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THE POTENTIAL, BARRIERS. AND STRATEGIES TO UPSCALE RENEWABLE ENERGY ADOPTION IN DEVELOPING COUNTRIES: NIGERIA AS A CASE STUDY

Afor Avwioroko¹

¹Consultant, PwC, Nigeria

*Corresponding Author: Afor Avwioroko

Corresponding Author Email: Aforavwioroko@yahoo.com

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ABSTRACT

Renewable energy plays a crucial role in sustainable development strategies, especially for developing countries like Nigeria that face energy challenges. This paper explores how deploying renewable energy in Nigeria can contribute to meeting the country's energy needs, drive economic growth, and support to achieve Nigeria's environmental sustainability goal. As Africa's most populous nation and largest economy, Nigeria depends heavily on fossil fuels for its energy needs despite having abundant renewable energy resources such as solar, wind, hydro, and biomass. Harnessing renewable energy in Nigeria offers numerous benefits. First, renewable energy offers a pathway to diversify Nigeria's energy sources, reducing dependence on fossil fuels and enhancing energy security. Second, deploying renewable energy can stimulate economic growth by attracting investment, fostering local entrepreneurship and creating job opportunities. Third, transitioning to renewable energy sources helps to reduce greenhouse gas emissions, and alleviate environmental issues associated with traditional energy sources. However, several challenges hinder the widespread adoption of renewable energy in Nigeria. These challenges include policy and regulatory barriers, limited access to financing, inadequate infrastructure, and a lack of technical capacity. Overcoming these obstacles requires a multi-faceted approach, including policy

reforms, financial incentives, infrastructure development, capacity building, and fostering public-private partnerships. By drawing insights from successful renewable energy projects and initiatives in other developing countries, Nigeria can develop tailored strategies to effectively harness its renewable energy potential. The application of these strategies offers Nigeria an opportunity to achieve its sustainable development goals, enhance energy access, and promote prosperity. Achieving these goals will also require collaboration from government, industry stakeholders, and civil society.

Keywords: Renewable energy, strategy, Developing countries, Nigeria, Case study.

INTRODUCTION

Renewable energy has become a focal point in the global dialogue on sustainable development and addressing climate change. The transition to renewable energy sources has gained substantial traction as the world grapples to address climate change and seeks to ensure energy diversity and reliability (Abdmouleh et al., 2015). This introduction section gives an overview of renewable energy and highlights its importance especially in developing countries. Using Nigeria as a case study, it illustrates how renewable energy strategies can make a significant difference in addressing energy needs and fostering sustainable growth.

Renewable energy sources, unlike finite fossil fuels, are replenishable and offer abundant, clean, and sustainable alternatives (Gielen et al., 2019). Renewable energy includes solar, wind, hydroelectric, biomass, and geothermal energy. Solar power utilizes sunlight through photovoltaic panels or solar thermal systems to produce electricity or heat water for diverse purposes. Similarly, wind turbines transform the kinetic energy of wind into electricity, offering a scalable and eco-friendly energy solution (Abdmouleh et al., 2015). Hydroelectric dams utilize the power of flowing water to generate electricity. Biomass energy utilizes organic materials like wood, agricultural residues, and organic waste to create heat, electricity, or biofuels through combustion, fermentation, or chemical processes. Geothermal energy uses the heat stored below the earth's surface to produce electricity or heating and cooling. Renewable energy technology is constantly advancing. This technological advancement has led to increased efficiency and cost-effectiveness of the technologies (Cicilio et al., 2021). This progress has driven the proliferation of renewable energy projects globally, facilitating the global transition to a more sustainable future in energy usage.

