

Exploring the Renewable Energy Potential of Nigeria's Blue Economy: Significance, Opportunities and Challenges



NWEKE, Chiedozie Cyprain¹, Prof. Dr. Dhakir Abbas Ali²

¹Lincoln University College, Malaysia

²Deputy Dean for Postgraduate Studies.

ABSTRACT: Renewable in Nigeria shows a huge potential with numerous prospects, however, it remains widely untapped considering its abundance. This research focuses on investigating exploring the renewable energy potential of the blue economy of Nigeria with emphasis on its significance and potential, opportunities as well as challenges. A systematic literature review has been used in gathering information from previous researchers. Types of renewable energy in Nigeria are solar, wind, hydropower, Geothermal Tidal and Wave Energy, as well as Biomass Energy. Its significance is demonstrated in energy security and reliability, employment opportunities and economic growth, diversification and energy mix, environmental sustainability, as well as cost savings and accessibility. Its opportunities are indicated in the different types of renewable energy presents in Nigeria. The challenges include inadequate infrastructure, high initial investment cost, regulatory and policy gaps, technical and skills labour, accessing finance, as well as public awareness and acceptance. The findings shows that renewable energy in Nigeria is abundantly available, but can only be explored if tapped into, taking into consideration, the right tools and policy and infrastructure. The potential and opportunities of renewable energy in Nigeria cannot be undermined. However, the challenges facing renewable energy can hinder its progress.

KEYWORD: Renewable Energy, Solar, Wind, Hydropower, Biomass, Geothermal Energy

1. INTRODUCTION

Renewable energy is described as the energy that is derived from natural resources that replenished at a faster rate than they are consumed, such as sunlight, wind, rain, tides, waves, and geothermal heat. Unlike fossil fuels that are finite and contribute immensely to climate change, renewable energy sources offer a sustainable and environmentally friendly alternative. Renewable energy is a very significant part of the Nigerian blue economy as it offers sustainable sources of energy that can be tapped into (Kehinde et al, 2018)

The blue economy in Nigeria is still considered under developed, or in its developing stages owing to the fact that many of its sectors have not been fully explored and taken advantage of. However, the renewable aspect of it remains a priority, as Nigeria explore alternative sources of energy and power. The current energy generated is not enough to serve the entire nation, further leading to rationing of electricity in which some communities don't have power for months (Shaaban and Petinrin, 2014)

Renewable energy provides a wide alternative of power sources, which can be explored, further leading to generation of power from different sources, and subsequently leading to abundance of electricity. It is believed that the abundance of power from different source will make it readily available, and over time becomes cheap due to the fact that there is numerous alternative and options for consumer (Aliyu et al, 2015).

This research paper focuses on identifying the renewable energy sources in the Nigerian blue economy, investigate and examine their respective potential while paying attention to significance, opportunities and challenges that comes with the exploration of these renewable energy potential. In doing so, it will further help in having a clear overview and understanding of the potential, impactful significance, the explorable opportunities and the preventive challenges.

2. BACKGROUND AND LITERATURE

2.1 Renewable Energy in the Nigerian Blue Economy

Nigeria's Blue Economy, which prioritizes the sustainable use of ocean and aquatic resources, offers substantial potential for renewable energy generation. The country's extensive 850 km coastline and numerous water bodies provide ideal conditions for harnessing energy from sources such as offshore wind, tides, and waves (Akuru et al, 2017)

Through harnessing the power of the ocean, Nigeria can achieve its goals of energy diversification, emissions reduction, and sustainable development. Offshore wind energy, which capitalizes on the strong coastal winds, and tidal and wave energy, which utilize the natural movement of water, can provide reliable and environmentally friendly power (Akorede et al, 2017).

