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Challenges and Opportunities in Nigeria's Renewable Energy Policy and Legislation

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Abstract

Endowed with abundant renewable energy resources, Nigeria stands at a pivotal point in its energy development journey. This study explores the landscape of renewable energy policy and legislation in Nigeria, highlighting the challenges and opportunities that shape the sector. The research begins with an overview of Nigeria's current energy framework, emphasizing the critical role of renewable energy in achieving sustainable development. It examines existing policies and legislative frameworks, identifying the key government agencies responsible and outlining their respective functions. Despite the country's vast potential, numerous barriers impede the growth of renewable energy. These include legal and regulatory inconsistencies, institutional inefficiencies, financial constraints, and technical challenges. The study delves into these issues, providing a comprehensive analysis of how they hinder progress in renewable energy adoption. Conversely, the research identifies significant opportunities to enhance renewable energy policy and legislation including potential legislative reforms, institutional strengthening, financial incentives, and the promotion of technological innovation and infrastructure development. By leveraging these opportunities, Nigeria can create a more robust and conducive environment for renewable energy growth. The study concludes with strategic recommendations for policymakers and stakeholders to bridge the existing gaps and foster a sustainable energy future for Nigeria. It also outlines future research directions aimed at optimizing renewable energy policies and practices. Through this comprehensive analysis, the study aims to contribute to the ongoing discourse on renewable energy in Nigeria, providing insights to guide effective policy-making and legislative action.

Keywords: Renewable Energy; Policy; Legislation; Nigeria; Sustainable Development

1. Introduction

1.1. Background and Context

Nigeria, the most populous country in Africa, faces significant energy challenges, with a large portion of its population lacking access to reliable electricity. According to the International Renewable Energy Agency (IRENA, 2022), Nigeria's renewable energy potential is vast, with the country having an estimated solar energy potential of 427,000 MW, wind energy potential of 11,000 MW, and hydropower potential of 14,750 MW. Despite this potential, the country's energy sector remains heavily reliant on fossil fuels, particularly oil and gas, contributing to over 80% of its energy mix (Energy Commission of Nigeria, 2022).

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In recent years, the Nigerian government has taken steps to diversify its energy sources and promote renewable energy through various policies and legislative measures. The Renewable Energy Master Plan (REMP), developed by the Energy Commission of Nigeria, aims to increase the contribution of renewable energy to the national energy mix from 13% in 2015 to 23% by 2025 and 36% by 2030 (Energy Commission of Nigeria, 2022). Additionally, the National Renewable Energy and Energy Efficiency Policy (NREEEP), introduced in 2015, provides a framework for the development, utilization, and efficient management of renewable energy resources in Nigeria (Federal Republic of Nigeria, 2015).

Despite these efforts, several challenges hinder the effective implementation of renewable energy policies and legislation in Nigeria. These include inadequate legal and regulatory frameworks, insufficient funding and investment, and limited technological and infrastructural development (IRENA, 2020; Energy Commission of Nigeria, 2022). Addressing these challenges is crucial for Nigeria to harness its renewable energy potential and achieve sustainable development.



Figure 1 Balancing Challenges and Opportunities in Nigeria's Renewable Energy Policy and Legislation

Figure 1 illustrates the duality of challenges and opportunities in Nigeria's renewable energy policy and legislation. On the left, a dark, stormy scene symbolizes challenges, featuring broken solar panels, oil rigs, and legal documents entangled in red tape, representing dependency on fossil fuels and bureaucratic obstacles. On the right, a bright, sunny scene highlights opportunities, showcasing functioning wind turbines, solar panels, a green landscape, and a legislative building displaying the Nigerian flag, symbolizing progress. Icons of people working together, a lightbulb representing innovation, and a scale of justice emphasize balanced legislation and collaborative efforts.

1.2. Objectives and Scope of the Study

The primary objective of this study is to evaluate the current state of renewable energy policy and legislation in Nigeria, identifying the key challenges and opportunities that influence the sector. This research aims to provide a comprehensive analysis of the legal and regulatory frameworks governing renewable energy in Nigeria, assess the effectiveness of existing policies, and propose actionable recommendations for improvement.

The scope of the study includes an examination of various renewable energy resources such as solar, wind, hydro, and biomass, focusing on their potential and current utilization in Nigeria. It also covers the roles and responsibilities of key government agencies involved in the renewable energy sector, the legislative measures in place, and the institutional frameworks supporting policy implementation.

Furthermore, the study will explore financial, technical, and infrastructural challenges that hinder the development of renewable energy in Nigeria. It will analyze market incentives, investment opportunities, and the impact of international collaborations and agreements on the country's renewable energy landscape.

By addressing these areas, the study aims to provide insights into the ways Nigeria can overcome existing barriers and leverage opportunities to enhance its renewable energy sector, contributing to sustainable development and energy security in the country.

1.3. Significance of the Study

The significance of this study on renewable energy policy and legislation in Nigeria lies in its potential to address critical issues related to energy access, environmental sustainability, and economic development. Nigeria's energy sector is currently dominated by fossil fuels, with oil and gas accounting for over 80% of the country's energy mix (Energy Commission of Nigeria, 2022). This heavy reliance on non-renewable energy sources has significant environmental and health impacts, contributing to air pollution and greenhouse gas emissions (International Energy Agency, 2019).

Transitioning to renewable energy is essential for Nigeria to meet its international commitments to climate change mitigation. Nigeria is a signatory to the Paris Agreement, which aims to limit global temperature rise to well below 2 degrees Celsius above pre-industrial levels (Federal Ministry of Environment, 2021). Achieving this goal requires a substantial increase in the share of renewable energy in the national energy mix. Currently, renewable energy sources such as solar, wind, and hydro contribute only about 13% to Nigeria's electricity generation (Energy Commission of Nigeria, 2022).

Furthermore, the development of renewable energy can significantly enhance energy security and reduce energy poverty in Nigeria. According to the World Bank (2023), approximately 45% of Nigeria's population lacks access to electricity, which hampers economic growth and development. By diversifying its energy sources and investing in renewable energy infrastructure, Nigeria can improve energy access, particularly in rural and underserved areas.

Additionally, fostering renewable energy development can create economic opportunities, including job creation and technological innovation. The renewable energy sector is a growing industry with the potential to generate employment and stimulate local economies (International Renewable Energy Agency, 2020). Effective policies and legislation are crucial for creating an enabling environment for renewable energy investments and development.

In summary, this study aims to provide insights that can guide policymakers and stakeholders in addressing the challenges and leveraging the opportunities in Nigeria's renewable energy sector. By doing so, it contributes to the broader goals of sustainable development, environmental protection, and economic prosperity.

1.4. Organization of the Paper

This paper is organized into five main sections, each addressing critical aspects of renewable energy policy and legislation in Nigeria. The first section provides an introduction, setting the stage with background information, the objectives and scope of the study, and the significance of examining renewable energy in the Nigerian context. It highlights the country's energy challenges, the importance of transitioning to renewable energy, and the potential benefits of such a transition. The introduction establishes the foundational understanding necessary for delving into the more detailed analyses in the subsequent sections.

The second section outlines the current state of renewable energy in Nigeria, including an overview of available resources, existing policies, and legislative frameworks. It reviews the progress and achievements to date, identifying the key government agencies involved in the sector. The third section explores the challenges hindering the effective implementation of renewable energy policies and legislation, covering legal, institutional, financial, and technical barriers. The fourth section identifies opportunities for enhancing renewable energy development, proposing legislative reforms, institutional strengthening, financial incentives, and technological innovations. The paper concludes with strategic recommendations for policymakers and stakeholders, summarizing key findings and suggesting future research directions to further optimize Nigeria's renewable energy landscape.