Nigeria faces a unique challenge related to energy access, economic development, and environmental sustainability. Nigeria's high reliance on fossil fuels for energy production has contributed to the current energy poverty and increased climate vulnerability. Renewable energy offers a solution to these issues as well as many other benefits. Renewable energy technologies, especially decentralized systems like solar home systems and mini grids, can provide reliable electricity to remote and underserved communities, improving livelihoods and driving socio-economic development (Starke, 2013). Investing in renewable energy infrastructure stimulates local economies by creating jobs, attracting investment, and fostering innovation in clean energy industries. Additionally, renewable energy projects promote technology transfer, skills development, and entrepreneurship, driving sustainable economic growth. Renewable energy also mitigates environmental degradation and reduces greenhouse gas emissions, helping countries meet their climate commitments under international agreements like the Paris Agreement (Komor and Bazilian, 2005). Transitioning to renewable

energy sources allows developing countries to reduce the adverse impacts of climate change, preserve ecosystems, and protect public health.

Nigeria, Africa's most populous nation and largest economy, faces significant energy challenges despite its rich natural resources. The country heavily relies on fossil fuels, particularly oil and gas, for electricity generation and economic revenue. However, inefficiency, insufficient infrastructure, and widespread energy poverty plague Nigeria's energy sector, leaving millions without reliable electricity access. Despite Nigeria's abundant renewable energy resources, including solar, wind, hydro, and biomass, the country is yet to fully exploit these clean energy sources (Geels et al., 2020). Exploring the opportunities, challenges, and policy implications of adopting renewable energy in Nigeria reveals insights into the broader implications for sustainable development in developing countries.

In conclusion, renewable energy offers significant potential for alleviating energy poverty, stimulating economic development, and advancing environmental sustainability in developing countries such as Nigeria (Lewis, 2016). Through the utilization of renewable energy resources and the enactment of supportive policies and frameworks, countries chart a course towards a more equitable, prosperous, and sustainable future.

Current Energy Situation in Nigeria

Nigeria is one of the world's leading oil producers and exporters. The country relies on fossil fuels, particularly crude oil and natural gas, as the major sources of its export earnings and government revenue. In the electricity sector, fossil fuels, primarily natural gas, dominate the energy mix. Gas-fired power plants contribute the majority of Nigeria's electricity generation capacity, with oil-fired plants playing a smaller role (Sambo et al., 2010). Despite being a major oil producer, Nigeria grapples with widespread energy poverty, with a significant portion of its population lacking access to reliable electricity. For example, rural areas in Nigeria face acute energy deficits, hindering socio-economic development and exacerbating inequalities (Terluin, 2003). Nigeria's energy infrastructure is characterized by aging facilities, transmission losses, and insufficient capacity, hindering its ability to meet growing demand. Inadequate investment in grid infrastructure contributes to frequent power outages, limiting industrial productivity and stifling economic growth. Limited access to financing and uncertainties in the country's energy policies further impede the development of energy projects, particularly in renewable energy (Just, 2003).

Nigeria's reliance on fossil fuels for energy generation has significant environmental consequences, including air and water pollution, deforestation, and greenhouse gas emissions. This highlights the need to transition to cleaner and more sustainable energy sources (Wierling et al., 2018). Diversifying Nigeria's energy mix with renewable energy sources contributes to achieving energy security by reducing the reliance on imported fuels and the volatile global oil markets. Renewable energy provides decentralized, and resilient solutions to achieve energy independence (Lewis et al., 2003). These solutions could help Nigeria attain its development goals, support economic diversification, job creation, and inclusive growth. Investing in renewable energy infrastructure would provide power to support local industries, support small and medium enterprises, and empower communities through access to clean energy services (Stewart, 1981).

The current energy situation in Nigeria indicates the need for urgent action to address energy poverty and the infrastructure deficiencies plaguing the energy sector (Cerulli, 2010). The

increased integration of renewable energy solutions into Nigeria's energy mix presents a viable pathway towards achieving energy security, promoting sustainable development, and mitigating the impact of climate change. Moreover, transitioning to renewable energy aligns with Nigeria's climate change mitigation efforts, as outlined in its nationally determined contributions (NDCs) under the Paris Agreement. This will help Nigeria reduce its greenhouse gas emissions, achieve a low-carbon economy, and contribute to mitigating global warming. However, realizing the full potential of renewable energy requires concerted efforts from policymakers, investors, and stakeholders to overcome existing barriers and accelerate the transition to a cleaner, more resilient energy future.

