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Exploring financing models for clean energy adoption: Lessons from the United States and Nigeria

Portia Oduro ^{1,*}, Peter Simpa ² and Darlington Eze Ekechukwu ³

¹ Energy Law Center, Paul M. Hebert Law Center, Louisiana State University, USA

² Faculty of Science and Engineering, University of Hull, UK

³ Independent Researcher, UK

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Abstract

This paper examines financing models for clean energy adoption, drawing insights from experiences in the United States and Nigeria. It underscores the significance of clean energy and the need to explore effective financing mechanisms to facilitate its widespread adoption. Through an analysis of the current state of clean energy adoption in both countries, existing initiatives and challenges are outlined. Lessons gleaned from successful financing models in the United States, including government incentives, public-private partnerships, and renewable energy credits, are then explored. These lessons serve as a foundation for assessing how similar approaches can be adapted to the Nigerian context. Specific attention is given to the unique challenges facing Nigeria, such as infrastructure limitations and socioeconomic disparities, and how financing models can be tailored to address these obstacles. A comparative analysis between the two countries identifies similarities, differences, and the potential transferability of financing models. Based on these insights, recommendations are proposed for Nigeria, emphasizing the importance of context-specific approaches to accelerate clean energy adoption. Overall, this paper provides a comprehensive exploration of financing models for clean energy adoption, offering valuable insights for policymakers, stakeholders, and practitioners in both the United States and Nigeria.

Keywords: Financing Models; Clean Energy; Adoption; United States; Nigeria.

1. Introduction

The transition towards clean energy sources is imperative in addressing global challenges such as climate change, air pollution, and energy security (Haines et al., 2007). Clean energy, including renewable sources such as solar, wind, hydroelectric, and geothermal power, offers a sustainable alternative to fossil fuels, which are finite resources and major contributors to greenhouse gas emissions (Oriekhoe et al., 2024). As the world grapples with the urgent need to mitigate the impacts of climate change, the adoption of clean energy technologies becomes increasingly critical. Clean energy adoption contributes significantly to reducing carbon emissions, thus mitigating the adverse effects of climate change (Haines et al., 2007). By harnessing renewable energy sources, countries can decrease their reliance on fossil fuels, which are major contributors to carbon dioxide emissions (Ajayi & Udeh, 2024, Familoni, Abaku & Odimarha, 2024). This shift not only helps combat climate change but also promotes environmental sustainability by reducing air and water pollution associated with conventional energy production. Furthermore, clean energy adoption enhances energy security by diversifying energy sources and reducing dependence on imported fossil fuels. Countries heavily reliant on fossil fuel imports are vulnerable to price volatility, geopolitical tensions, and supply disruptions (Esan, Ajayi & Olawale, 2024, Igbinenikaro & Adewusi, 2024, Okatta, Ajayi & Olawale, 2024). By investing in clean energy infrastructure, nations can bolster their energy independence and resilience, ensuring a more stable and sustainable energy future. The

* Corresponding author: Portia Oduro.