2. Current State of Renewable Energy in Nigeria

2.1. Overview of Renewable Energy Resources

Nigeria is endowed with diverse renewable energy resources that, if effectively harnessed, can significantly contribute to the country's energy mix and reduce its dependence on fossil fuels. Solar energy is one of the most abundant resources in Nigeria, with an average solar radiation of about 5.5 kWh/m²/day, which can generate over 427,000 MW of power (Energy Commission of Nigeria, 2022). The geographical distribution of solar radiation is relatively uniform, making solar energy a viable option for both urban and rural electrification.

Wind energy also presents considerable potential, particularly in the northern regions of Nigeria where wind speeds range between 2.0 and 4.0 m/s at 10 meters above ground level (International Renewable Energy Agency, 2020). These wind speeds are sufficient for small to medium-scale wind energy installations. The estimated wind energy potential in Nigeria is around 11,000 MW, which remains largely untapped due to various infrastructural and investment challenges.

Hydropower is another significant renewable resource in Nigeria, with the country possessing substantial large and small-scale hydropower potentials. Large hydropower installations, such as the Kainji and Jebba dams, have a combined capacity of approximately 2,000 MW, contributing to about 30% of Nigeria's electricity generation (Federal Ministry of Power, 2020). Additionally, the small hydropower potential is estimated to be around 3,500 MW, which can be developed to provide power to remote and rural areas, enhancing energy access and promoting socio-economic development.

Biomass resources, including agricultural waste, wood, and animal dung, are widely available in Nigeria and have significant potential for energy generation. The country's biomass energy potential is estimated at 144 million tons per year, which can be converted into various forms of bioenergy such as biogas and biofuels (Energy Commission of Nigeria, 2022). Despite the availability of these resources, the adoption of biomass energy technologies is still in its infancy, hindered by a lack of technical expertise and supportive policies.

Nigeria's renewable energy resources are plentiful and diverse, encompassing solar, wind, hydro, and biomass. However, realizing the full potential of these resources requires substantial investment in technology, infrastructure, and supportive legal frameworks. Addressing these issues is crucial for the sustainable development of Nigeria's renewable energy sector and the achievement of energy security and environmental sustainability.

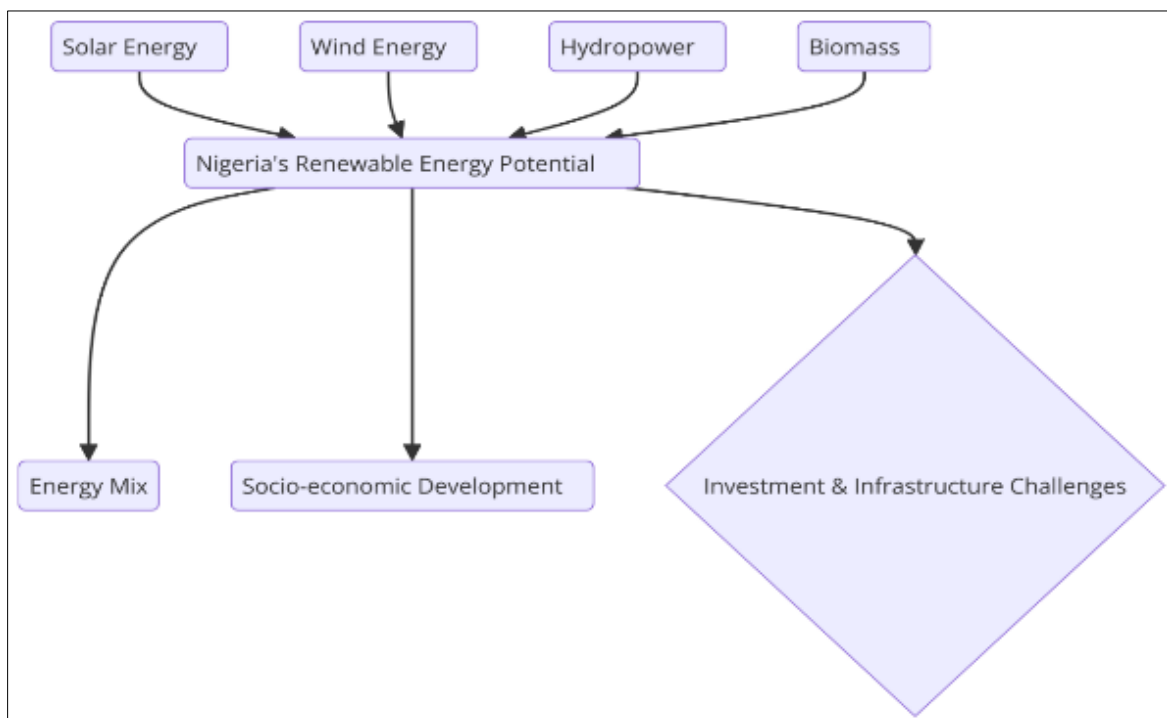


Figure 2 Overview of Nigeria's Renewable Energy Potential and Challenges

Figure 2 provides an overview of Nigeria's renewable energy resources, highlighting the key types: solar, wind, hydropower, and biomass. It illustrates how these resources contribute to Nigeria's overall renewable energy potential, which plays a crucial role in the country's energy mix and socio-economic development. The diagram also notes the investment and infrastructure challenges that need to be addressed to fully realize this potential.

2.2. Existing Renewable Energy Policies and Legislation

Nigeria has developed several policies and legislative frameworks to promote the growth and utilization of renewable energy resources. One of the cornerstone policies is the Renewable Energy Master Plan (REMP), which aims to increase the contribution of renewable energy to Nigeria's total energy mix from 13% in 2015 to 23% by 2025 and 36% by 2030 (Energy Commission of Nigeria, 2022). The REMP outlines specific strategies for the development and integration of renewable energy sources such as solar, wind, biomass, and small hydropower into the national grid.

Another significant legislative measure is the National Renewable Energy and Energy Efficiency Policy (NREEEP), which was introduced in 2015. The NREEEP provides a comprehensive framework for the development, utilization, and efficient management of renewable energy resources in Nigeria (Federal Republic of Nigeria, 2015). This policy emphasizes the need for creating a conducive environment for private sector investment, setting up regulatory frameworks, and ensuring the availability of financing mechanisms to support renewable energy projects.

The Electric Power Sector Reform Act (EPSRA) of 2005 is another critical piece of legislation that has impacted the renewable energy sector. The EPSRA aims to liberalize the power sector by encouraging private sector participation and investment in electricity generation, transmission, and distribution (Federal Ministry of Power, 2020). While the Act primarily focuses on the power sector, it provides an enabling environment for renewable energy projects by facilitating independent power producers (IPPs) and promoting competition within the sector. The Act established the Nigerian Electricity Regulatory Commission (NERC), responsible for regulating the electricity sector, including the development of renewable energy. In 2015, the NERC introduced the Renewable Energy Feed-in Tariff Regulation, a scheme aimed at attracting investments in renewable energy projects. Successful implementation of this scheme has the potential to generate at least 1000 MW of power from renewable sources. However, Nigeria encounters challenges in effectively implementing these policies (Akinbami, 2001).

The National Energy Policy 2003 is designed to ensure a sufficient, reliable, and affordable energy supply that is also environmentally responsible, supporting Nigeria's economic development. The policy emphasizes the use of alternative energy sources to safeguard the environment for the benefit of current and future generations. It seeks to increase the growth of the power sector through efficient regulatory tools. Additionally, the policy includes the establishment of the Rural Electrification Funds under Policy 5 of the Guidelines. The Renewable Electricity Trust Fund, funded by contributions from the private and governmental sectors, aims to finance renewable power projects.