By incorporating renewable energy into its Blue Economy, Nigeria can strengthen its energy security, especially in underserved coastal and island regions. This approach also stimulates job growth, fosters technological advancements, and improves the country's resilience to climate change by promoting clean and sustainable energy solutions. Furthermore, utilizing ocean-based renewable energy minimizes the negative environmental impacts associated with fossil fuel extraction, safeguarding Nigeria's rich marine biodiversity (Efurumibe et al, 2014)

By harnessing renewable energy within its Blue Economy, Nigeria can establish itself as a global leader in sustainable ocean resource management. This approach enables the country to drive economic growth while safeguarding its marine environment and contributing to global efforts to combat climate change (Riti and Shu, 2016).

2.2 Types and Potential of Renewable Energy in Nigeria

There are various types of renewable energy, with each having its potential and area of application, with the ultimate aim of providing unlimited energy that replenishes itself over time. These includes

2.2.1 Solar Energy

Nigeria receives an average of 5.5 kWh/m²/day of solar radiation, ranking it among the world's most solar-rich countries. This abundant energy resource presents significant opportunities for sustainable power generation, particularly in regions with limited access to traditional electricity sources. Solar energy, being clean and renewable, can meet Nigeria's increasing energy needs while decreasing dependence on fossil fuels. Its decentralized nature makes it particularly advantageous for rural and off-grid areas, where extending the national power grid is often impractical or expensive (Agbo et al, 2021)

Solar energy can be utilized through various technologies, such as solar panels for generating electricity in homes and industries. It is also ideal for solar water heaters, providing an environmentally friendly option for heating water in domestic and commercial settings. Additionally, solar-powered streetlights offer a sustainable and economical solution for lighting urban and rural areas, improving safety and reducing energy costs (Chanchangi et al, 2023).

2.2.2 Wind Energy

Nigeria has considerable wind energy resources, with wind speeds ranging from 2.0 to 5.0 m/s, especially in northern states such as Sokoto, Kano, and Katsina. These regions offer ideal conditions for wind energy development due to their steady wind patterns. Additionally, the country's coastline presents opportunities for offshore wind projects, leveraging stronger and more consistent ocean winds. By tapping into wind energy, Nigeria can adopt a sustainable and renewable alternative to fossil fuels, supporting efforts to diversify its energy portfolio and reduce greenhouse gas emissions (Idris et al, 2020)

Wind energy can be harnessed through wind turbines to generate electricity, making it a practical solution for supplying power to residential, industrial, and commercial sectors. Combining wind with solar energy in hybrid systems can further enhance energy reliability, particularly in remote and off-grid locations, ensuring a steady and sustainable power supply (Adedipe et al, 2018).

2.2.3 Hydropower

The country possesses an impressive hydropower potential of 11,250 MW, with 2,062 MW already in operation and contributing to the national power supply. The country's vast network of rivers and water bodies makes hydropower a reliable and sustainable energy source. Key facilities such as the Kainji, Jebba, and Shiroro dams significantly support the nation's electricity generation. Furthermore, small and micro-hydro systems provide practical and cost-effective options for delivering power to remote and underserved areas. These systems are particularly suited for rural regions without access to the national grid, helping to alleviate energy deficits in these communities (Ugwu et al, 2022).

Hydropower plays a dual role in Nigeria's energy landscape. Large-scale plants supply electricity to the national grid, supporting urban centers and industries, while micro-hydro systems offer localized power solutions, driving rural electrification and promoting economic growth in isolated areas (Fakehinde et al, 2019)

2.2.4 Biomass Energy

Nigeria holds vast biomass energy resources, with over 144 million tons of agricultural residues, animal waste, and forest materials produced annually. This rich supply includes crop residues such as cassava peels, maize stalks, and rice husks; animal waste from

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livestock operations; and forestry by-products like wood and sawdust. Biomass energy represents a renewable and eco-friendly solution to Nigeria's energy demands, especially in rural and agricultural regions. Transforming waste into energy not only addresses environmental pollution but also serves as a cost-efficient alternative to fossil fuels. Leveraging this potential can diversify Nigeria's energy mix, improve energy security, and help lower greenhouse gas emissions (Jekayinfa et al, 2020)