transition to clean energy offers economic benefits, including job creation, innovation, and economic growth (Ram et al., 2020). The renewable energy sector has experienced rapid expansion in recent years, generating employment opportunities across various skill levels, from manufacturing and installation to research and development. Additionally, investing in clean energy technologies stimulates innovation and drives down costs, making renewable energy more competitive with traditional fossil fuels (Oriekhoe et al., 2023). Clean energy adoption is crucial for mitigating climate change, improving environmental quality, enhancing energy security, and fostering economic prosperity (Haines et al., 2007). Recognizing its importance, policymakers, businesses, and communities worldwide are increasingly prioritizing efforts to accelerate the transition towards a clean energy future. The purpose of this study is to explore financing models for clean energy adoption, with a specific focus on lessons learned from experiences in the United States and Nigeria (Akintuyi, 2024, Joel & Oguanobi, 2024, Ogundipe, Odejide & Edunjobi, 2024). By examining successful financing mechanisms, identifying challenges, and comparing strategies between these two countries, this study aims to provide valuable insights for policymakers, investors, and stakeholders seeking to promote clean energy development (Eleogu, et. al., 2024, Nwankwo, et. al., 2024, Okatta, Ajayi & Olawale, 2024). Through a comprehensive analysis of existing initiatives, policy frameworks, and financing mechanisms, this study seeks to elucidate the factors driving successful clean energy adoption and the barriers hindering progress (Chai and Yeo, 2012). By synthesizing lessons learned from both the United States and Nigeria, this study aims to inform evidence-based decision-making and facilitate the development of tailored financing approaches to accelerate clean energy deployment in diverse contexts (Adama, et. al., 2024, Igbinenikaro & Adewusi, 2024, Okeke, et. al., 2023). Ultimately, the goal of this study is to contribute to the advancement of clean energy adoption globally by providing actionable recommendations, best practices, and policy insights gleaned from real-world experiences (Familoni & Onyebuchi, 2024, Nzeako, et. al., 2024, Olawale, et. al., 2024). By leveraging the knowledge gained from studying financing models in two distinct contexts, this study aims to promote collaboration, knowledge sharing, and capacity building to drive the transition towards a more sustainable and resilient energy future (Okorie et al., 2024).

2. Current state of clean energy adoption

United States - The United States has made significant strides in clean energy adoption in recent years, driven by a combination of federal and state-level policies, technological advancements, and market forces (Byrne et al. 2007). Key initiatives include the Clean Power Plan, Renewable Portfolio Standards (RPS), investment tax credits (ITC), production tax credits (PTC), and the deployment of renewable energy technologies such as solar and wind power (Akinsanya, Ekechi & Okeke, 2024, Igbinenikaro & Adewusi, 2024, Shoetan & Familoni, 2024). The Clean Power Plan, introduced by the Obama administration, aimed to reduce carbon emissions from the power sector by setting state-specific targets for emissions reductions (Esho, et. al., 2024, Joel & Oguanobi, 2024, Ogundipe, Odejide & Edunjobi, 2024). While the plan faced legal challenges and policy reversals under the Trump administration, many states continued to pursue ambitious clean energy goals through state-level regulations and initiatives. Renewable Portfolio Standards (RPS) require utilities to generate a specified percentage of their electricity from renewable sources by a certain deadline (Heeter et al., 2019). These standards have been implemented in many states, driving demand for renewable energy and spurring investment in solar, wind, and other clean energy technologies. Financing models for clean energy in the United States encompass a range of mechanisms, including government incentives, tax credits, grants, loans, and private sector investments (Adama & Okeke, 2024, Nzeako, et. al., 2024, Okatta, Ajayi & Olawale, 2024). Government incentives such as the Investment Tax Credit (ITC) and Production Tax Credit (PTC) provide financial incentives for the deployment of renewable energy projects, making them more economically viable for developers and investor (Ajayi & Udeh, 2024, Igbinenikaro & Adewusi, 2024, Okeke, et. al., 2023)s. Public-private partnerships, such as the Department of Energy's loan guarantee program and the establishment of green banks in several states, facilitate access to capital for clean energy projects by leveraging public funds to attract private investment (Leonard, 2014). The United States has experienced significant success in clean energy adoption, with renewable energy capacity expanding rapidly in recent years. Solar and wind power, in particular, have become increasingly cost-competitive with fossil fuels, driving widespread deployment and job creation in the clean energy sector (Esan, Ajayi & Olawale, 2024, Ochulor, et. al., 2024, Shoetan & Familoni, 2024). However, challenges remain, including policy uncertainty, regulatory barriers, and intermittency issues associated with renewable energy sources (Oriekhoe et al., 2024). Additionally, access to financing can be a barrier for smaller-scale clean energy projects, particularly in underserved communities and rural areas (Doukas and Ballesteros, 2015).

