Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/GC03.20260199
Published: February 2, 2026

Developing New Realities Beyond Traditional Boundaries: Enhancing African Renewable Energy Transition

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Abstract

Africa is richly endowed with renewable energy resources, including solar, wind, and hydropower, yet the continent faces a significant energy access deficit, with over 600 million people lacking reliable electricity. Traditional fossil fuel-based energy models have proven inadequate for meeting the region's growing energy demands while posing environmental and economic challenges. This study explores the need to transcend these conventional energy paradigms by accelerating the adoption of sustainable, inclusive renewable energy systems tailored to Africa's unique context. Adopting a qualitative research approach, the study employed document analysis of policy reports, scholarly literature, and energy market trends to examine the continent's renewable energy transition. Thematic analysis identified key barriers such as limited access to financing, fragmented regulatory frameworks, and insufficient technical capacity. However, the findings also highlight transformative opportunities, including decentralized energy

systems for off-grid rural communities, digital innovations, and international climate finance. The study recommends empowering community-driven energy models, adopting innovative financing mechanisms such as microcredit and crowdfunding and fostering cross-sectoral collaboration. These measures will not only expand energy access but also position Africa as a leader in global climate action, environmental sustainability, and inclusive energy innovation.

Keywords
Renewable Energy Transition; Decentralized Energy Systems; Sustainable Development; Africa Energy Policy

1. Introduction
The African continent is endowed with abundant renewable energy resources, including vast solar, wind, hydropower, and geothermal reserves. However, the current energy mix remains heavily skewed toward fossil fuels, with oil accounting for approximately 38% of primary energy consumption, followed by natural gas (30%) and coal (14%) (Abas et al., 2015). Renewable sources, including hydro, solar, and wind, contribute only about 17% of the total. In terms of energy end-use, thermal needs such as cooking and industrial heating represent 40–45% of consumption, followed by mobility (30–35%) and electricity (20–25%). Despite having 60% of the world's best solar resources, Africa generates only about 1% of global solar capacity (Fajardy and Reiner, 2021). Moreover, over 600 million Africans still lack access to electricity, particularly in rural regions. While Africa contributes just 3% of global CO_2 emissions, the continent's path toward carbon neutrality is fragmented, with few countries like South Africa and Morocco setting clear targets (Nwokolo et al, 2024). This context underscores the urgent need for a transformative and inclusive renewable energy transition. Despite this wealth of natural resources, energy poverty remains a significant challenge, with over 600 million Africans lacking access to reliable electricity (IRENA, 2024; IEA, 2022).

Historically, the energy sector in many African nations has relied heavily on traditional fossil fuel-based systems, which are not only unsustainable but also contribute to environmental degradation and economic instability (Aniebo and Akpan, 2022). Global climate change imperatives and rising energy demands have made the shift to renewable energy both urgent and inevitable for sustainable development (IRENA, 2021). In recent years, there have been remarkable advancements in renewable energy technologies and growing interest from international development agencies and private investors (IRENA, 2024). Countries such as South Africa, Morocco, and Kenya have made significant strides in deploying large-scale solar, wind, and geothermal energy projects (IEA, 2022). However, many African nations continue to face barriers such as weak institutional frameworks, inadequate investment, limited technical capacity, and fragmented policy implementation (IRENA, 2021; Assis and Ribeiro, 2023). Traditional approaches to energy development, often characterized by centralized power generation and slow bureaucratic processes, have proven insufficient in addressing the continent's diverse energy needs (Nikolina, 2016). The transition to renewable energy in Africa requires a paradigm shift that goes beyond traditional boundaries. It necessitates the adoption of innovative financing mechanisms, decentralized energy systems, community-driven solutions, and the integration of digital technologies to ensure efficiency and sustainability (IRENA, 2024). The development of robust legal and regulatory frameworks is also essential to attract investments and foster cross-sectoral collaboration (Aniebo and Akpan, 2022). This study, therefore, seeks to explore how new realities can be developed and embraced to enhance Africa's renewable energy transition, with a focus on sustainable and inclusive solutions that address the continent's unique challenges

1.1 Problem Statement
Africa's energy landscape is marked by persistent deficits, environmental concerns, and socio-economic challenges (IEA, 2022). While there is growing recognition of the need for a renewable energy transition, the continent grapples with structural and technological hurdles. Traditional energy development models, which prioritize centralized fossil fuel-based systems, have failed to provide universal energy access and are increasingly untenable in the face of climate change and global decarbonization targets (IRENA, 2021; Aniebo and Akpan, 2022). Despite abundant renewable energy resources, the adoption of clean energy technologies in Africa has been slow and fragmented (IRENA, 2024). A major barrier is the lack of innovative financing mechanisms and supportive regulatory frameworks that can attract investments and spur large-scale adoption of renewable energy solutions (IRENA, 2024; Assis and Ribeiro, 2023). Additionally, the centralized approach to energy generation has proven inadequate for rural and remote areas, where off-grid renewable systems can provide more practical and sustainable solutions (IRENA, 2021).