Biomass can be harnessed through various technologies, including biogas plants that process organic waste into cooking gas and electricity, biofuel production for transportation and industrial use, and biomass-powered systems for rural electrification. These applications foster sustainability, decrease dependency on traditional energy sources, and stimulate economic development in both urban and rural communities (Okafor, et al, 2022)

2.2.5 Geothermal Energy

Geothermal energy in Nigeria, though still largely untapped, holds significant potential for diversifying the country's renewable energy portfolio. Promising sites include the Benue Trough and the volcanic regions of the Jos Plateau, where underground heat sources can be harnessed. These geothermal resources provide a stable and reliable energy supply, unaffected by weather variability, making them well-suited to addressing Nigeria's growing energy needs. Investing in geothermal energy development can improve energy security, lower greenhouse gas emissions, and promote sustainable growth, particularly in regions where other renewable energy options may be less effective (Abraham and Nkitnam, 2017)

Geothermal energy can be utilized for generating electricity, converting heat from the earth into power for residential, industrial, and commercial use. It is also ideal for direct heating applications such as space heating, agricultural product drying, and various industrial processes (Okolie et al, 2019)

2.2.6 Tidal and Wave Energy

Nigeria's vast coastline, spanning over 850 kilometers, holds considerable promise for tidal and wave energy, although these resources remain largely unexplored. Tidal energy utilizes the predictable movement of sea levels, while wave energy captures the motion of surface waves to generate power. Coastal regions such as Lagos, Delta, and Bayelsa States experience strong tidal flows and wave activity, making them prime locations for such initiatives. With ongoing advancements in marine renewable energy technology, Nigeria is well-positioned to harness these resources to create sustainable energy solutions that enhance and diversify its power infrastructure (Amoo, 2018)

Tidal and wave energy can be utilized to provide electricity to coastal and island communities, decreasing dependence on fossil fuels and boosting energy security. These resources can supply power to local industries, fishing operations, and residential areas while contributing to the national grid. Investing in marine energy can also generate employment opportunities and accelerate Nigeria's shift to a low-carbon economy (Lawal et al, 2018).

2.3 Significance of Renewable Energy towards Nigeria's Economy

The significance of renewable energy in Nigerian cannot be overemphasized due to the fact that it creates and triggers processes that directly affects the economy of the country, in ways that cannot be imagined. These includes

2.3.1 Energy Security and Reliability

Renewable energy sources such as solar, wind, and hydropower are crucial in decreasing Nigeria's reliance on fossil fuels and imported energy. By broadening the energy mix, these renewable options deliver a stable and reliable power supply, particularly in remote areas with limited access to the national grid. Enhanced energy security reduces the risks linked to fuel shortages and price fluctuations, ensuring uninterrupted electricity for critical services and industries. Additionally, improved energy availability in off-grid and rural regions stimulates economic activity, increases productivity, and supports socio-economic growth across multiple sectors, contributing to a more resilient and sustainable economy (Ovwigho et al, 2020).

2.3.2 Employment Opportunities and Economic Growth

The development of renewable energy plays a crucial role in job creation and economic growth in Nigeria. Building and deploying renewable energy infrastructure create employment opportunities in areas such as manufacturing, installation, system maintenance, and research and development. These efforts enhance local expertise, cultivate a skilled workforce, and empower communities by reducing unemployment. Moreover, the expanding renewable energy sector attracts both domestic and international investments, fostering innovation and driving technological progress. By opening new business opportunities and supporting sustainable industries, renewable energy development bolsters economic growth, diversifies revenue streams, and strengthens Nigeria's position in the global clean energy market (Okwanya et al, 2021)

2.3.3 Diversification of Energy Mix

Integrating renewable energy into Nigeria's energy portfolio is crucial for reducing its dependence on oil and gas. This shift fosters a more robust and adaptable energy sector, better equipped to handle global oil price fluctuations that can destabilize the economy. By utilizing resources such as solar, wind, hydropower, and biomass, Nigeria can create a balanced and sustainable