Renewable Energy Resource In Nigeria

Nigeria possesses abundant renewable energy resources. This presents the potential to diversify its energy mix while improving energy reliability and security. This section examines Nigeria's renewable energy sources and their potential impact across various sectors.

Solar Energy

Solar photovoltaic (PV) system converts solar radiation into electricity (Jebaraj & Iniyar, 2006). Nigeria receives an average solar radiation of about 5.5 kWh/m²/day across the country, making it conducive for solar energy generation. Nigeria's large landmass and favorable solar irradiation make it suitable for utility-scale solar PV projects, as well as distributed solar systems for residential, commercial, and industrial use. Solar-powered irrigation systems also have the potential to transform Nigeria's agriculture sector by providing reliable and sustainable water supply for crop irrigation, especially in remote and off-grid areas (Dimos & Pugh, 2016).

Wind Energy

Nigeria possesses significant wind energy potential, particularly in coastal and northern states with favorable wind profile (Idris, Ibrahim, & Albani, 2020). Wind turbines, mostly in wind farms, are used to harness wind energy at a large scale. Promising sites for wind farm development include coastal areas and northern regions with favorable wind regimes (Hung et al., 2016). Moreover, in these areas, hybrid systems such as wind-diesel systems or wind-solar systems can be utilized to provide a reliable and cost-effective solution for electrification.

Hydroelectric Power

Hydroelectric power is a major source of power in Nigeria, with several dams and hydroelectric power stations contributing to the country's electricity generation (Schermeier et al., 2018). The major hydroelectric power stations include the Kanji Dam, Jebba Dam, and Shiroro Dam. Challenges such as maintenance issues, water management, and environmental concerns, including the displacement of communities and ecological impacts, have affected the hydro power generation in Nigeria. Despite these challenges, hydroelectric power holds significant potential, especially small-scale hydropower projects. These small-scale hydro projects have the potential to provide decentralized power to rural communities and off-grid areas, improving energy access.

Biomass

Biomass, which includes organic materials such as agricultural residues, forest residues, and dedicated energy crops, can be converted into valuable biogas using different technologies. Anaerobic digestion technology, using agricultural feedstock such as crop residues, animal

waste, and agro-industrial, is a common technology in Nigeria. This technology converts organic waste to produce biogas (Jasiūnas et al., 2021). Biomass to energy provide a sustainable waste management solution while producing clean energy for cooking, heating, and electricity generation. Additionally, biomass-derived biofuels like ethanol and biodiesel can replace fossil fuels in transportation and industrial applications, reducing greenhouse gas emissions and enhancing energy security.

ADVANTAGES OF ADOPTING RENEWABLE ENERGY IN NIGERIA

Implementing renewable energy solutions in Nigeria provides a variety of benefits across economic, environmental, and social aspects.

Economic Benefits

Investing in renewable energy infrastructure stimulates economic activity and creates job opportunities across the renewable energy value chain, including manufacturing, installation, operation, and maintenance. Renewable energy sources offer the potential for long-term cost savings by reducing the country's energy import bill and enhancing energy affordability for consumers and businesses (Dong et al., 2018). Renewable energy projects generate revenue through electricity sales, exports, carbon credits, and other financial mechanisms, boosting government revenue and contributing to economic diversification.

Environmental Benefits

The transition from fossil fuels to renewable energy would help Nigeria reduce its greenhouse gas emissions, mitigate against environmental degradation, thereby improving air quality. The deployment of renewable energy supports would help Nigeria in its climate change mitigation efforts, reducing the country's carbon footprint, and assisting in meeting its international commitments under the Paris Agreement (Papaefthymiou and Dragoon, 2016).