Nigeria - Nigeria possesses abundant renewable energy resources, including solar, wind, hydroelectric, and biomass, yet the country continues to rely heavily on fossil fuels for electricity generation (Mohammed et al., 2013). The government has recognized the potential of clean energy and has set ambitious targets for renewable energy deployment as part of its National Renewable Energy Action Plan. Despite the potential for clean energy development, progress has been slow due to various challenges, including inadequate infrastructure, limited access to financing, and policy and regulatory uncertainties (Akintuyi, 2024, Joel & Oguanobi, 2024, Ogundipe, 2024). Nigeria has implemented

various financing mechanisms to support clean energy adoption, including government grants, loans, and initiatives such as the Rural Electrification Fund (REF) and the Nigerian Electrification Project (NEP) (Isah et al., 2023). Additionally, international organizations and development agencies have provided funding and technical assistance for clean energy projects in Nigeria. Barriers to clean energy adoption in Nigeria include limited access to financing, high upfront costs, lack of supportive policies and regulatory frameworks, and inadequate infrastructure (Esho, et. al., 2024, Igbinenikaro & Adewusi, 2024, Thompson, et. al., 2022). Additionally, political and economic instability, as well as issues related to land tenure and community engagement, pose challenges for clean energy project development and implementation (Egieya et al., 2023). While both the United States and Nigeria have made efforts to promote clean energy adoption, each country faces unique opportunities and challenges. By understanding the current state of clean energy adoption and the financing mechanisms in use, policymakers and stakeholders can identify strategies to overcome barriers and accelerate the transition to a more sustainable energy future (Cantarero, 2020).

2.1. Lessons from the United States

Government incentives and subsidies have played a crucial role in driving clean energy adoption in the United States. Programs such as the Investment Tax Credit (ITC) and Production Tax Credit (PTC) provide financial incentives for renewable energy projects, making them more attractive to developers and investors (Bolinger, 2014). The ITC, for example, offers a tax credit of up to 30% for eligible renewable energy projects, while the PTC provides a per-kilowatt-hour credit for electricity generated from qualified renewable sources like wind, biomass, and geothermal (Abaku & Odimarha, 2024, Nzeako, et. al., 2024, Olawale, et. al., 2024). These incentives help offset the higher upfront costs associated with clean energy technologies and encourage investment in renewable energy projects (Familoni & Shoetan, 2024, Jambol, et. al., 2024, Popoola, et. al., 2024, Wisner & Pickle, 1998). By reducing financial barriers, government incentives have spurred significant growth in renewable energy capacity across the United States. Public-private partnerships have emerged as effective mechanisms for financing clean energy projects in the United States. These partnerships leverage public funds and expertise to attract private sector investment and expertise, facilitating the development and deployment of clean energy technologies (Akinsanya, Ekechi & Okeke, 2024, Ochulor, et. al., 2024, Udeh, et. al., 2023). Initiatives such as the Department of Energy's loan guarantee program and the establishment of green banks in several states have successfully mobilized private capital for clean energy projects (Barua and Aziz, 2022). By sharing risks and resources between the public and private sectors, these partnerships help address financing gaps and accelerate the transition to a clean energy economy. Renewable energy credits (RECs) and trading schemes have created additional revenue streams for renewable energy generators and incentivized investment in clean energy projects. RECs represent the environmental attributes of renewable energy generation and can be bought and sold separately from the physical electricity (Adama, et. al., 2024, Joel & Oguanobi, 2024, Ogundipe, Babatunde & Abaku, 2024). States with Renewable Portfolio Standards (RPS) use trading schemes to meet their renewable energy targets by allowing utilities to buy and sell RECs to comply with regulatory requirements. This flexibility encourages market participation and promotes the development of renewable energy projects in regions with favorable resources (Abdmouleh et al., 2015, Ajayi & Udeh, 2024, Ogundipe & Abaku, 2024, Popo-Olaniyan, et. al., 2022).