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energy system. Diversifying energy sources enhances energy security while promoting long-term economic growth by minimizing exposure to price volatility. Additionally, this transition supports the development of a cleaner, more sustainable economy, encouraging innovation and attracting investments in renewable energy technologies and infrastructure (Eweka et al, 2022)

2.3.4 Environmental Sustainability

Renewable energy is instrumental in lowering greenhouse gas emissions, playing a key role in Nigeria's pursuit of its climate goals. Adopting clean energy sources like solar, wind, and hydropower helps combat the adverse effects of carbon emissions, such as deforestation, biodiversity loss, and climate change. This transition also reduces the economic burden of environmental degradation, addressing issues like soil erosion, flooding, and diminished agricultural yields. Furthermore, renewable energy minimizes air and water pollution, enhancing public health and reducing healthcare expenses linked to pollution-related diseases. Overall, it promotes a sustainable and resilient environment, ensuring a healthier future for generations to come (Akuru et al, 2017)

2.3.5 Cost Savings and Accessibility

Renewable energy, particularly solar and wind, provides cost-effective and sustainable options for electricity generation, especially in remote and off-grid regions of Nigeria. By decreasing dependence on expensive diesel generators, which require high maintenance and fuel costs, renewable energy helps reduce overall energy expenses for both businesses and households. This shift not only lowers energy costs but also fosters greater economic inclusion by delivering reliable electricity to underserved areas, boosting local industries, and improving access to essential services such as education and healthcare. Additionally, the scalability of renewable energy solutions allows them to be tailored to meet the diverse needs of different communities, supporting long-term economic growth (Joshua, 2020).

2.4 Renewable Energy Opportunities in Nigeria

Renewable energy opportunities are numerous in Nigeria, however, these opportunities come based on the different types of renewable energy, meaning that each individual renewable energy type has an extended opportunity. These include

2.4.1 Solar Energy

Nigeria benefits from plentiful sunlight year-round, making solar power a highly promising renewable energy source. With an average solar radiation of 5.5 kWh/m²/day, solar energy can be effectively harnessed for various uses. Solar panels can be installed for residential, commercial, and industrial electricity generation, greatly improving energy access, particularly in off-grid and rural areas where traditional power infrastructure is scarce or unavailable. Utilizing this resource allows Nigeria to decrease its dependence on imported fuels, reduce energy costs, and support sustainable development, while addressing energy shortages and fostering socio-economic growth (Ozoegwu et al, 2017).

2.4.2 Wind Energy

Nigeria holds significant wind energy potential, with wind speeds between 2.0 and 5.0 m/s in areas like Sokoto, Kano, and Katsina. These regions offer favorable conditions for establishing wind farms, which can diversify the country's energy mix and decrease dependence on fossil fuels. Wind energy can be instrumental in supplying reliable electricity to both urban and rural areas, particularly in northern Nigeria, where access to the national grid is limited. By harnessing this renewable resource, Nigeria can improve energy security, foster sustainable development, and generate new economic opportunities (Dalero and Musa, 2018)

2.4.3 Hydropower

Nigeria's rivers, including the Niger and Benue, offer considerable potential for hydropower generation. Major hydropower plants, such as the Kainji and Jebba dams, already make significant contributions to the national grid, helping meet the country's electricity demands. Beyond these large-scale projects, small and micro-hydro systems present valuable opportunities for addressing energy needs in remote and off-grid regions where other power options may be limited or costly. Utilizing hydropower can alleviate energy shortages and promote sustainable energy solutions for Nigeria's future (Ibegbulam et al, 2023).

2.4.4 Biomass Energy

The country holds significant potential for utilizing biomass energy, thanks to its abundant agricultural residues, animal waste, and forest resources. Biomass can be transformed into various energy forms such as biogas, biofuels, and electricity, offering a renewable and sustainable alternative to fossil fuels. Materials like crop residues, rice husks, cassava peels, and animal waste from livestock farming provide a steady supply of organic matter for energy generation. Biomass energy helps reduce waste, mitigate environmental pollution, and contributes to rural development by creating job opportunities in the energy sector. Leveraging this resource allows Nigeria to address its rising energy needs while supporting sustainability (Jekayinfa et al, 2020).