The absence of cohesive regional strategies and limited cross-sectoral collaboration further complicate the continent's energy transition efforts (Nikolina, 2016). Without a strategic shift that embraces new realities beyond traditional

energy models, Africa risks being left behind in the global renewable energy transition. There is a critical need for research and action focusing on developing decentralized, community-driven, and technologically advanced energy systems (Aniebo and Akpan, 2022). Driven by the identified research gaps, this study undertakes a thorough examination of existing literature to highlight the urgent need for Africa to move beyond conventional energy frameworks in order to accelerate the uptake of sustainable and inclusive renewable energy solutions. It specifically investigates the imperative of shifting from traditional energy systems toward more modern, equitable, and environmentally friendly alternatives across the continent. The core research questions guiding this study are:

What are the main challenges hindering the adoption of sustainable and inclusive renewable energy systems in Africa?

What new opportunities are emerging to support the transition to sustainable and inclusive renewable energy in Africa?

What proven strategies and practices can promote sustainable energy development across the continent? The subsequent sections of the manuscript are structured as follows: The study methodology, literature review, discussion of the findings, and concluding remarks with recommendations.

2. Literature Review

2.1 African Renewable Energy Transition

The 2019 Climate Action Summit, convened by the United Nations (UN) in New York, emphasised the imperative of global climate action, imposing an enhanced obligation on states to address climate change and promote environmental sustainability. An essential global obligation is to attain net-zero emissions by 2050 and reduce greenhouse gas emissions by 45% (United Nations, 2019). The increasing effects of climate change evident in heightened heat waves, extended droughts, rising sea levels, and extensive deforestation—necessitate urgent and resolute action. A fundamental transition from fossil fuel reliance to renewable energy sources is not merely advisable but essential for ensuring a habitable planet (Mutezo and Mulopo, 2021). As such, this global discourse on climate change regarding energy is the shift from fossil fuels to renewable energy sources. Mutezo and Mulopo (2021) conducted a study to see if Africa's energy transition may be directed by circular economy concepts. The research indicated that Africa's energy demand is projected to increase substantially, propelled by industrialisation and population expansion. Although a significant portion of sub-Saharan Africa utilises renewable energy, prominent economies such as Algeria, Nigeria, Morocco, South Africa, and Egypt—the "Big Five"—continue to rely extensively on fossil fuels. Mutezo and Mulopo (2021) suggest that circular economy concepts can promote the use of renewable energy and enable a just energy transition. The study asserts that to facilitate a sustainable energy transition, regional financial institutions like the African Development Bank and governments must finance scalable renewable technology and enforce deliberate policies consistent with circular economy concepts.

Müller et al.,(2020) performed a comparative analysis of renewable energy policies across 34 African nations to examine the energy transition process. The study primarily emphasises the justice aspect of energy transitions, informed by current debates on distributive, recognitional, and procedural energy justice. The analysis indicates that African energy policies encompass issues of recognitional and distributive justice while also emphasising the trade-offs between market-oriented strategies and justice considerations. The study's findings enhance the ongoing discourse on "just transition" and "energy justice," which have become increasingly significant in transition management discussions, especially in the Global South. Consequently, there is a necessity for equitable policy frameworks that promote renewable energy adoption while ensuring fairness and inclusivity during the transition process. Policymakers must reconcile the conflict between market efficiency and social equality to realise a genuinely just and sustainable energy transformation throughout Africa.