Policy and regulatory uncertainty have posed challenges for clean energy development in the United States, with shifting political landscapes and changing priorities impacting the stability of incentives and support mechanism (Akintuyi, 2024, Igbinenikaro, Adekoya & Etukudoh, 2024, Popoola, et. al., 2024)s. However, proactive measures such as long-term policy commitments, bipartisan support for clean energy initiatives, and state-level regulations have helped mitigate uncertainty and provide a more favorable investment climate for clean energy projects (Bayulgen, 2020). Access to capital has been a barrier for clean energy projects, particularly for smaller-scale developments and underserved communities. To address this challenge, financial innovations such as securitization, crowdfunding, and community solar programs have expanded access to financing for clean energy projects (Esho, et. al., 2024, Odimarha, Ayodeji & Abaku, 2024, Onwuka, et. al., 2023). Additionally, public-private partnerships and initiatives like the Green Bank Network have provided alternative financing options and technical assistance to support clean energy deployment (David and Venkatachalam, 2018). Public perception and awareness play a significant role in shaping clean energy adoption, with misconceptions and lack of understanding hindering progress (Sovacool, 2009). Education campaigns, outreach programs, and public engagement efforts have helped raise awareness about the benefits of clean energy and dispel myths surrounding renewable technologies. By fostering a supportive policy environment and promoting public acceptance, stakeholders have overcome resistance to clean energy projects and built momentum for sustainable development (Ekechi, et. al., 2024, Igbinenikaro, Adekoya & Etukudoh, 2024). The United States has demonstrated the effectiveness of various financing models in driving clean energy adoption (Malik et al., 2019). By leveraging government incentives, public-private partnerships, and trading schemes, policymakers and stakeholders have addressed challenges related to policy uncertainty, access to capital, and public perception, laying the foundation for a more sustainable and resilient energy future (Ajayi & Udeh, 2024, Joel & Oguanobi, 2024, Onwuka & Adu, 2024).

3. Lessons for Nigeria

Nigeria must adapt financing models to its local context by establishing a supportive policy framework and clarifying the government's role in promoting clean energy development (Ekechi, et. al., 2024, Ikegwu, et. al., Isah et al., 2023, 2017, Onwuka & Adu, 2024)). This includes setting clear renewable energy targets, implementing supportive regulations, and providing incentives such as tax breaks, grants, and feed-in tariffs to attract investment in clean energy projects (Esho, et. al., 2024, Igbinenikaro, Adekoya & Etukudoh, 2024). By creating a stable and predictable policy environment, the government can instill confidence among investors and stimulate private sector participation in clean energy initiatives (Oriekhoe et al., 2024). Nigeria can leverage international support and investments to finance clean energy projects and bridge funding gaps. Partnerships with multilateral organizations, development banks, and foreign investors can provide access to capital, technical expertise, and innovative financing mechanisms (Adama & Okeke, 2024, Odimarha, Ayodeji & Abaku, 2024). International collaborations can also facilitate technology transfer, knowledge sharing, and capacity building, enabling Nigeria to accelerate the deployment of clean energy technologies and overcome barriers to adoption ((Akinsanya, Ekechi & Okeke, 2024, Nwokolo et al., 2023, Oguanobi & Joel, 2024). To ensure the sustainable development of clean energy projects, Nigeria must prioritize building local capacity and expertise across the clean energy value chain. This includes investing in education, training, and skills development programs to cultivate a skilled workforce capable of designing, installing, and maintaining clean energy infrastructure (National Academies of Sciences et al., 2017). Additionally, fostering local manufacturing and supply chains for clean energy components can create employment opportunities, stimulate economic growth, and enhance energy security by reducing reliance on imported technologies (Familoni & Babatunde, 2024, Odimarha, Ayodeji & Abaku, 2024). Nigeria faces significant infrastructure limitations, including inadequate grid infrastructure, transmission losses, and electricity access gaps in rural and remote areas (Dada, 2014). To address these challenges, investments in grid modernization, decentralized energy solutions, and off-grid electrification initiatives are essential (Akinsanya, Ekechi & Okeke, 2024, Olawale, et. al., 2024, Popoola, et. al., 2024). By leveraging innovative technologies such as mini-grids, solar home systems, and energy storage solutions, Nigeria can expand energy access, improve reliability, and enhance the resilience of its energy infrastructure (Sesan et al., 2024). Socioeconomic disparities exacerbate energy poverty in Nigeria, with marginalized communities disproportionately affected by lack of access to reliable and affordable electricity (Ajayi & Udeh, 2024, Ikegwu, et. al., 2022, Popoola, et. al., 2024). Addressing socioeconomic inequalities requires targeted interventions that prioritize energy access for underserved populations, including rural communities, women, and vulnerable groups (Akintuyi, 2024, Joel & Oguanobi, 2024, Onwuka & Adu, 2024). Community-based approaches, participatory decision-making processes, and inclusive business models can empower local communities and ensure that clean energy benefits are equitably distributed across society (Lennon et al., 2019). Political and regulatory instability pose challenges for clean energy investment in Nigeria, creating uncertainty and deterring investors. To mitigate these risks, Nigeria must strengthen governance, rule of law, and transparency in the energy sector, ensuring consistency and predictability in regulatory frameworks (Esho, et. al., 2024, Igbinenikaro, Adekoya & Etukudoh, 2024). Stakeholder engagement, dialogue, and collaboration between government, industry, and civil society can foster trust, build consensus, and promote long-term stability conducive to clean energy development (Emeka-Okoli et al., 2024).