2.4.5 Geothermal Energy

Although geothermal energy is still largely unexplored in Nigeria, regions like the Benue Trough and Jos Plateau hold significant untapped potential. These areas, characterized by volcanic activity, contain geothermal heat resources that could be harnessed

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for electricity generation and direct heating. Utilizing this resource would offer a stable and dependable energy supply, particularly for remote and off-grid communities with limited access to other energy sources. Developing geothermal energy could help diversify Nigeria's energy mix, enhance energy security, and promote sustainable economic development, especially in underserved regions (Jekayinfa et al, 2020)

2.4.6 Marine and Tidal Energy

Nigeria's vast coastline provides significant opportunities for harnessing tidal and wave energy, especially in coastal states like Lagos, Bayelsa, and Delta. The predictable rise and fall of ocean tides, along with wave movements, offer a reliable and sustainable source of energy. Developing these resources could help meet electricity demands in coastal communities while also contributing to the country's broader energy goals. Marine and tidal energy projects would also support national efforts to diversify the energy mix and reduce reliance on fossil fuels (Garba, 2017).

2.5 Challenges Facing Renewable Energy Exploration in Nigeria

In as much as the significance of renewable energy cannot be undermined and its opportunities brings huge potential, it is also important to take into consideration, the challenges facing the exploration of renewable energy in Nigeria. These include

2.5.1 Inadequate Infrastructure

A key challenge to the exploration of renewable energy in Nigeria is the insufficient infrastructure, especially in rural and remote areas. Limited grid connectivity prevents the effective transmission of renewable energy from sources such as solar, wind, and hydropower to communities that need it most. Additionally, there is a lack of energy storage systems necessary for storing excess energy during peak production times for later use. The current transmission networks are also outdated and unable to accommodate the variable nature of renewable energy generation. Without substantial investment in modernizing and expanding infrastructure, Nigeria will face difficulties in fully utilizing renewable energy to meet its rising energy needs (Olanipekun and Adelakun, 2020).

2.5.2 High Initial Investment Cost

A major obstacle to the widespread adoption of renewable energy in Nigeria is the significant upfront investment needed for technologies such as solar panels, wind turbines, and hydroelectric plants. These projects require substantial capital for installation, infrastructure, and ongoing maintenance, which can discourage both government and private sector involvement. The high initial costs make renewable energy less appealing, especially in a country with limited resources and competing priorities. Consequently, many investors may choose traditional energy sources, which, despite lower initial costs, tend to incur higher long-term environmental and economic consequences (Elum and Mjimba, 2020).

2.5.3 Regulatory and Policy Gaps

The absence of clear and consistent policies and regulatory frameworks to support renewable energy development in Nigeria presents a major obstacle. Without well-defined guidelines, investors and developers face uncertainty about the long-term feasibility and profitability of renewable energy projects. This lack of regulatory clarity deters both local and foreign investments, stalling the sector's growth. Furthermore, inconsistent policies and the lack of incentives for renewable energy projects create financing challenges, slowing the transition to cleaner energy. Establishing a strong and transparent policy framework is crucial to attract investment and accelerate the adoption of renewable energy (Aliyu et al, 2015).

2.5.4 Technical and Skilled Labour Shortage

One of the major obstacles to renewable energy development in Nigeria is the shortage of locally trained technicians and engineers with expertise in renewable energy technologies. This shortage hinders the effective installation, deployment, and maintenance of systems like solar panels, wind turbines, and hydropower plants. The lack of skilled labor leads to project delays and higher costs, as foreign professionals may need to be hired, putting additional strain on resources. To address this issue, it is crucial to invest in local training programs and capacity-building initiatives that will develop a skilled workforce, reduce reliance on foreign expertise, and support the sustainable growth of the renewable energy sector (Onuh et al, 2024).