The expansion of renewable energy in Africa is evident; yet, advancement towards Sustainable Development Goal 7 is sluggish and difficult to monitor. Current policies frequently neglect environmental justice, resulting in compromises throughout energy transitions. Muller et al. (2021) conducted a study examining the renewable energy policies of 34 African countries, proposing four transition scenarios that underscore problems in achieving energy justice. The report contended that tracking SDG 7 should incorporate justice components to facilitate a more equitable and sustainable energy transition. Francis et al. (2022) asserts that Ghana's transition to renewable energy encounters inadequate stakeholder participation, despite the necessity for network governance to attain low-carbon objectives. Francis et al. (2022) analysed key challenges, including political influence, stakeholder collaboration, funding, policy deficiencies, and market structure. The study's findings underscore insufficient policy understanding, restricted access to credit, and elevated costs of renewable technology as significant obstacles. The study advocates for a more robust

collaboration among public, commercial, and NGO sectors, the inclusion of independent experts, and the establishment of solid financial policies to stimulate investment. Improved stakeholder involvement and policy openness are essential for a successful transition to renewable energy in Ghana.

In Nigeria, the Energy Transition Plan, initiated in the last quarter of 2022, is a crucial program designed to establish Nigeria as a significant participant in the worldwide transition to sustainable energy (Kabeer and Ayodele, 2023). Ekpotu et al. (2024) assert that Nigeria's energy transition necessitates a meticulously organised and efficient execution plan that surpasses the existing frameworks. This demand stems from Nigeria's substantial dependence on fossil fuel-based energy, which is both unsustainable and has considerable environmental hazards. For the nation to achieve a successful transition, it is imperative to implement audacious policy reforms, make smart investments, and commit to the use of renewable energy.

2.2 Barriers to the Adoption of Sustainable Renewable Energy Systems in Africa

The adoption of sustainable renewable energy systems in Africa has garnered significant scholarly attention due to the continent's vast renewable resources and the urgent need to bridge energy access gaps. However, a broad spectrum of literature highlights persistent barriers undermining the integration and widespread adoption of these systems. A systematic review by Obuseh et al. (2025) identifies multi-dimensional barriers to renewable energy adoption, categorizing them into technical, financial, institutional, and socio-cultural barriers. These barriers not only hinder project implementation but also limit the scalability and sustainability of renewable energy initiatives across the continent. Similarly, Asante et al. (2020), through the MULTIMOORA-EDAS multi-criteria decision-making approach, demonstrate that economic and infrastructural barriers are among the most critical challenges facing renewable energy adoption, especially in sub-Saharan Africa. Policy and regulatory inefficiencies are consistently highlighted in the literature. Adelaja (2020), in a case study of Nigeria, notes the absence of a coherent national renewable energy policy and a lack of continuity in energy governance as central barriers to progress. Ouedraogo (2019) echoes this by pointing to inconsistent energy policies, limited institutional capacities, and weak enforcement mechanisms as significant deterrents to renewable energy investment and development in Africa.

Financial constraints further complicate the adoption landscape. Bishoge et al. (2020) emphasize the challenge of mobilizing adequate investment for large-scale renewable projects due to high capital costs and perceived investment risks. Fischer, Lopez, and Suh (2011) add that underdeveloped financial markets and the lack of incentives, such as feed-in tariffs or tax credits, discourage private sector involvement. Moreover, local entrepreneurs often face difficulties in accessing credit due to limited collateral and high interest rates. Technical and infrastructural inadequacies are also prevalent. Ouedraogo (2019) and Luthra et al. (2015) identify issues such as outdated grid infrastructure, low grid penetration, and a lack of localized technical expertise as key obstacles. These issues lead to unreliable energy transmission and discourage the integration of variable renewable energy sources like solar and wind into national grids.

From a socio-cultural perspective, public awareness and acceptance remain low in several regions. Obuseh et al. (2025) report that limited education and misinformation about renewable energy technologies contribute to public skepticism, particularly in rural areas. Additionally, cultural attachment to traditional energy sources and insufficient stakeholder engagement impede community participation in renewable energy projects (Bishoge et al., 2020).

Institutional and governance challenges are another recurring theme in the literature. Adelaja (2020) and Fischer et al. (2011) discuss how corruption, bureaucratic inefficiency, and lack of inter-agency coordination undermine policy implementation and discourage donor and investor confidence. These governance issues, coupled with the dominance of state-owned utilities, create an unfavourable environment for independent power producers and decentralized energy systems. literature reveals that while Africa holds immense potential for sustainable renewable energy development, its realization is impeded by a combination of policy, financial, technical, socio-cultural, and institutional barriers. Addressing these challenges requires integrated and context-specific strategies, involving robust policy reforms, stakeholder collaboration, capacity building, and innovative financing mechanisms.