The recently enacted Petroleum Industry Act (PIA) in 2021 is expected to bring extensive changes to the legal, administrative, and budgetary outline of Nigeria's oil and gas production and to encourage oil and gas companies in Nigeria to adopt more sustainable energy sources. Section 64 of the Act mandates NNPC Limited to collaborate with private financiers to expand renewable energy resources, providing a supervisory framework and appropriate funding for the energy transition. The implementation of the PIA is expected to attract significant investments and, if strictly enforced, could lead to substantial changes in the regulatory landscape of the industry [Olujobi et al., 2023].

Despite these policies and legislative measures, several challenges persist in the effective implementation and enforcement of renewable energy laws in Nigeria. Issues such as inadequate regulatory frameworks, limited access to financing, and insufficient technical capacity have hindered the growth of the renewable energy sector (International Renewable Energy Agency, 2020). To address these challenges, the Nigerian government has engaged in various international collaborations and agreements aimed at enhancing the development of renewable energy. For instance, Nigeria's participation in the Sustainable Energy for All (SE4ALL) initiative reflects its commitment to improving energy access and sustainability through the adoption of renewable energy technologies.

Nigeria has established a range of policies and legislative frameworks to support the growth of renewable energy. However, the effective implementation of these measures requires addressing existing challenges and creating a more supportive environment for renewable energy development.

Table 1 Summary of Key Policies and Legislation in Nigeria's Renewable Energy Sector

Policy/Legislation	Year	Key Objectives	Key Features	Challenges
Renewable Energy Master Plan (REMP)	2015	Increase renewable energy contribution to Nigeria's energy mix: 23% by 2025, 36% by 2030	Development and integration of solar, wind, biomass, and small hydropower into the national grid	Implementation challenges, regulatory frameworks, technical capacity limitations
National Renewable Energy and Energy Efficiency Policy (NREEEP)	2015	Provide a framework for the development and efficient management of renewable energy	Encourages private sector investment, sets regulatory frameworks, ensures financing mechanisms	Limited access to financing, inadequate regulatory enforcement
Electric Power Sector Reform Act (EPSRA)	2005	Liberalize the power sector, encourage private investment in electricity generation, transmission, and distribution	Facilitates Independent Power Producers (IPPs), promotes competition, established NERC, introduced Feed-in Tariff Regulation	Slow implementation, competition barriers, regulatory challenges
National Energy Policy	2003	Ensure reliable, affordable, and environmentally responsible energy supply	Promotes alternative energy sources, established Rural Electrification Funds, Renewable Electricity Trust Fund	Inefficient regulatory tools, slow progress in power sector growth
Petroleum Industry Act (PIA)	2021	Encourage oil and gas companies to adopt sustainable energy sources, support energy transition	Mandates NNPC Limited to collaborate with private financiers, provides funding and a supervisory framework	Enforcement challenges, industry resistance, limited investments so far
International Collaborations and Agreements	Various	Enhance development of renewable energy, improve energy access and sustainability	Participation in initiatives like Sustainable Energy for All (SE4ALL)	Implementation and sustainability challenges, dependence on international support

Table 1 summarizes Nigeria's key renewable energy policies and legislation, outlining their objectives, features, and challenges. Policies like the Renewable Energy Master Plan (REMP) and the National Renewable Energy and Energy Efficiency Policy (NREEEP) aim to boost renewable energy contributions and encourage private investment.

2.3. Status of Renewable Energy Development

Nigeria has made notable strides in developing its renewable energy sector, but significant gaps remain in achieving its full potential. As of 2023, the country's total installed capacity for renewable energy remained at approximately 2,000 MW, which includes contributions from solar, wind, small hydropower, and biomass sources (International Renewable Energy Agency, 2023). Solar energy has seen the most significant growth, with numerous off-grid solar projects and mini-grids being deployed to enhance electricity access in rural and underserved areas.

Solar power development has been particularly prominent due to Nigeria's high solar radiation levels, averaging 5.5 kWh/m²/day (Energy Commission of Nigeria, 2022). Initiatives such as the Nigeria Electrification Project (NEP) have facilitated the deployment of solar home systems and mini-grids, reaching over 500,000 households as of 2020 (Federal Ministry of Power, 2020). These projects are instrumental in reducing energy poverty and improving the quality of life in remote areas.

Wind energy development has, however, advanced at a slower pace compared to other renewable energy technologies. Despite an estimated potential of 11,000 MW, only a few small-scale wind projects are operational, primarily due to challenges in financing and technological expertise (International Renewable Energy Agency, 2020). The development of wind energy requires substantial investment in infrastructure and a supportive regulatory framework to attract private sector participation.

Hydropower remains a significant component of Nigeria's renewable energy landscape, contributing about 30% to the national grid through large-scale installations such as the Kainji and Jebba dams (Federal Ministry of Power, 2020). Additionally, small hydropower projects are being developed to serve local communities, with a potential capacity of around 3,500 MW. These projects are crucial for rural electrification and sustainable water management.

Biomass energy, encompassing agricultural residues, wood, and animal manure, presents significant potential but remains underutilized. Nigeria generates approximately 144 million tons of biomass annually, which can be converted into bioenergy (Energy Commission of Nigeria, 2019). The adoption of biomass energy technologies is still limited, primarily due to a lack of awareness, technical skills, and financial resources.

Although Nigeria has made advancements in the development of its renewable energy sector, particularly in solar and hydropower technologies, substantial challenges persist. Addressing these issues through targeted investments, policy reforms, and capacity building is essential for harnessing the full potential of renewable energy in Nigeria and achieving sustainable energy development.

Table 2 Current Status of Renewable Energy Development in Nigeria

Renewable Energy Source	Current Status (2023)	Installed Capacity	Key Developments	Challenges
Solar Energy	Significant growth in off-grid solar projects and mini-grids	High growth	Deployed through the Nigeria Electrification Project (NEP), reaching over 500,000 households	Financing, and expanding infrastructure in rural areas
Wind Energy	Limited development with only a few small-scale projects	Minimal development	Estimated potential of 11,000 MW, but only small projects operational	Financing, lack of technological expertise, need for a supportive regulatory framework
Hydropower	Major contributor to the national grid	Contributes about 30%	Large-scale installations like Kainji and Jebba dams, small hydropower projects for rural communities	Infrastructure maintenance, rural electrification efforts
Biomass Energy	Underutilized despite considerable potential	Limited adoption	Potential from 144 million tons of biomass annually	Lack of awareness, technical skills, and financial resources

Table 2 provides a snapshot of the status of renewable energy development in Nigeria, as of 2023. It highlights the progress in solar energy, which has seen significant growth due to off-grid projects and mini-grids, contributing to increased electricity access in rural areas. Hydropower remains a major contributor to the national grid, while biomass energy is underutilized despite its potential. Wind energy development lags, facing challenges in financing and technological expertise. The table also outlines the installed capacities, key developments, and challenges associated with various renewable energy sources.

3. Challenges in Renewable Energy Policy and Legislation

3.1. Legal and Regulatory Barriers

The development of renewable energy in Nigeria is significantly hampered by various legal and regulatory barriers. One of the primary challenges is the inadequacy and inconsistency of the existing legal frameworks. Although Nigeria has established several policies and legislative measures to promote renewable energy, there is often a lack of coherence

and alignment between these policies and the broader energy sector regulations (Energy Commission of Nigeria, 2022). For instance, the Renewable Energy Master Plan (REMP) and the National Renewable Energy and Energy Efficiency Policy (NREEEP) aim to increase renewable energy contributions but face implementation hurdles due to overlapping mandates and conflicting regulations.