2.5.5 Access to Financing

Access to financing is a major obstacle to the advancement of renewable energy projects in Nigeria. These initiatives require significant capital to get started, but the high cost of borrowing poses a substantial challenge for both public and private investors. Moreover, there is a lack of financial incentives, such as tax incentives or subsidies, to stimulate private sector involvement in renewable energy ventures. Without these favorable financing options, it becomes difficult for renewable energy projects to secure the required funding, impeding their progress and delaying Nigeria's shift toward cleaner, more sustainable energy solutions (Adebanji, et al, 2022)

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2.5.6 Public Awareness and Acceptance

In Nigeria, a major challenge to the adoption of renewable energy is the lack of public awareness and acceptance. Many rural communities have limited understanding of the benefits and potential of renewable energy sources like solar, wind, and hydropower. This lack of knowledge often leads to skepticism and reluctance to switch from traditional energy sources. Additionally, misconceptions and misinformation about renewable energy contribute to this resistance. To overcome these challenges, it is crucial to raise awareness through education, targeted campaigns, and community engagement, which will help promote understanding and encourage the widespread adoption of renewable energy solutions (Amadi et al, 2024).

3. METHODOLOGY

The methodology approach used in this research is qualitative in nature, however, no data was collected whatsoever. A systematic literature review was conducted on previous research that has been in done in this regard, relating to the research domain area. A search process was conducted using key terms such as "Renewable Energy", "Nigerian Blue Economy" "Solar Energy", "Wind Energy", "Hydropower", "Biomass Energy", "Geothermal Energy", "Marine and Tidal Energy". This further produced around 116 results in which around 27 were eventually used. The findings and results are further explained extensively in the next part of the article.

4. FINDINGS AND RESULTS

Nigeria, blessed with rich renewable energy resources, has both great opportunities and challenges in tapping into these energy sources. With vast potential in solar, wind, hydropower, biomass, geothermal, and marine energy, the country is well-positioned to play a key role in the global transition to sustainable energy. However, several obstacles hinder the efficient development and adoption of renewable energy technologies, preventing the country from fully realizing their vast potential (Shaaban and Petinrin, 2014)

Nigeria's renewable energy sector is diverse, offering vast potential across various areas. Solar energy stands out due to the country's abundant sunshine, with an average solar radiation of 5.5 kWh/m²/day, making it well-suited for residential, commercial, and industrial applications. Wind energy is also promising, particularly in regions such as Sokoto, Kano, and Katsina, where wind speeds of 2.0-5.0 m/s are ideal for power generation (Akorede et al, 2017).

Hydropower, supported by major plants like Kainji and Jebba, alongside smaller micro-hydro projects, plays a key role in the energy mix. Biomass energy, derived from agricultural residues, animal waste, and forest resources, offers another significant opportunity. While geothermal energy remains largely untapped, regions like the Benue Trough and Jos Plateau show potential for electricity generation and direct heating. Additionally, marine and tidal energy along Nigeria's coastline holds great promise for contributing to clean energy production (Chanchangi et al, 2023).

The role of renewable energy in Nigeria's economy is highly significant. First, it strengthens energy security and reliability by decreasing the country's dependence on fossil fuels and oil imports. This diversification of the energy mix helps stabilize the economy, especially during times of fluctuating oil prices. Furthermore, the growth of the renewable energy sector creates employment opportunities in manufacturing, installation, maintenance, and research, which fuels economic expansion and encourages innovation (Ugwu et al, 2022).

These advancements support economic diversification, reducing the nation's reliance on the oil industry. Additionally, renewable energy contributes to environmental sustainability by lowering greenhouse gas emissions and addressing the economic costs linked to environmental damage and pollution-related health issues (Ovwigho et al, 2020).

Nigeria's abundant renewable energy resources present substantial opportunities for projects of various scales. Solar energy can effectively meet the energy needs of remote and off-grid areas, offering affordable solutions for homes and businesses. Wind energy, especially in the northern regions, can aid both urban and rural electrification efforts (Akuru et al, 2017).