3.3 Opportunities for the Adoption of Sustainable Renewable Energy Systems in Africa

While numerous challenges hinder the widespread adoption of renewable energy in Africa, the continent is simultaneously positioned to benefit from a range of promising opportunities. These opportunities stem from its natural resource abundance, emerging technological innovations, evolving policy frameworks, and increasing

international collaboration, all of which create a fertile ground for transitioning toward sustainable energy systems. Africa's vast and largely untapped renewable energy potential is a fundamental starting point. Ouedraogo (2019) underscores the continent's exceptional solar irradiance, as well as substantial wind, hydro, and biomass resources, which offer an opportunity to establish decentralized, off-grid solutions tailored to rural and peri-urban communities. These resources, if harnessed effectively, could enable energy autonomy for millions of underserved households and catalyze local development. Emerging technologies and innovative frameworks are also facilitating a shift towards sustainable energy models. Kylili et al. (2021) advocate for a holistic approach that integrates energy planning with smart grid technologies, battery storage, and digital monitoring systems. Such frameworks enhance energy efficiency and system reliability, enabling countries to leapfrog traditional infrastructure constraints and implement context-specific, scalable solutions.

Policy reforms and supportive institutional environments are further driving adoption. According to Moyo and Oree (2024), several African governments have initiated comprehensive renewable energy strategies, including feed-in tariffs, tax incentives, and public-private partnerships. These measures not only attract foreign direct investment but also create a stable and predictable environment for renewable energy development. Notable examples include the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) in South Africa and Kenya's progress in geothermal and wind energy. The socio-economic benefits associated with renewable energy deployment offer additional motivation for adoption. Nyika and Dinka (2024) highlight the potential for job creation across the energy value chain, from manufacturing to installation and maintenance. Moreover, access to clean and reliable energy empowers local businesses, improves educational and health services, and reduces the economic burden of fuel imports, thus contributing to inclusive development. Africa is also benefiting from increased access to international financing and technical assistance.

Agoundedemba et al. (2023) note that multilateral institutions and donor agencies are actively supporting renewable energy projects through grants, concessional loans, and capacity-building initiatives. These partnerships, often aligned with global climate goals, are instrumental in scaling up pilot projects and enabling knowledge transfer across the continent. In addition to economic and policy-based drivers, environmental and public health considerations offer long-term advantages. Bishoge et al. (2020) observe that renewable energy adoption can reduce greenhouse gas emissions, limit deforestation, and improve indoor air quality by reducing reliance on biomass and diesel generators. These benefits align with national and global sustainable development objectives, reinforcing the case for cleaner energy transitions. The opportunities for adopting sustainable renewable energy systems in Africa are robust and multi-dimensional. From natural endowments and innovative technology to policy momentum and international cooperation, these factors collectively present a strong foundation for scaling renewable energy across the continent. However, realizing these opportunities requires strategic alignment among governments, investors, local communities, and development partners to build a resilient and inclusive energy future.

2.4 Best Practices for Fostering Sustainable Energy Development in Africa

Achieving sustainable energy development in Africa requires the implementation of innovative and context-sensitive best practices that go beyond traditional models. A notable approach gaining traction is the ***Sustainable Product-Service System (S.PSS) design***, which emphasizes integrating products and services to deliver decentralized renewable energy solutions that are environmentally sound, socially inclusive, and economically viable (Vezzoli et al., 2015). This model supports community-based energy solutions, allowing local stakeholders to co-design and co-manage renewable energy systems tailored to their specific needs, thereby fostering ownership and long-term sustainability. Another best practice involves ***redefining the role of system design*** in addressing the energy access gap. Vezzoli, Delfino, and Ambole (2014) advocate for a holistic design approach that aligns technical innovation with social and cultural contexts. Their framework encourages inclusive participation, systems thinking, and localized solutions, recognizing that sustainable energy interventions must be adaptable to the socio-economic realities of African communities. This approach not only strengthens local capacities but also empowers communities to become active agents in their energy transitions.

Moreover, Falcone (2023) highlights the importance of adaptive and participatory policy frameworks as critical best practices in developing countries. These include transparent regulatory systems, incentives for private sector participation, and cross-sectoral collaboration. According to Falcone, successful energy transitions in Africa are often driven by policies that integrate local governance structures, foster stakeholder engagement, and encourage innovation in financing mechanisms—such as pay-as-you-go models and energy cooperatives. Such practices are essential in overcoming financial and infrastructural barriers while promoting inclusive and resilient energy systems. Collectively,

these studies underline the need for a multi-dimensional and integrative strategy in fostering sustainable energy development in Africa one that bridges design, policy, and community engagement to create lasting impact.