Another critical issue is the absence of a comprehensive and integrated renewable energy law that provides clear guidelines for the development, financing, and deployment of renewable energy projects. The existing legal instruments, such as the Electric Power Sector Reform Act (EPSRA) of 2005, primarily focus on liberalizing the power sector and encouraging private sector participation but do not adequately address the specific needs of renewable energy development (Federal Ministry of Power, 2020). This lack of specificity often results in regulatory uncertainties that deter potential investors and project developers from entering the renewable energy market.

Moreover, the regulatory environment is characterized by bureaucratic inefficiencies and procedural delays, which further complicate the approval and implementation of renewable energy projects. Obtaining necessary permits and licenses can be a protracted process, involving multiple agencies with overlapping jurisdictions (International Renewable Energy Agency, 2020). These delays not only increase the costs and risks associated with renewable energy projects but also discourage investment and innovation in the sector.

The lack of effective enforcement mechanisms is another significant barrier. While policies and regulations exist, their enforcement is often weak due to limited institutional capacity and resources. Regulatory bodies such as the Nigerian Electricity Regulatory Commission (NERC) and the Rural Electrification Agency (REA) are tasked with overseeing the implementation of renewable energy projects, but they frequently lack the necessary financial and technical resources to fulfil their mandates effectively (Energy Commission of Nigeria, 2022).

To address these legal and regulatory barriers, it is essential for Nigeria to develop a unified and comprehensive legal framework that integrates renewable energy policies with broader energy sector regulations. This framework should provide clear guidelines for project development, streamline regulatory processes, and enhance the capacity of regulatory institutions to enforce compliance. By doing so, Nigeria can create a more conducive environment for renewable energy investments and accelerate the transition towards a sustainable energy future.

Table 3 Key Legal and Regulatory Barriers to Renewable Energy Development in Nigeria

Barrier	Description	Impact on Renewable Energy Development
Inadequate and Inconsistent Legal Frameworks	Lack of coherence and alignment between renewable energy policies and broader energy sector regulations	Implementation hurdles due to overlapping mandates and conflicting regulations, slowing progress
Absence of Comprehensive Renewable Energy Law	No integrated law providing clear guidelines for development, financing, and deployment of projects	Regulatory uncertainties deter investors and project developers, limiting market growth
Bureaucratic Inefficiencies and Delays	Procedural delays in obtaining permits and licenses due to multiple agencies with overlapping jurisdictions	Increased costs and risks, discouraging investment and innovation in renewable energy projects
Weak Enforcement Mechanisms	Insufficient enforcement of existing policies and regulations due to limited institutional capacity and resources	Ineffective regulation, hindering the successful implementation and scaling of renewable energy projects

Table 3 outlines the key legal and regulatory barriers that hinder the development of renewable energy in Nigeria. It highlights issues such as inadequate and inconsistent legal frameworks, the absence of a comprehensive renewable energy law, bureaucratic inefficiencies, and weak enforcement mechanisms. These barriers create regulatory uncertainties, procedural delays, and challenges in policy implementation, which collectively deter investment and impede the growth of renewable energy projects in the country.

3.2. Institutional Challenges

The development of renewable energy in Nigeria is impeded by several institutional challenges that complicate the implementation and scaling of renewable energy projects. One major challenge is the fragmentation and lack of coordination among various government agencies responsible for renewable energy policy and implementation. The overlapping roles and responsibilities of institutions such as the Energy Commission of Nigeria (ECN), the Rural Electrification Agency (REA), and the Nigerian Electricity Regulatory Commission (NERC) often lead to inefficiencies and delays in project execution (Olujobi et al., 2023).

Another significant issue is the insufficient capacity and expertise within these institutions to effectively manage and oversee renewable energy projects. Many of these agencies are underfunded and lack the necessary human resources to carry out their mandates efficiently (Adekoya et al., 2022). This deficiency in institutional capacity impedes the planning, implementation, and monitoring of renewable energy initiatives, leading to suboptimal outcomes.

Furthermore, there is a critical need for stronger institutional frameworks that can provide clear and consistent guidelines for renewable energy development. The current policy and regulatory environment is perceived as unstable and unpredictable, discouraging investment by both local and international stakeholders (Mafimidiwo & Saha, 2013). Investors require a stable and supportive regulatory environment to commit to long-term renewable energy projects. However, the frequent changes in policies and regulatory guidelines create uncertainty, making it difficult for investors to plan and execute projects effectively.

Additionally, corruption and bureaucratic red tape within these institutions pose significant barriers. The process of obtaining permits and approvals for renewable energy projects is often cumbersome and plagued by bureaucratic inefficiencies. This not only increases the cost and time required to develop projects but also creates opportunities for corrupt practices, further deterring potential investors (Adewuyi & Awodumi, 2021).

Addressing these institutional challenges is crucial for the sustainable development of renewable energy in Nigeria. Enhancing the capacity of regulatory bodies, improving coordination among agencies, and establishing a stable and transparent policy environment are essential steps towards overcoming these barriers. By strengthening institutional frameworks and reducing bureaucratic obstacles, Nigeria can create a more conducive environment for the growth of its renewable energy sector.

Table 4 Institutional Challenges Impacting Renewable Energy Development in Nigeria

Institutional Challenge	Description	Impact on Renewable Energy Development
Fragmentation and Lack of Coordination	Overlapping roles and responsibilities among government agencies (e.g., ECN, REA, NERC)	Inefficiencies and delays in project execution due to poor coordination
Insufficient Capacity and Expertise	Underfunded institutions lacking human resources and technical expertise	Hinders effective management, planning, and monitoring of renewable energy projects
Unstable Policy and Regulatory Environment	Frequent changes in policies and regulations, creating uncertainty for investors	Discourages long-term investment in renewable energy projects due to its unpredictability
Corruption and Bureaucratic Red Tape	Cumbersome permit and approval processes, prone to inefficiencies and corruption	Increases costs and delays, deterring potential investors from entering the renewable energy market

Table 4 summarizes the institutional challenges that impede the development of renewable energy in Nigeria. It highlights issues such as the fragmentation and lack of coordination among government agencies, insufficient capacity and expertise within institutions, an unstable policy and regulatory environment, and the prevalence of corruption and bureaucratic red tape. These challenges contribute to inefficiencies, delays, and increased costs in project execution, making it difficult for Nigeria to effectively implement and scale renewable energy initiatives. Addressing these challenges is crucial for creating a more supportive environment for renewable energy development in the country.

3.3. Financial and Economic Barriers

The development of renewable energy in Nigeria is significantly hindered by financial and economic barriers that impact project feasibility and scalability. One of the primary challenges is the high upfront cost of renewable energy technologies. Compared to conventional fossil fuel-based energy systems, renewable energy projects require substantial initial capital investments. For instance, the cost of solar photovoltaic (PV) systems, wind turbines, and small hydropower installations can be prohibitively high, especially in a developing country context where financial resources are limited (Akinola et al., 2017).

Access to finance is another critical barrier. Many renewable energy projects in Nigeria struggle to secure adequate funding due to the perceived high risks and uncertainties associated with the sector. Financial institutions are often reluctant to provide loans for renewable energy projects due to the long payback periods and the lack of a track record of successful projects (Mas'ud et al., 2024). Additionally, high interest rates and stringent lending criteria further complicate access to capital, making it difficult for project developers to obtain the necessary funding.

Government subsidies and incentives, which are crucial for offsetting the high costs of renewable energy technologies, are insufficient or inconsistently applied in Nigeria. While some policies and programs exist to support renewable energy, such as feed-in tariffs and tax incentives, their implementation has been sporadic and often marred by bureaucratic delays and corruption (Adaramola, Paul, & Oyewola, 2014). This lack of reliable and consistent financial support undermines investor confidence and hinders the growth of the renewable energy sector.

