate a PV panel, battery, and lamp.
8. Invest in lighting that is safer, convenient, and at a lower LCOE than fuel-based lights.

5.4 Renewable energy sources and region of potential

Table 5 presents the different renewable energy sources and the part of the country these sources have the potential to be most effective. Nigeria, as a country, is divided into three main regions, which are Northern, Southern and Western region. Nigeria is very rich in biomass resources such as wood, shrubs and forage grasses, forest wastes, agricultural waste, industrial and municipal wastes and aquatic biomass. This is because all the regions are major producers of one economic crop or another [69]. Although wind energy is yet to be considered or implemented for commercial electricity production in Nigeria, it is perceived to be in abundant in the northern part of Nigeria as this part of the country possesses high wind speed amidst condition such as roughness and topography of surfaces [70]. Likewise, solar energy is perceived to be enormous and in abundance in the northern part of Nigeria due to its geographical location in the equatorial region and the high sunshine belt [69]. While hydropower, which is the country's major source of electricity generation, can be found in all the regions of Nigeria because she is endowed with large rivers, waterfalls and dams [33].

6 Conclusion

The Nigerian electricity sector is crucial to reducing the carbon emission generated in the country. Likewise, it is of no doubt that Nigeria is endowed with a different mix of renewable energy sources. Exploring and developing these renewable energy sources will aid the effort of the government in reducing the country's input to the global carbon emission. Also, it will be instrumental to the socio-economic development of the country and improved well-being of the society at large. The deployment of the different mix of renewable energy sources will enable the country to meet its energy demand due to increase and improved standard of living, industrialisation and growing population. However, the country has experienced poor implementation of renewable energy policies.

Reducing the impact of carbon emission in Nigeria will involve making policies that will sustainably foster development. Policymakers should take into consideration the country's future energy demand, energy supply, setting a target for carbon emission reduction and seeing such policies through its implementation. To address renewable energy barriers in Nigeria, the government should consider making policy in support of the following:

1. Create more awareness of the impacts of climate change on the environment. This will include both formal and informal campaigns.
2. The government should foster research and development activities into different renewable energy sources available in the country to inform a potent mix of policy options needed in attaining a cost-effective strategy.
3. Involve the various stakeholders within the electricity sector in policy formulation. This will encourage stakeholder participation and transparency towards reducing the country's carbon emission.
4. Introduction of fiscal incentives. This will involve giving renewable energy companies tax rebates to attract private investors into the sector. Also, companies that comply with the set standard for pollution should be compensated or rewarded. Other fiscal incentives such as investment grants, tax holiday and import exemption duties could be taken on board to foster foreign investment within the country.
5. Learning from the success of developed countries to comply with best practices.

Taking the above points into consideration could result in a win–win strategy for a developing country. This is because successful investment in renewable energy development will result in job creation, climate protection, technology development and poverty alleviation.

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