Hydropower, through large-scale dams and small micro-hydro systems, has the potential to fulfill national electricity demands while also serving remote locations. Biomass energy offers a sustainable alternative to fossil fuels by converting organic waste into electricity, biofuels, and biogas. Additionally, tapping into geothermal and marine energy further expands the country's energy options (Elum and Mjimba, 2020).

Despite the significant opportunities, several challenges impede renewable energy development in Nigeria. A key obstacle is the lack of adequate infrastructure, including limited grid connectivity and insufficient energy storage systems. The high upfront costs of renewable energy technologies make them less appealing to investors, further complicated by the absence of clear and consistent regulatory frameworks (Adebanji, et al, 2022).

Additionally, there is a shortage of skilled technicians and labor, hindering the effective deployment, installation, and maintenance of renewable energy systems. Access to financing remains another critical challenge, with high borrowing costs and few incentives

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for private sector investment. Public awareness and acceptance of renewable energy are also limited, particularly in rural areas, where communities are often unfamiliar with the benefits of these energy sources.

5. DISCUSSION

The adoption and development of renewable energy in Nigeria present both substantial opportunities and significant challenges, as highlighted in the results. Nigeria possesses a wide range of renewable energy resources, including solar, wind, hydropower, biomass, geothermal, and marine energy, all of which offer the potential to diversify the country's energy mix, reduce reliance on fossil fuels, and foster sustainable economic growth. Solar energy, with Nigeria's abundant sunlight, is particularly promising for both off-grid and on-grid applications.

Wind energy, especially in regions like Sokoto, Kano, and Katsina, complements this potential. Hydropower, through large plants such as Kainji and Jebba, already plays a key role in meeting national electricity demands, while smaller hydro systems could serve remote areas. Biomass energy, sourced from agricultural and forest residues, along with untapped geothermal and marine resources, further contributes to the country's renewable energy prospects.

Despite this promising potential, the growth of renewable energy in Nigeria is hindered by several challenges. One of the primary obstacles is inadequate infrastructure, including insufficient grid connectivity, which limits the effective distribution of energy, especially in rural and off-grid locations. The lack of adequate energy storage systems also impedes the efficient use of intermittent renewable sources such as wind and solar.

The high initial investment required for renewable energy technologies makes them less attractive to investors, compounded by the absence of clear, consistent regulatory frameworks. Additionally, the shortage of skilled labor delays the deployment, installation, and maintenance of renewable energy systems.

Another critical challenge is access to financing, with high borrowing costs and limited incentives for private sector investment hindering the growth of renewable energy projects. Public awareness and acceptance of renewable energy, particularly in rural areas, also remain low, with many communities unfamiliar with the benefits of these technologies, thus slowing their adoption. To overcome these challenges, Nigeria must prioritize improving infrastructure, creating favorable financial conditions, expanding technical training programs, and raising public awareness. With appropriate policies, investments, and commitment, renewable energy can play a pivotal role in Nigeria's energy future, supporting both economic development and environmental sustainability.

6. CONCLUSION

In conclusion, Nigeria's renewable energy sector offers significant potential, with diverse resources including solar, wind, hydropower, biomass, geothermal, and marine energy. These resources can diversify the country's energy mix, decrease dependence on fossil fuels, and drive sustainable economic growth. However, the growth and development of renewable energy are impeded by several challenges, such as inadequate infrastructure, high upfront investment costs, regulatory inconsistencies, a lack of skilled labor, limited financing options, and low public awareness.

To unlock the full benefits of renewable energy, Nigeria must tackle these challenges by enhancing infrastructure, creating favorable financing conditions, establishing clear regulatory frameworks, and investing in capacity building. With the right strategies and investments, renewable energy could transform Nigeria's energy landscape, provide reliable power to underserved areas, reduce environmental impacts, and stimulate economic development.

Future research should aim to identify the most effective methods for integrating renewable energy into Nigeria's current grid, investigate local financing models for renewable energy projects, and assess the impact of renewable energy adoption on rural development. Furthermore, examining the long-term economic and environmental benefits of transitioning to renewable energy will be essential.

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