Furthermore, the economic environment in Nigeria presents additional challenges. The country's economy is heavily dependent on oil exports, resulting in a volatile economic landscape subject to fluctuations in global oil prices. This economic instability affects the availability of public funds for renewable energy investments and can lead to policy shifts detrimental to long-term project planning (Ogunjuyigbe, Ayodele & Akinola, 2016). Additionally, the lack of economic diversification limits the capacity to absorb the economic shocks associated with transitioning to renewable energy.

To overcome these financial and economic barriers, Nigeria needs to develop more robust and supportive financial mechanisms. This includes creating dedicated renewable energy funds, providing low-interest loans and grants, and implementing consistent and transparent subsidy programs. By addressing these financial challenges, Nigeria can create a more favorable environment for renewable energy investments and accelerate the adoption of sustainable energy technologies.

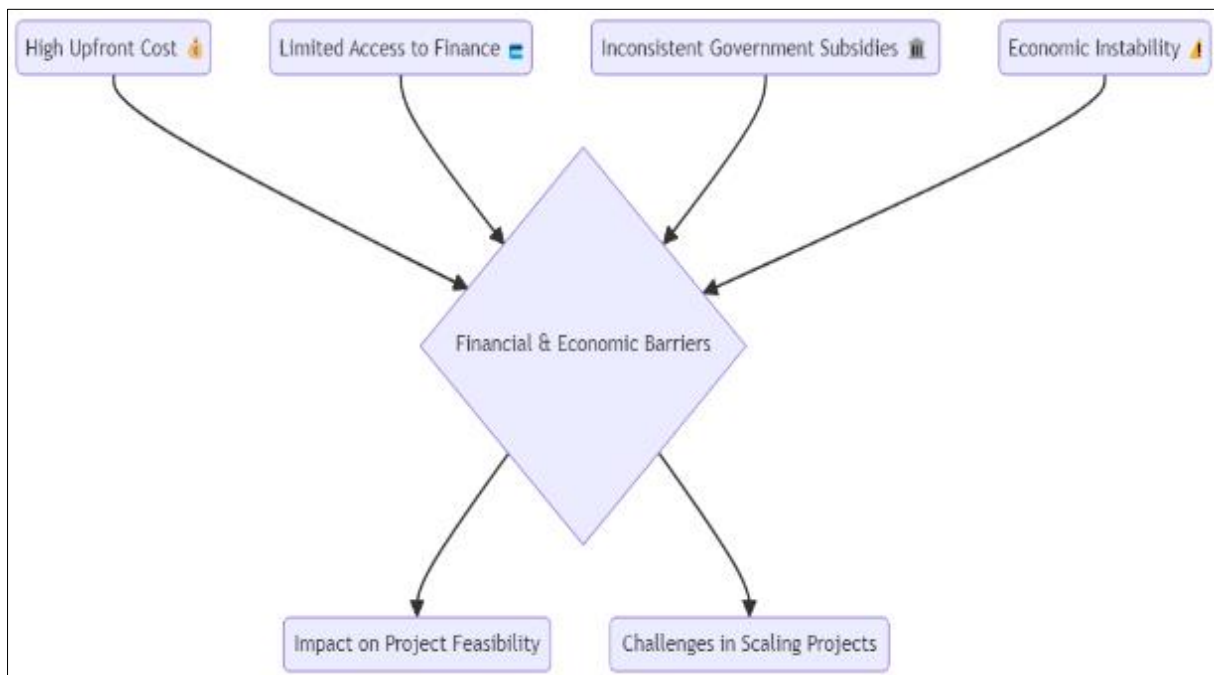


Figure 3 Key Financial and Economic Barriers to Renewable Energy Development in Nigeria

Figure 3 highlights the key financial and economic barriers that impede the development of renewable energy in Nigeria. It outlines four main obstacles: high upfront costs of renewable technologies, limited access to finance, inconsistent government subsidies, and economic instability. These barriers collectively impact the feasibility of renewable energy projects and present significant challenges to scaling up these initiatives in Nigeria.

3.4. Technical and Infrastructure Challenges

The advancement of renewable energy in Nigeria faces significant technical and infrastructure challenges, which impede the widespread adoption and implementation of renewable energy projects. One of the primary technical barriers is the lack of advanced technology and expertise required for the installation, maintenance, and operation of renewable energy systems. Nigeria's renewable energy sector is still in its nascent stage, and there is a critical shortage of skilled professionals and technical know-how (Ajayi et al., 2014). This deficiency affects the efficiency and reliability of renewable energy installations, leading to frequent breakdowns and suboptimal performance.

In addition, the existing power infrastructure in Nigeria is inadequate and outdated, posing a significant obstacle to the integration of renewable energy sources into the national grid. The national grid is characterized by high transmission losses, frequent outages, and limited reach, particularly in rural areas (Oyedepo, 2012). This outdated infrastructure makes it challenging to effectively distribute renewable energy generated from decentralized sources such as solar and wind farms. The lack of a robust and modernized grid infrastructure significantly limits the potential for scaling up renewable energy projects.

Furthermore, Nigeria lacks the necessary manufacturing capacity for renewable energy technologies. Most of the equipment and components for renewable energy projects, such as solar panels, wind turbines, and batteries, are imported, which increases the cost and delays the deployment of these technologies (Akinola et al., 2017). The reliance on imports also exposes the renewable energy sector to exchange rate fluctuations and international market dynamics, which can adversely affect project feasibility and sustainability.

Another critical challenge is the insufficient investment in research and development (R&D) for renewable energy technologies. There is a dire need for indigenous R&D efforts to adapt renewable energy technologies to local conditions and develop innovative solutions tailored to Nigeria's unique energy needs (Ajayi et al., 2014). However, funding for R&D in the renewable energy sector is limited, and there is a lack of collaboration between research institutions, industry, and government agencies. This gap hampers the development of homegrown technologies and the capacity to address technical challenges effectively.

To overcome these technical and infrastructure challenges, Nigeria must invest in capacity building and training programs to develop a skilled workforce for the renewable energy sector. Additionally, significant investments are needed to modernize the power grid and expand its reach to facilitate the integration of renewable energy. Promoting local manufacturing of renewable energy technologies and increasing funding for R&D are also critical steps towards enhancing the technical capabilities of the sector. By addressing these challenges, Nigeria can create a more resilient and efficient renewable energy infrastructure, paving the way for sustainable energy development.

Table 5 Technical and Infrastructure Challenges in Nigeria's Renewable Energy Sector

Challenge	Description	Impact on Renewable Energy Development
Lack of Advanced Technologies and Expertise	Shortage of skilled professionals and technical know-how in renewable energy	Affects efficiency, reliability, and performance of renewable energy systems, leading to frequent breakdowns
Inadequate and Outdated Power Infrastructure	Outdated national grid with high transmission losses and limited reach	Limits the integration of renewable energy into the grid, particularly in rural areas
Dependence on Imported Technologies	Reliance on imported equipment for renewable energy projects	Increases costs, delays deployment, and exposes the sector to exchange rate fluctuations
Insufficient Investment in R&D	Limited funding for research and development in renewable energy	Hampers the development of homegrown technologies and innovative solutions tailored to local conditions

Table 5 highlights the key technical and infrastructure challenges facing Nigeria's renewable energy sector. These include a lack of advanced technology and skilled professionals, outdated power infrastructure that limits the integration of renewable energy into the grid, reliance on imported technologies that increase costs and deployment delays, and insufficient investment in research and development. These challenges collectively hinder the efficiency, scalability, and sustainability of renewable energy projects in Nigeria, making it difficult to fully harness the country's renewable energy potential.