Nigeria can learn valuable lessons from international experiences and adapt financing models to its local context to accelerate clean energy adoption (Abaku, Edunjobi & Odimarha, 2024, Ogundipe & Abaku, 2024, Popoola, et. al., 2024). By establishing a supportive policy framework, leveraging international support, and addressing unique challenges related to infrastructure limitations, socioeconomic disparities, and political instability, Nigeria can unlock its vast clean energy potential and achieve sustainable and inclusive development (Orieno et al., 2024).

3.1. Comparative analysis

Both the United States and Nigeria possess abundant renewable energy resources, including solar, wind, hydroelectric, and biomass, offering significant potential for clean energy development (Mohammed et al., 2013). Both countries face challenges related to policy and regulatory uncertainty, access to financing, and public perception and awareness, which can hinder clean energy adoption and investment (Ajayi & Udeh, 2024, Joel & Oguanobi, 2024, Onwuka & Adu, 2024). Both countries have implemented various financing mechanisms, including government incentives, public-private partnerships, and renewable energy credits, to promote clean energy deployment and address energy access gaps (Adama & Okeke, 2024, Odimarha, Ayodeji & Abaku, 2024, Popo-Olaniyan, et. al., 2022). The United States has a more mature clean energy market with established regulatory frameworks, incentives, and infrastructure, whereas Nigeria is still in the early stages of transitioning to clean energy and faces greater challenges related to infrastructure limitations, socioeconomic disparities, and political instability (Adewuyi et al., 2020). Nigeria has a higher proportion of off-grid populations and rural communities without access to reliable electricity, making decentralized energy solutions and off-grid electrification strategies more critical compared to the United States, where grid infrastructure is more developed (Udeh et al., 2024). While both countries rely on international support and investments to finance clean