3. Methods

This study adopts a qualitative research approach, utilizing document analysis as the primary method for data collection and interpretation. Document analysis involves systematically reviewing and evaluating existing texts such as policy reports, scholarly articles, industry publications, and grey literature to extract meaningful insights and identify emerging themes. This method is particularly effective in understanding complex phenomena, such as Africa's renewable energy transition, by examining patterns, perspectives, and discourses present in existing literature (Bowen, 2009; Creswell, 2014). The data collection process was conducted between 10 January and 24 March 2025, beginning with an initial non-systematic search. This search was informed by insights emerging from recent UN Climate Summit outcomes, which have consistently highlighted the need for innovative solutions to energy access challenges in Africa (UN, 2023). The review included secondary sources and grey literature, such as institutional websites, online news media, energy policy documents, and development reports (Falcone, 2023). To enhance the scope of analysis, additional searches focused on documents produced by key stakeholders, including the African Development Bank (AfDB) and other regional institutions involved in energy transition and access across the continent (AfDB, 2022).

Keywords and thematic patterns related to renewable energy systems, circular economy, energy access, and sustainable development were identified and refined throughout the review process (Vezzoli et al., 2015; Vezzoli et al., 2014). The collected documents were subjected to thematic analysis, which enabled the identification and organization of data around three core themes aligned with the study's objectives: (1) barriers to the adoption of sustainable renewable energy systems, (2) emerging opportunities for renewable energy development, and (3) best practices for fostering sustainable energy solutions (Creswell, 2014; Bowen, 2009). This methodological approach ensured consistency, transparency, and replicability while maintaining sensitivity to the contextual realities of the African energy landscape. Figure 1 below describes the study schematic diagram outlining the study framework from conceptualization to the conclusion.

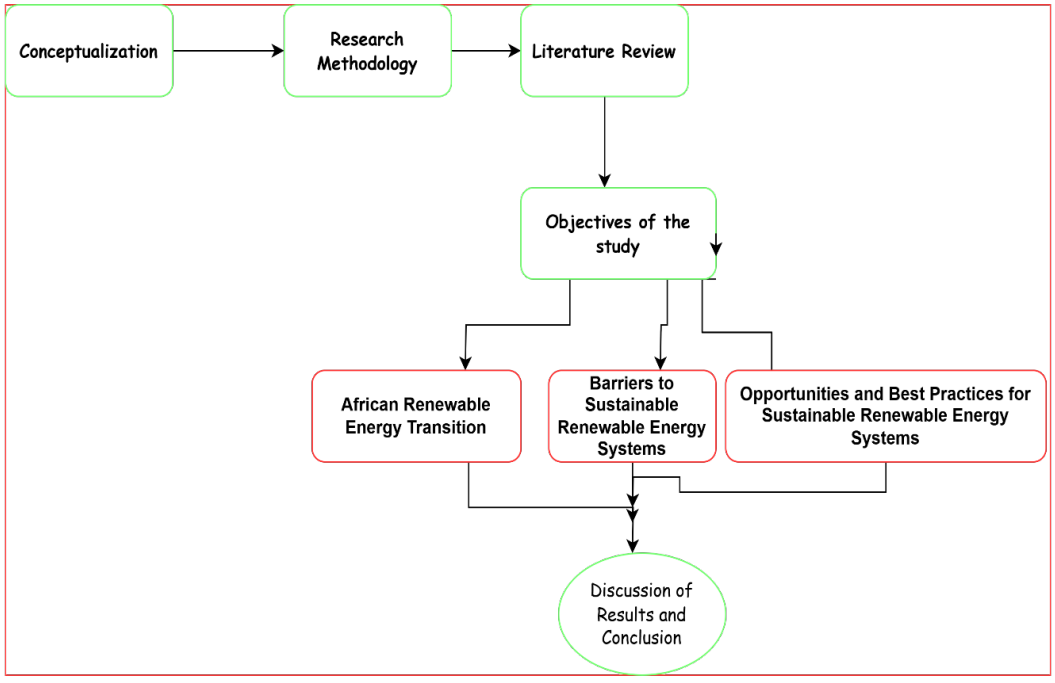

Figure 1. Schematic diagram for the study

Source: (Authors own creation, 2025)

4. Result discussion and Findings

This study set out to explore how Africa can enhance its renewable energy transition. Based on the findings from the literature, several core themes emerged, which provide insight into both the challenges and opportunities for scaling renewable energy across the continent. This section synthesizes the key findings and propose strategic axes for accelerating Africa's energy transition. Africa's vast renewable energy resources, particularly solar, wind, and hydropower, provide a solid foundation for transitioning to sustainable energy. The potential of decentralized systems, such as mini-grids and solar home systems, offers an immediate solution to rural communities that remain off the grid. These systems can empower local communities by providing sustainable energy and reducing their dependence on fossil fuels.