4. Opportunities for Enhancing Renewable Energy Policy and Legislation

4.1. Legislative Reforms

Legislative reforms are critical for advancing the renewable energy sector in Nigeria, addressing existing barriers, and creating a conducive environment for investment and development. One of the key areas for legislative reform is the harmonization of existing renewable energy policies and regulations. Currently, overlapping and occasionally conflicting policies and regulations create confusion and inefficiencies (Olujobi et al., 2023). Streamlining these regulations into a cohesive framework would provide clearer guidelines for stakeholders and enhance policy implementation.

Another significant legislative reform needed is the introduction of specific laws that directly target the promotion and support of renewable energy projects. For example, while the Electric Power Sector Reform Act (EPSRA) of 2005 aimed to liberalize the electricity market, it did not adequately address the unique challenges and requirements of renewable energy development (Okoro, Govender & Chikuni, 2007). New legislation that includes provisions for incentives such as tax breaks, subsidies, tendering arrangements, feed-in-tariff (FiT), net-metering programs, and green certificates for renewable energy projects would help attract both local and international investors (Nnaemeka & Nebedum, 2016).

In addition to creating new laws, it is essential to strengthen the capacity of regulatory bodies responsible for overseeing the renewable energy sector. Institutions such as the Nigerian Electricity Regulatory Commission (NERC) and the Rural Electrification Agency (REA) need enhanced legislative backing to enforce regulations effectively and support the development of renewable energy projects (Adaramola, Paul, & Oyewola, 2014). Strengthening these institutions would involve not only providing them with more resources but also ensuring that they have the legal authority to implement and enforce renewable energy policies.

Furthermore, legislative reforms should also focus on facilitating access to finance for renewable energy projects. This could include establishing renewable energy funds, providing guarantees for loans, and reducing the financial risks associated with renewable energy investments (Olujobi et al., 2023). By addressing the financial challenges through legislative measures, Nigeria can significantly increase the flow of capital into the renewable energy sector.

Finally, there is a need for legislation that supports research and development (R&D) in renewable energy technologies. Encouraging innovation through grants, tax incentives, and collaborations between universities, research institutions, and the private sector can drive technological advancements and local adaptation of renewable energy solutions (Okoro, Govender & Chikuni, 2007). Such reforms would ensure that Nigeria not only adopts but also innovates within the renewable energy sector.

Comprehensive legislative reforms that harmonize existing policies, introduce supportive laws, strengthen regulatory institutions, facilitate access to finance, and promote R&D are crucial for the sustainable development of the renewable energy sector in Nigeria.

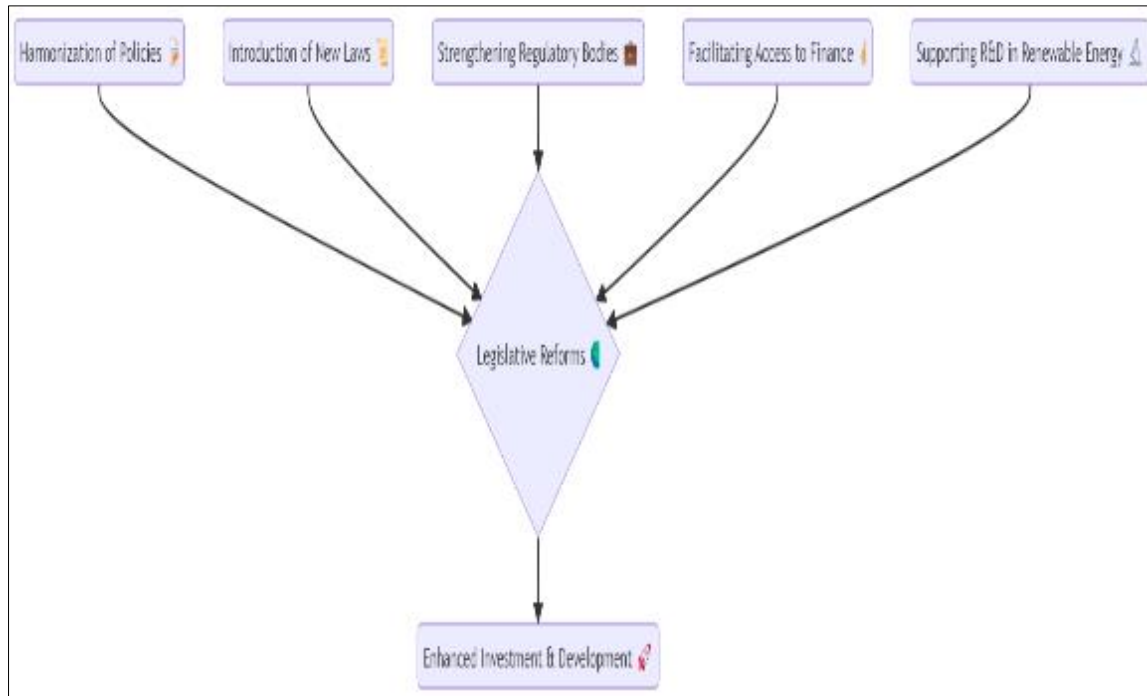


Figure 4 Key Legislative Reforms to Boost Renewable Energy in Nigeria

Figure 4 outlines the essential legislative reforms needed to drive the growth of renewable energy in Nigeria. It focuses on harmonizing existing policies, introducing new supportive laws, strengthening regulatory bodies, facilitating financial access, and promoting research and development. These reforms are crucial for creating a favorable environment for investment and development in the renewable energy sector, leading to increased adoption and innovation in sustainable energy solutions.

4.2. Institutional Strengthening

Institutional strengthening is crucial for the effective implementation of renewable energy policies in Nigeria. One of the main areas needing improvement is the capacity building of key regulatory agencies such as the Nigerian Electricity Regulatory Commission (NERC) and the Rural Electrification Agency (REA). These institutions are often under-resourced and lack the necessary technical expertise to oversee and manage renewable energy projects efficiently (Mas'ud et al., 2024). Enhancing their capacity through training programs, increased funding, and adoption of best practices from other countries can significantly improve their effectiveness.

Another critical aspect of institutional strengthening is the improvement of inter-agency coordination. The current landscape is characterized by overlapping responsibilities and a lack of clear communication channels among various government bodies involved in the energy sector (Akinbami, 2001). Establishing a centralized body or a clear framework for coordination can help streamline processes, reduce bureaucratic delays, and ensure that policies are implemented more consistently across the board.

Moreover, transparency and accountability within these institutions must be enhanced to build investor confidence and attract more private-sector participation in the renewable energy sector. Instances of corruption and inefficiency have been reported, which undermine the trust of both local and international investors (Resimić, 2023). Implementing robust anti-corruption measures, ensuring transparent procurement processes, and regularly auditing the activities of regulatory bodies can help mitigate these issues.

Additionally, there is a need for better data management and dissemination practices within these institutions. Accurate and timely data is essential for planning, monitoring, and evaluating renewable energy projects (Adaramola, Paul, & Oyewola, 2014). Investing in modern data management systems and training personnel to use these systems effectively can enhance the decision-making process and improve the overall efficiency of project implementation.

Finally, strengthening institutional frameworks should also involve creating an enabling environment for research and development (R&D). Government agencies should collaborate with universities, research institutions, and the private

sector to foster innovation and adapt renewable energy technologies to local conditions (Mas'ud et al., 2024). By supporting R&D initiatives, Nigeria can develop homegrown solutions that are more suited to its unique energy needs and challenges.

Institutional strengthening through capacity building, improved coordination, enhanced transparency, better data management, and support for R&D is vital for the successful implementation of renewable energy policies in Nigeria. These measures will not only improve the effectiveness of regulatory bodies but also create a more conducive environment for the growth of the renewable energy sector.