energy projects, Nigeria may face additional barriers related to foreign exchange risks, currency fluctuations, and geopolitical uncertainties, which could impact the transferability of financing models from the United States (AGYEMANG-BADU, 2021). While some financing models implemented in the United States may be transferable to Nigeria, it is essential to consider the differences in context, including regulatory frameworks, market dynamics, and institutional capacity (Babatunde, et. al., 2024, Ogedengbe, 2022, Ogundipe, Odejide & Edunjobi, 2024). Government incentives such as tax credits and grants can be adapted to suit Nigeria's policy priorities and investment climate, but may require adjustments to align with local conditions and priorities. Public-private partnerships can be transferable to Nigeria, leveraging international expertise and resources to address infrastructure limitations, capacity constraints, and financing gaps (Shendy, 2011). However, successful implementation may require tailored approaches to accommodate Nigeria's unique market dynamics, regulatory environment, and governance structures. Renewable energy credit schemes may also be transferable to Nigeria, providing opportunities to monetize environmental attributes and incentivize renewable energy deployment (Familoni, 2024, Igbinenikaro, Adekoya & Etukudoh, 2024, Popoola, et. al., 2024). However, regulatory frameworks and market structures may need to be adapted to reflect Nigeria's energy landscape and ensure the effectiveness of trading schemes (Adama, et. al., 2024, Joel & Oguanobi, 2024, Osimobi, et. al., 2023).

Recommendation, establish a supportive policy framework and regulatory environment to provide certainty and incentives for clean energy investment. Strengthen governance, rule of law, and transparency in the energy sector to enhance investor confidence and mitigate political and regulatory risks (Sovacool et al., 2016). Prioritize investments in grid modernization, decentralized energy solutions, and off-grid electrification to expand energy access and improve reliability (Aturamu, Thompson & Akintuyi, 2021, Oguanobi & Joel, 2024). Foster partnerships with international organizations, development banks, and foreign investors to mobilize capital, expertise, and technology for clean energy projects (Adaga et al., 2023). Invest in education, training, and capacity building to develop a skilled workforce and local expertise across the clean energy value chain. Promote public awareness and engagement to build support for clean energy initiatives and ensure equitable distribution of benefits across society (Sen and Ganguly, 2017).

A comparative analysis between the United States and Nigeria reveals both similarities and differences in their clean energy landscapes and financing models (Edu, et. al., 2022, Jambol, et. al., 2024, Onwuka & Adu, 2024). By leveraging lessons learned from the United States and tailoring financing approaches to suit Nigeria's local context, policymakers and stakeholders can accelerate the transition to a more sustainable and inclusive energy future (Isah et al., 2023).

4. Conclusion

In the United States, government incentives, public-private partnerships, and renewable energy credit schemes have proven effective in driving clean energy deployment. However, challenges such as policy uncertainty, access to capital, and public perception remain. In Nigeria, despite abundant renewable energy resources, infrastructure limitations, socioeconomic disparities, and political instability pose significant barriers to clean energy adoption. Nonetheless, Nigeria has implemented various financing mechanisms and can draw lessons from international experiences to overcome these challenges and unlock its clean energy potential. While financing models from the United States can provide valuable insights, they must be adapted to suit Nigeria's unique context, including regulatory frameworks, market dynamics, and institutional capacity. Tailored financing approaches consider local priorities, challenges, and opportunities, ensuring that interventions are effective, sustainable, and inclusive. By aligning financing mechanisms with Nigeria's specific needs and circumstances, policymakers and stakeholders can maximize the impact of clean energy investments and accelerate the transition to a more sustainable energy future.

Looking ahead, the future outlook for clean energy adoption in Nigeria is promising yet challenging. Despite the obstacles, Nigeria has immense clean energy potential and a growing recognition of the importance of sustainable development. By leveraging lessons learned from international experiences, strengthening policy frameworks, fostering partnerships, and investing in local capacity and expertise, Nigeria can overcome barriers to clean energy adoption and emerge as a leader in renewable energy development. A concerted effort from government, industry, civil society, and international partners is needed to drive progress and realize Nigeria's clean energy ambitions. With the right policies, investments, and partnerships in place, Nigeria can harness its renewable energy resources to improve energy access, spur economic growth, and mitigate the impacts of climate change, ensuring a brighter and more sustainable future for generations to come. While challenges lie ahead, the journey towards clean energy adoption in Nigeria presents immense opportunities for progress, innovation, and collaboration. By embracing tailored financing approaches and leveraging lessons learned from global experiences, Nigeria can chart a path towards a cleaner, more resilient, and sustainable energy future.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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