4.1 Propositions for Accelerating the Renewable Energy Transition

Building on these findings, several propositions can be made to further enhance the adoption of renewable energy in Africa. These propositions focus on addressing the unique challenges of rural areas and leveraging innovative financial models to scale energy solutions. A key proposition is the expansion of community-based decentralized energy solutions. Many rural areas in Africa remain off-grid due to the high cost and logistical difficulties of extending national grid infrastructure. Decentralized solutions, such as solar mini-grids and solar home systems, can provide immediate relief by offering clean, affordable, and reliable energy to underserved populations.

4.1.1. Microcredit and Crowdfunding as Financial Solutions

While access to financing remains a significant barrier, alternative financial models such as microcredit and crowdfunding offer promising solutions for scaling decentralized energy systems. Microcredit allows individuals and small communities to access small loans to invest in renewable energy solutions, such as solar home systems or mini-grids. These financial products can be tailored to meet the specific needs of low-income households and rural communities, providing them with the capital to implement clean energy solutions without requiring large upfront investments. Crowdfunding, on the other hand, leverages the power of community financing to support renewable energy projects. By engaging local and international donors, crowdfunding platforms can pool resources to finance community energy initiatives. This approach democratizes access to renewable energy, ensuring that marginalized communities are not left behind in the energy transition.

4.1.2. Policy Support and Regulatory Alignment

For these community-based and financial solutions to be effective, there must be supportive policies and regulatory frameworks at both the national and local levels. Governments should work towards creating enabling environments for decentralized energy solutions by aligning national energy policies with local regulations. This includes streamlining permitting processes, offering tax incentives, and ensuring that rural areas have access to the same financing opportunities as urban centers. Furthermore, local governments must play a pivotal role in ensuring that energy projects are well-integrated into local development plans, providing infrastructure and technical support where needed.

4.1.3. Digital Innovation and Smart Grids

Leveraging digital technologies and smart grids can enhance the management and distribution of renewable energy in decentralized systems. Innovations such as the Internet of Things (IoT) can provide real-time monitoring and optimization of energy use in rural areas, ensuring efficient energy management and reducing waste. Smart grids, integrated with renewable energy sources, can help distribute energy more efficiently across communities, reduce transmission losses, and ensure that energy is available when needed. By focusing on these axes community-based decentralized energy solutions, microcredit and crowdfunding financial models, supportive policies, and digital innovations Africa can accelerate its renewable energy transition, particularly in rural areas where the need for reliable, clean energy is most urgent.

4.1.4 Implications for Africa's Energy Transition

The adoption of these best practices will not only improve energy access but also position Africa as a key player in global climate action. By focusing on sustainable energy solutions and inclusive development, Africa has the potential to leapfrog traditional energy systems and establish itself as a global leader in renewable energy innovation (Nsafon et al, 2023; Aniebo and Akpan, 2022). Moreover, the recommendations outlined in this study, particularly around financing, decentralization, and community empowerment, will help ensure that the energy transition is equitable and inclusive, benefiting all African citizens, including marginalized communities (UN, 2023; Nsafon et al, 2023).

5. Conclusion and Area for Further Research

The transition to renewable energy in Africa is a complex but critical undertaking that requires coordinated efforts across multiple sectors. This study has highlighted the urgency of moving beyond traditional energy models to embrace sustainable and inclusive renewable energy solutions. By addressing challenges such as financial constraints, fragmented regulatory frameworks, and the lack of technical capacity, while also recognizing the opportunities inherent in decentralized energy systems, digital technologies, and international climate financing, this research outlines a clear path forward for the continent. Key strategies, such as adopting innovative financing mechanisms, empowering community-driven energy models, and fostering cross-sectoral collaboration, are essential to overcoming existing barriers. These approaches not only address immediate energy access gaps but also align with global climate goals, positioning Africa for long-term energy resilience. By tapping into its renewable energy potential, engaging local communities, and ensuring that policies are well-aligned with practical implementation, Africa can emerge as a leader in green innovation and climate action.