Social Benefits

Nigerians, particularly in rural and underserved communities, are exposed to pollution and health hazards as result of using traditional biomass for cooking (Sa'ad & Bugaje, 2016). Transitioning to renewable energy provides access to clean and reliable energy (Stem et al., 2005) and minimizes the health risk exposure from the use of traditional biomass, improving the quality of life, especially for women and children, who are mostly impacted (Clinch & Healy, 2001). Renewable energy projects foster community engagement, capacity building, and local empowerment, promoting social cohesion, resilience, and inclusive development.

CHALLENGES AND BARRIERS TO RENEWABLE ENERGY ADOPTION IN NIGERIA

The largescale adoption of renewable energy solutions in Nigeria has been impeded by many factors. These include uncertain policy and regulatory frameworks, financial constraints, and inadequate infrastructure limitations (Frieden, 1991).

Policy and Regulatory Challenges

Establishing clear regulatory frameworks is essential for attracting investment, facilitating project implementation, and ensuring regulatory compliance (Seufert & Andrew, 2012). Nigeria's uncertain policy landscape and administrative bottlenecks and inconsistencies leading to delays in project approvals and inconsistent enforcement of regulations, poses risks and barriers to renewable energy development (Kushler et al., 2006). Moreover, Nigeria's regulatory institutions and energy agencies often lack the technical expertise, resources, and institutional capacity to effectively oversee and regulate the renewable energy sector.

Strengthening institutional capacity, enhancing regulatory enforcement mechanisms, and streamlining administrative processes are crucial to increase renewable energy deployment.

Financial Constraints

Small and medium-sized enterprises (SMEs) and project developers face challenges in investing in renewable energy due to limited access to finance. High lending rates, coupled with the scarcity of long-term financing options, make it challenging to secure funds. These risks discourage potential investors and constrain the development of renewable energy projects (Pattberg & Widerberg, 2016). Renewable energy projects, like solar photovoltaic (PV) installations and wind farms, require significant upfront financial investments, posing challenges for project financing and cash flow management. Moreover, revenue uncertainty stemming from non-cost reflective tariffs and payment delays from utilities undermines the financial viability of renewable energy projects. Addressing these challenges requires innovative financing approaches, such as green bonds, implementing feed-in tariffs, venture capital financing, blended finance, and power purchase agreements (PPAs). These measures can mitigate revenue risks, improve project bankability, and attract investment (Acharya, 2021).

Infrastructure Limitations

Nigeria's electricity grid infrastructure suffers from aging assets, transmission losses, and insufficient capacity to accommodate renewable energy integration (Adeniyi, 2019). Grid constraints, including voltage fluctuations and grid instability, pose technical challenges for renewable energy deployment and grid connection, particularly in remote and underserved areas. Inadequate transmission and distribution infrastructure, coupled with grid unreliability and network losses, constrain the effective delivery of renewable energy to end-users.

Nigeria's electricity grid infrastructure is old and has insufficient capacity and robustness to accommodate renewable energy integration (Adeniyi, 2019). Technical issues like voltage fluctuations and grid instability hinder renewable energy deployment and grid connection. To support renewable energy grid integration, it is essential to expand and upgrade the existing grid infrastructure, leveraging smart grid technologies (Rehmani et al., 2018). This will require a huge financial investment, alongside investment in off-grid infrastructure in remote and rural areas.

STRATEGIES TO UPSCALE RENEWABLE ENERGY ADOPTION

A multifaceted approach is necessary to address the challenges and barriers to renewable energy deployment in Nigeria. Addressing these challenges and barriers to renewable energy adoption and harnessing Nigeria's renewable energy potential can accelerate the country's transition towards a sustainable energy future, drive inclusive growth, and achieve its development objectives. This would require a holistic approach encompassing policy reforms, investment mobilization, capacity building, and stakeholder collaboration (Lewandowski et al., 2020).