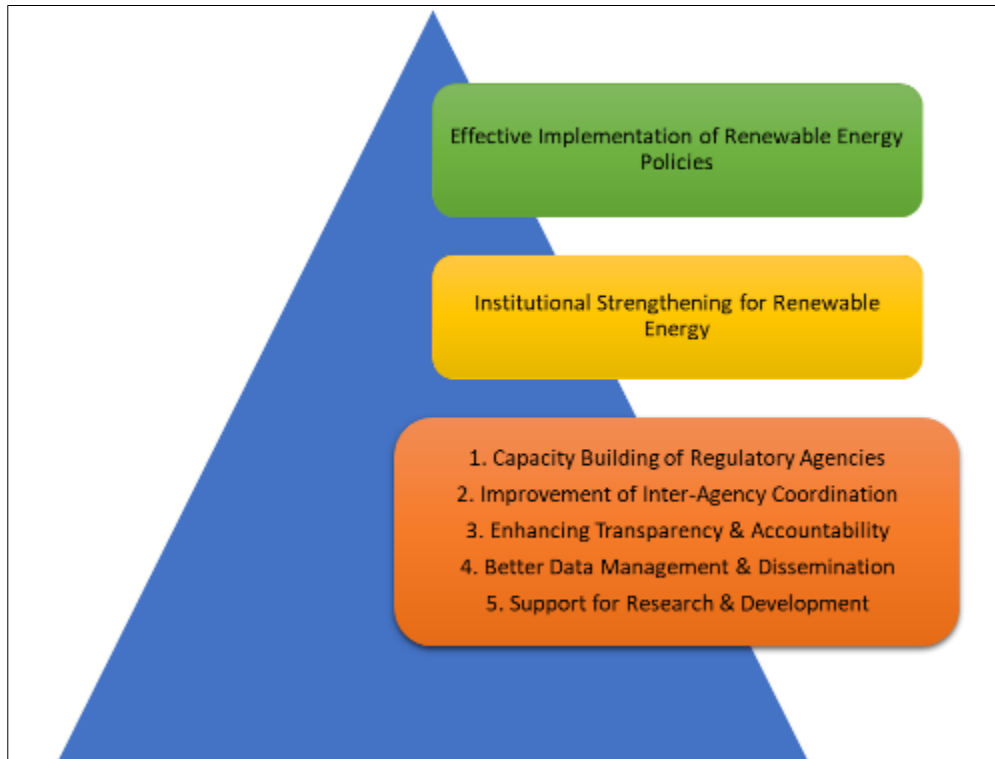


Figure 5 Key Components of Institutional Strengthening for Renewable Energy in Nigeria

Figure 5 highlights the key components necessary for institutional strengthening in Nigeria's renewable energy sector. It outlines five critical areas: capacity building of regulatory agencies, improvement of inter-agency coordination, enhancing transparency and accountability, better data management, and support for research and development (R&D). These elements are vital for building stronger institutions that can effectively implement and enforce renewable energy policies, ultimately leading to more successful and sustainable energy projects in Nigeria.

4.3. Financial and Economic Incentives

Financial and economic incentives are crucial for fostering the growth of the renewable energy sector in Nigeria. One of the main financial incentives that can drive renewable energy development is the implementation of a feed-in tariff (FIT). FIT is a policy designed to offer long-term contracts to renewable energy producers, typically based on the cost of generation of each technology (Dugeri, 2021). This mechanism provides a guaranteed market and stable prices for renewable energy, ensures a shorter payback period on investments, avoids market monopolies by removing market entry barriers for small investors and secures returns over the long term, thereby reducing investment risks and encouraging more stakeholders to enter the market. The United States pioneered the implementation of Feed-in Tariff Systems (FITS), a policy subsequently adopted by other nations, including the United Kingdom, Japan, and Germany.

Another significant incentive is the provision of tax credits and subsidies for renewable energy projects. These financial incentives can lower the initial capital costs associated with renewable energy installations, making them more competitive with traditional fossil fuel-based energy sources (Akuru et al., 2017). Providing tax rebates or exemptions on imported renewable energy technologies and equipment can significantly reduce project costs and stimulate market growth. In the Netherlands, industries benefit from accelerated depreciation on investments in equipment when they invest in renewable energy and energy efficiency projects (Ruijs, & Vollebergh, 2013).

Access to low-interest loans and grants is also essential for promoting renewable energy projects in Nigeria. Financial institutions in Nigeria are often reluctant to finance renewable energy projects due to the perceived high risks and long payback periods (Adenikinju, 2003). Establishing dedicated renewable energy funds and providing government-backed loan guarantees can mitigate these financial risks and attract more private-sector investment. For example, creating green bonds specifically for renewable energy projects can mobilize capital from investors interested in sustainable and environmentally friendly projects.

Furthermore, performance-based incentives can play a significant role in encouraging renewable energy production. These incentives reward producers based on the amount of renewable energy generated, thus promoting efficiency and innovation in the sector (Dugeri, 2021). Such incentives can be particularly effective in encouraging the adoption of new technologies and improving the overall productivity of renewable energy installations.

Finally, financial incentives should also target research and development (R&D) in the renewable energy sector. Providing grants and funding for R&D initiatives can drive technological advancements and adaptation of renewable energy technologies to local conditions. Collaborative efforts between government, private sector, and academic institutions can foster innovation and create more efficient and cost-effective renewable energy solutions (Akuru et al., 2017).

Implementing financial incentives such as feed-in tariffs, tax credits, low-interest loans, performance-based rewards, and R&D funding are crucial for accelerating the development of renewable energy in Nigeria. These incentives can lower financial barriers, reduce investment risks, and stimulate market growth, thereby contributing to a sustainable energy future for the country.

4.4. Technological Innovation and Infrastructure Development

Technological innovation and infrastructure development are critical components for the successful deployment and scaling of renewable energy projects in Nigeria. One of the main challenges facing the renewable energy sector in Nigeria is the lack of advanced technology and the necessary infrastructure to support large-scale renewable energy projects (Olujobi et al., 2023). To address this, there must be a concerted effort to promote technological innovation through research and development (R&D) initiatives, alongside investments in modern infrastructure.

Technological innovation plays a pivotal role in reducing costs and improving the efficiency of renewable energy technologies. For example, advancements in photovoltaic (PV) technology have led to significant reductions in the cost of solar panels, making solar energy more accessible and affordable (Akinwale, Akinbami & Akarakiri, 2018). Additionally, innovations in battery storage technology can help address the intermittent issues associated with renewable energy sources, ensuring a more stable and reliable energy supply (Olujobi et al., 2023).

Infrastructure development is equally important. The current state of Nigeria's energy infrastructure is inadequate to support the integration of renewable energy sources into the national grid. The national grid is characterized by high transmission losses and frequent outages, which undermine the reliability of energy supply (Okoro, Govender & Chikuni, 2007). Upgrading and expanding the grid infrastructure is essential to accommodate the increased generation capacity from renewable energy projects and ensure efficient electricity distribution.

Moreover, establishing renewable energy parks and hubs can act as centers for innovation and development. These hubs can foster collaboration among researchers, industry players, and government agencies, creating an ecosystem that supports the advancement of renewable energy technologies (Akinwale, Akinbami & Akarakiri, 2018). Such initiatives can also attract foreign direct investment (FDI) by offering a conducive environment for technological innovation and business development.

Furthermore, policy measures should be implemented to incentivize private sector investment in renewable energy infrastructure. This can include public-private partnerships (PPPs) where the government collaborates with private entities to finance and develop renewable energy projects. Providing tax incentives, grants, and subsidies for infrastructure development can also stimulate investment and accelerate the growth of the renewable energy sector (Olujobi et al., 2023).