Ultimately, the renewable energy transition in Africa is not just a technical shift, it is an opportunity to advance equity, empower local communities, and promote long-term environmental sustainability. Through strategic action and commitment, Africa can pave the way for a more sustainable and inclusive energy future, positioning itself as a global example of transformative climate leadership. By leveraging collective efforts, Africa can fully realize its renewable energy potential, ensuring both socio-economic and environmental benefits for generations to come.

Acknowledgements

We wish to convey our profound appreciation to the anonymous reviewers and the research team under the leadership of Professor Ramabodu for their invaluable assistance and insightful critiques. This research was funded and supported by the Directorate for Research and Postgraduate Support at Durban University of Technology, South Africa.

References

Abas, N., Kalair, A. and Khan, N., Review of fossil fuels and future energy technologies. *Futures*, 69, pp.31–49, 2015.

Adelaja, A.O., Barriers to national renewable energy policy adoption: Insights from a case study of Nigeria. *Energy Strategy Reviews*, 30, p.100519, 2020.

African Development Bank (AfDB), *Annual Report on Energy Access in Africa*. AfDB Publications, 2022.

Agoundedemba, M., Kim, C.K. and Kim, H.G., Energy status in Africa: challenges, progress and sustainable pathways. *Energies*, 16(23), p.7708, 2023.

Agyeman, S.D. and Lin, B., Nonrenewable and renewable energy substitution, and low–carbon energy transition: Evidence from North African countries. *Renewable Energy*, 194, pp.378–395, 2022.

Aniebo, I.N. and Akpan, J.S., Energy transition: implications, considerations, and roadmap development for Sub-Saharan Africa. In *SPE Nigeria Annual International Conference and Exhibition*, p. D031S017R004, 2022.

Asante, D., He, Z., Adjei, N.O. and Asante, B., Exploring the barriers to renewable energy adoption utilising MULTIMOORA-EDAS method. *Energy Policy*, 142, p.111479, 2020.

Assis, C.C.D. and Ribeiro, R.A., An overview of Chinese action and presence at Africa's energy transition, 2023.

Bishoge, O.K., Kombe, G.G. and Mvile, B.N., Renewable energy for sustainable development in sub-Saharan African countries: Challenges and way forward. *Journal of Renewable and Sustainable Energy*, 12(5), 2020.

Bowen, G.A., Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), pp.27–40, 2009.

Creswell, J.W., *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th ed.). SAGE Publications, 2014.

Ekpotu, W., Akintola, J., Moses, Q., Obialor, M., Osagie, E., Utoh, I.O. and Akpan, J., Nigeria's Energy Transition Plan: A Technical Analysis, Opportunities, and Recommendations for Sustainable Development. In *SPE Nigeria Annual International Conference and Exhibition*, p. D032S030R007, 2024.

Evans, O., The investment dynamics in renewable energy transition in Africa: The asymmetric role of oil prices, economic growth and ICT. *International Journal of Energy Sector Management*, 18(2), pp.229–247, 2024.

Fajardy, M. and Reiner, D.M., Electrification of residential and commercial heating. In *Handbook on Electricity Markets*, pp.506–539. Edward Elgar Publishing, 2021.

Falcone, P.M., Sustainable energy policies in developing countries: a review of challenges and opportunities. *Energies*, 16(18), p.6682, 2023.

Fischer, R., Lopez, J. and Suh, S., Barriers and drivers to renewable energy investment in sub-Saharan Africa. *Journal of Environmental Investment*, 2(1), pp.54–80, 2011.

Francis, K., Dongying, S., Dennis, A., Edmund, N.N.K. and Kumah, N.Y.G., Network governance and renewable energy transition in sub-Saharan Africa: Contextual evidence from Ghana. *Energy for Sustainable Development*, 69, pp.202–210, 2022.

International Energy Agency (IEA), *Africa Energy Outlook 2022*. Retrieved from iea.org, 2022.

International Renewable Energy Agency (IRENA), *Sub-Saharan Africa: Policies and finance for renewable energy deployment*. Retrieved from irena.org, 2024.

International Renewable Energy Agency (IRENA), *The Renewable Energy Transition in Africa*. Retrieved from irena.org, 2021.

IRENA, *The energy transition in Africa: Opportunities for international collaboration with a focus on the G7*. International Renewable Energy Agency, Abu Dhabi, 2024.