Implementation of Policy Reforms and Incentives

Nigeria has formulated many policies to create an enabling environment for renewable energy development, attract investments, and promote sustainable energy solutions. These policies include the National Renewable Energy and Energy Efficiency Policy (NREEEP), the Renewable Energy Master Plan. Agencies such as the Rural Electrification Agency, were also established to increase access to electricity in rural areas through renewable energy projects.

However, the effective implementation and continuous improvement of these policies are crucial for achieving Nigeria's renewable energy goals. To achieve this, Nigeria would have to strengthen its institutional capacity by empowering regulatory energy agencies with the right capabilities, resources, and institutional capacity to oversee and regulate the renewable energy sector effectively. Simplifying and expediting permitting processes for renewable energy projects could potentially help in supporting the large-scale deployment of renewable energy. Moreover, market liberalization through reforms aimed at enhancing market dynamics, promoting private sector participation, and ensuring fair and efficient energy market operation could further catalyze investments in renewable energy (Li and Taghizadeh-Hesary, 2022).

Incentives such as tax breaks, green bonds, and Feed-in Tariffs (FiTs) are some of the strategies for providing financial support for renewable energy generation (Shaaban & Petinrin, 2014). Nigeria has regulations designed to provide various tax and financial benefits to encourage investment in renewable energy generation. However, a crucial concern is how these tariffs have supported the adoption of renewable energy. More effort is required to monitor the implementation of these incentives, assess their impact, identify areas for improvement, and determine additional actions needed to enhance the effectiveness of these incentives in achieving their intended goals.

Investment in Renewable Energy Infrastructure

The government should invest in critical infrastructure such as grid enhancements, transmission lines, and storage facilities to support the integration of renewable energy into the existing energy infrastructure. By improving the grid infrastructure, the government can ensure reliable and efficient transmission of renewable energy, thereby encouraging private investors to enter the market. Moreover, strengthening public sector investment in renewable energy infrastructure through strategic planning, budgetary allocations, and public-private partnerships to catalyze market development, address market failures, and demonstrate government commitment to renewable energy (Akhtar et al., 2018). This proactive approach is crucial in attracting both local and foreign investment in renewable energy

Capacity Building and Education

Critical stakeholders would need to invest in capacity-building initiatives, vocational training programs, and technical education to develop a skilled workforce capable of designing, implementing, and maintaining renewable energy projects. This would create jobs and promote a robust local renewable energy industry. Imbibing renewable energy concept and awareness from childhood by integrating it into the education curriculum, designing campaigns to raise awareness about the benefits of renewable energy could play crucial role in educating Nigerians to support the transition to cleaner energy sources. Moreover, creating an environment that fosters local and international knowledge transfer, and collaboration among stakeholders, including government agencies, academia, civil society organizations, and the private sector, to exchange best practices, lessons learned, and innovative solutions for renewable energy implementation could support in increasing the large-scale adoption of renewable energy.

Public-Private Partnerships

Government agencies, development organizations, banks, project developers, and local communities need to collaborate to share risks, and mobilize resources for renewable energy projects. The government will have to play a critical role in leading the conversation and

ensuring private sector participation in renewable energy development through public-private partnerships (PPPs), joint ventures, and concession agreements to harness private sector expertise, innovation, and investment capital for project financing and implementation. These PPPs can provide funding, technical support, and operational management for large-scale renewable energy projects.

CONCLUSION

Nigeria's energy sector faces several challenges, including energy unreliability, poor infrastructure, and environmental pollution. However, renewable energy presents a promising solution, offering economic, environmental, and social benefits. It's vital for Nigeria's development, providing opportunities to improve energy access, diversify the economy, address climate change, and enhance citizens' quality of life. To tap into its abundant renewable resources, Nigeria must enact supportive policies and overcome existing barriers. This demands political commitment, policy reforms, investment, capacity building, and collaboration among stakeholders. Embracing renewable energy could play a pivotal role in securing Nigeria's energy future, spur inclusive growth, and contribute to global sustainability efforts.

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