Technological innovation and infrastructure development are crucial for the sustainable growth of Nigeria's renewable energy sector. By investing in advanced technologies, upgrading the national grid, and implementing supportive policies, Nigeria can address existing challenges and fully harness its vast renewable energy potential.

5. Summary of Key Findings

The exploration of renewable energy policy and legislation in Nigeria reveals a complex landscape characterized by significant challenges and substantial opportunities. One of the primary challenges is the inadequacy of the current legal and regulatory frameworks. Existing policies often lack coherence and alignment, creating an environment of uncertainty that hinders investment and project implementation (Olujobi et al., 2023). Furthermore, bureaucratic inefficiencies and corruption exacerbate these issues, making it challenging for renewable energy projects to progress smoothly.

Financial barriers also significantly challenge the development of renewable energy in Nigeria. The high upfront costs of renewable energy technologies, coupled with limited access to financing, restrict the ability of many projects to commence (Adenikinju, 2003). Despite some government incentives, these measures are often inconsistently applied and insufficient to offset the initial capital expenditures required for renewable energy projects (Adaramola, Paul, & Oyewola, 2014).

On the other hand, there are considerable opportunities for growth within the sector. Nigeria's abundant renewable energy resources, including solar, wind, hydro, and biomass, provide a strong foundation for developing a diversified energy portfolio. Technological innovations, particularly in solar and battery storage, have the potential to significantly lower costs and improve the efficiency of renewable energy systems (Olujobi et al., 2023). Moreover, institutional strengthening and better inter-agency coordination can streamline processes and enhance the implementation of renewable energy projects (Akinwale, Akinbami & Akarakiri, 2018).

Effective implementation of financial incentives, such as feed-in tariffs, tax credits, and low-interest loans, can stimulate investment and drive the growth of the renewable energy sector (Dugeri, 2021). Additionally, fostering a supportive environment for research and development can lead to technological advancements tailored to Nigeria's specific needs and conditions. By addressing existing challenges and leveraging these opportunities, Nigeria can significantly enhance its renewable energy capacity and advance towards a more sustainable and resilient energy future.

5.1. Policy Recommendations

To advance the renewable energy sector in Nigeria, several policy recommendations must be implemented to address the existing challenges and harness the available opportunities.

First, it is crucial to streamline and harmonize the existing renewable energy policies and regulations. Creating a cohesive and comprehensive policy framework will reduce regulatory uncertainties and foster a more conducive environment for investment and project development (Olujobi et al., 2023). This involves consolidating overlapping mandates and ensuring consistency in policy implementation across various government agencies.

Second, financial incentives should be enhanced to attract more private sector investment into the renewable energy sector. Implementing robust feed-in tariffs, offering tax breaks, and providing subsidies for renewable energy projects can significantly reduce the financial burden on investors (Dugeri, 2021). Additionally, establishing renewable energy funds and offering low-interest loans and grants can help bridge the financing gap and stimulate market growth (Akuru et al., 2017).

Third, there should be a concerted effort to build the technical capacity of regulatory bodies and industry stakeholders. This includes providing training programs for personnel in key agencies such as the Nigerian Electricity Regulatory Commission (NERC) and the Rural Electrification Agency (REA), as well as encouraging knowledge transfer through international collaborations (Mas'ud et al., 2024). Strengthening the technical expertise within these institutions will enhance their ability to effectively oversee and support renewable energy projects.

Fourth, investing in research and development (R&D) is vital for fostering innovation and adapting renewable energy technologies to local conditions. The government should allocate funds for R&D initiatives and promote partnerships between academic institutions, research centers, and the private sector (Akinwale, Akinbami & Akarakiri, 2018). Supporting indigenous innovation will lead to the development of cost-effective and efficient renewable energy solutions tailored to Nigeria's unique energy landscape.

Finally, enhancing infrastructure development is essential for integrating renewable energy sources into the national grid. Upgrading the existing grid infrastructure to reduce transmission losses and improve reliability is critical (Okoro,

Govender & Chikuni, 2007). Additionally, establishing renewable energy parks and hubs can serve as innovation centers that facilitate collaboration and attract investment.

Implementing these policy recommendations will address the challenges currently impeding the renewable energy sector in Nigeria. By creating a supportive regulatory environment, providing financial incentives, building technical capacity, investing in R&D, and improving infrastructure, Nigeria can unlock its vast renewable energy potential and achieve sustainable energy development.

5.2. Future Research Directions

Future research in Nigeria's renewable energy sector should address several key areas to bridge existing gaps and support the development of sustainable energy solutions. A critical focus should be on the economic viability and scalability of renewable energy projects. Research should investigate innovative financing models and mechanisms to mitigate the financial risks associated with renewable energy investments. This includes examining the impact of various financial incentives, such as green bonds and public-private partnerships, on the adoption and expansion of renewable energy technologies (Adaramola, Paul, & Oyewola, 2014).

Another important research direction is the integration of renewable energy into Nigeria's national grid. Given the current limitations of the grid infrastructure, studies should investigate advanced grid management techniques and smart grid technologies that can enhance the reliability and efficiency of electricity distribution. Research should also focus on developing decentralized energy systems, such as microgrids and off-grid solutions, to improve energy access in rural and underserved areas (Adenikinju, 2003).

Technological innovation is also a crucial area for future research. This includes developing and adapting renewable energy technologies to suit Nigeria's specific climatic and geographical conditions. For example, research can explore the potential of hybrid renewable energy systems that combine solar, wind, and biomass energy to provide a more stable and reliable power supply (Olujobi et al., 2023). Additionally, advancements in energy storage technologies, such as batteries and supercapacitors, are crucial for addressing the fluctuations and reliability issues associated with renewable energy sources.

Furthermore, research should focus on the socio-economic impacts of renewable energy deployment. This includes assessing the potential for job creation, local economic development, and improvements in quality of life resulting from increased access to clean energy. Studies should also examine the social acceptance of renewable energy projects and the effectiveness of community engagement strategies in fostering public support for renewable energy initiatives (Dugeri, 2021).

Lastly, policy and regulatory research is vital for informing the development of robust and supportive frameworks for renewable energy. This involves analyzing the effectiveness of current policies and regulations, identifying gaps and barriers, and proposing reforms that can enhance the regulatory environment for renewable energy development. Comparative studies with other countries that have successfully implemented renewable energy policies can provide valuable insights and best practices for Nigeria (Adaramola, Paul & Oyewola, 2014).

Future research should focus on financing models, grid integration, technological innovation, socio-economic impacts, and policy analysis to support the sustainable development of the renewable energy sector in Nigeria.

6. Conclusion

The development of renewable energy in Nigeria presents both significant challenges and substantial opportunities. To unlock the country's renewable energy potential, it is crucial to address the legal, financial, technical, and institutional barriers. Establishing a comprehensive and cohesive policy framework, along with robust financial incentives, will foster a more favorable environment for investment and project implementation. Enhancing the capacity of regulatory bodies, promoting technological innovation, and upgrading infrastructure are essential steps toward achieving a sustainable energy future.

Investing in research and development and encouraging public-private partnerships can drive technological advancements and produce solutions tailored to Nigeria's unique energy needs. Additionally, improving the socio-economic impacts of renewable energy projects, such as job creation and local economic development, will garner public support and ensure the long-term success of these initiatives.

By adopting a holistic approach that integrates policy reform, financial incentives, technological innovation, and institutional strengthening, Nigeria can significantly boost its renewable energy capacity. This effort will contribute not only to environmental sustainability but also to economic growth and improved quality of life for its citizens. While the journey toward a sustainable energy future is complex, it is achievable with the concerted efforts of all stakeholders.

Compliance with ethical standards

Disclosure of conflict of interest

There are no conflicts of interest to disclose.

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