Kabeer Abdulfatah, H. and Ayodele, E., Impact of Nigeria's Nationally Determined Contributions (NDC) on Energy Security as the Country Transition to Low Carbon or Net-Zero Energy Systems. In *SPE Nigeria Annual International Conference and Exhibition*, p. D022S025R006, 2023.

Kylili, A., Thabit, Q., Nassour, A. and Fokaides, P.A., Adoption of a holistic framework for innovative sustainable renewable energy development: A case study. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, pp.1–21, 2021.

Luthra, S., Kumar, S., Garg, D. and Haleem, A., Barriers to renewable/sustainable energy technologies adoption: Indian perspective. *Renewable and Sustainable Energy Reviews*, 41, pp.762–776, 2015.

McEwan, C., Spatial processes and politics of renewable energy transition: Land, zones and frictions in South Africa. *Political Geography*, 56, pp.1–12, 2017.

Moyo, B. and Oree, V., Renewable Energy Policies in Sub-Saharan Africa: An Analysis of Strategies, Challenges, and Pathways to Sustainable Development. In *2024 1st International Conference on Smart Energy Systems and Artificial Intelligence (SESAI)*, pp.1–6. IEEE, 2024.

Müller, F. and Claar, S., Auctioning a 'just energy transition'? South Africa's renewable energy procurement programme and its implications for transition strategies. *Review of African Political Economy*, 48(169), pp.333–351, 2021.

Müller, F., Claar, S., Neumann, M. and Elsner, C., Is green a Pan-African colour? Mapping African renewable energy policies and transitions in 34 countries. *Energy Research & Social Science*, 68, p.101551, 2020.

Müller, F., Neumann, M., Elsner, C. and Claar, S., Assessing African energy transitions: renewable energy policies, energy justice, and SDG 7. *Politics and Governance*, 9(1), pp.119–130, 2021.

Mutezo, G. and Mulopo, J., A review of Africa's transition from fossil fuels to renewable energy using circular economy principles. *Renewable and Sustainable Energy Reviews*, 137, p.110609, 2021.

Nikolina, S.A.J.N., International Renewable Energy Agency (IRENA), 2016.

Nsafon, B.E.K., Same, N.N., Yakub, A.O., Chaulagain, D., Kumar, N.M. and Huh, J.S., The justice and policy implications of clean energy transition in Africa. *Frontiers in Environmental Science*, 11, p.1089391, 2023.

Nwokolo, S.C., Obiwulu, A.U. and Okonkwo, P.C., *Africa's Propensity for a Net Zero Energy Transition*. CRC Press, 2024.

Nyika, J. and Dinka, M.O., The Push for Renewable Energy Adoption in Africa: Challenges and Prospects. In *Handbook of Energy and Environment in the 21st Century*, pp.187–203, 2024.

Obuseh, E., Eyenubo, J., Alele, J., Okpare, A. and Oghogho, I., A systematic review of barriers to renewable energy integration and adoption. *Journal of Asian Energy Studies*, 9, pp.26–45, 2025.

Ouedraogo, N.S., Opportunities, barriers and issues with renewable energy development in Africa: a comprehensible review. *Current Sustainable/Renewable Energy Reports*, 6, pp.52–60, 2019.

Ritchie, H. and Rosado, P., Energy mix. *Our World in Data*, 2020.

Ritchie, H. and Rosado, P., Energy mix. *Our World in Data*. Retrieved from https://ourworldindata.org/energy-mix, 2020.

Schwerhoff, G. and Sy, M., Developing Africa's energy mix. *Climate Policy*, 19(1), pp.108–124, 2019.

Smarte Anekwe, I.M., Akpasi, S.O., Mkhize, M.M., Zhou, H., Moyo, R.T. and Gaza, L., Renewable energy investments in South Africa: Potentials and challenges for a sustainable transition – a review. *Science Progress*, 107(2), p.00368504241237347, 2024.

United Nations (UN), *United Nations Climate Summit: Energy Access for All*. UN Publications, 2023.

United Nations, UN climate change summit. Available from https://www.un.org/en/climate-change/un-climate-summit-2019.shtml, 2019.

Vezzoli, C., Ceschin, F. and Diehl, J.C., Sustainable Product-Service System Design applied to distributed renewable energy fostering the goal of sustainable energy for all. *Journal of Cleaner Production*, 97, pp.134–136, 2015.
Vezzoli, C.A., Delfino, E. and Ambole, L., System design for sustainable energy for all: A new challenging role for design to foster sustainable development. *FORMakademisk*, 7, Art-3, 2014.

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