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Barriers and Policy Pathways for Renewable Energy Adoption in Developing Nations: The Case of Kenya

Running Title: *Adoption Challenges of RE in Developing Nations*

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Abstract: ***Renewable energy adoption in developing nations remains constrained by financial, infrastructural, technological, and policy-related barriers. Using Kenya as a case study, this paper examines the interplay of these challenges and their implications for sustainable development. Drawing on national energy data, policy reviews, and international reports, the study highlights Kenya's progress in expanding renewable capacity, its persistent reliance on external funding, and the role of governance in shaping adoption outcomes. The paper concludes with policy recommendations that include targeted financing mechanisms, accelerated infrastructure development, streamlined regulatory processes, and enhanced skills training. These measures enable a transition toward a resilient and inclusive energy future in Kenya and other developing contexts.***

Keywords: renewable energy adoption, developing countries, Kenya energy policy, energy transition, sustainable development

1. Introduction

In the past two decades, Kenya has had a rigorous electrification program that has seen the growth of its power sector. As it is, the country is a leader in Africa for renewable energy since 90% of Kenyan energy is derived from renewable energy.[1] However, the path to electrification has been challenging. Some of the challenges persist even in their success. Recently, there has been much focus on the adoption of renewable energy.[2] Because they can reduce global warming, improve energy security globally, and positively impact the environment locally, renewable energy sources would be one of the fossil fuel substitutes.[3] As a result, places where renewable power systems need to be developed may be especially appropriate in emerging nations, such as large cities and small rural villages. Specifically, today's global environmental crisis has compelled all countries, regardless of the level of development, to look for alternative energy sources and less environmentally harmful consumption habits. This paper aims to identify and analyze the primary barriers to renewable energy adoption in developing nations, use Kenya as a case study, and propose policy measures to facilitate a sustainable energy transition. The study's significance lies in its capacity to inform policymakers, investors, and development agencies on practical strategies to overcome renewable energy adoption barriers, aligning local actions with global climate and sustainability targets.

2. Research Methodology

This study looks at the problems developing countries face when using renewable energy, with Kenya as the main case study. It employs a qualitative case study methodology and thorough secondary data analysis to investigate the barriers to adopting renewable energy in developing countries. The research design is descriptive and analytical and combines policy analysis, statistical evaluation, and comparative assessment. Some data sources include strategic documents from Kenya's Ministry of Energy and Petroleum, reports from international organizations, scholarly works, and energy generation and capacity figures from the power industry. Kenya was chosen as the main case study because of its leadership role, development challenges, policy commitment, data availability, geographic representativeness, and economic context.

The study uses thematic content analysis to classify and examine the barriers to adopting renewable energy, particularly emphasizing infrastructure limitations, financial constraints, and the assessment of policy and regulatory frameworks. A systematic review, statistical analysis, cross-validation, comparative analysis, and policy evaluation are all used in this study. With an emphasis on recent policy initiatives and future projections through 2030 and 2050, the study examines developments in renewable energy from 2011 to 2024.

Secondary data dependency, case study limitations, data currency, perspective limitations, and language and accessibility are some of the research approach's drawbacks. The study does not require any additional ethical clearance beyond that required by standard academic research protocols, and it uses publicly available secondary data sources.

[1] International trade administration. 2024. Energy-Electrical Power Systems. https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems#:~:text=Renewable%20Sources%3A,from%20renewable%2Fclean%20energy%20sources.

[2] Kabel, Tarek Safwat, and Mohga Bassim. "Reasons for shifting and barriers to renewable energy: A literature review." *International Journal of Energy Economics and Policy* 10, no. 2 (2020): 89-94.

[3] Ibrahim, Hanif Auwal, Michael Kweneojo Ayomoh, Ramesh C. Bansal, Michael Njoroge Gitau, Venkatta SS Yadavalli, and Raj Naidoo. "Sustainability of power generation for developing economies: A systematic review of power sources mix." *Energy Strategy Reviews 47* (2023): 101085. https://www.sciencedirect.com/science/article/pii/S2211467X23000354

3. Adoption of Renewable Energy in developing countries

The term' Renewable Energy' (RE) can be used to describe many technologies and different sources. If the source is specified, terms such as solar, wind, hydro, geothermal, and biomass might be used. These sources have been broadly categorized into five main areas: solar, wind, water, geothermal, and biomass.[4] In the development process of any modern economy, the movement from a fuel-related energy system to an electrified energy system and the consequent reduced dependency on fossil fuels is a tested system.[5] In the current scenario of international movements towards cutting or eliminating greenhouse gas emissions, the importance of going for renewable energy sources must be emphasized.[6] Research has indicated that as long as the sun shines, hydropower flows, the wind blows, and the tides ebb and flow, there are indeed mountains that enjoy their thermal elevation as well as the earth's core, giving the geothermal production; the renewable energy resources requisite will be available sustainably.[7]

Developing countries have a vast potential for renewable energy to address energy consumption's environmental and social issues.[8] Adoption, however, is problematic in regions of the world with ***little financial resources***, ***inadequate infrastructure***, and ***inadequate policy assistance***.[9] All facets of development and integration have their share of challenges, including sociological, administrative, financial, and technological ones.[10] Barriers may also arise from indigenous people's resistance to these technologies.[11] Experience can inform several possible policy approaches to address these problems. The policy review concentrated on three key elements essential to the growth of renewable energy businesses in developing countries: ***the sustainability of industrial development***, ***support from foreign donors,*** and ***national policy support.***

Developing nations must invest more in infrastructure and resources to establish high-technology businesses than industrialized nations. The low levels of foreign direct investment in developing nations demonstrate this. These difficulties are common in the renewable energy market; small hydropower and biomass projects are currently the most mature and widely used sources.[12] When developing countries undertake projects that require them to incorporate renewable technologies—such as solar thermal power, wind, and photovoltaics—they experience additional challenges. ***Renewable energy technologies appear unfeasible to residents of underdeveloped nations because of inadequate infrastructure and the amenities brought about by poverty and a guaranteed low standard of living.***[13] This lot must be developed concurrently; thus, producing original goods for export at a reasonable price is not feasible. Therefore, there must be more significant incentives to attract foreign investors. In addition to taking into account the unique social and economic circumstances of developing countries, highly creative solutions will be needed in addition to financial support and active participation from international donors if these countries are to have access to renewable technologies.

4. Case Study: Renewable Energy in Kenya

Kenya is located along the equator, thus endowed with untapped wind, solar, hydropower, biomass, and geothermal resources.[14] In terms of policy, Kenya has been lauded for implementing effective administrative reforms that have removed most of the government regulations that inhibited renewable supply. Moreover, the Kenyan government has developed policies that could increase the share of renewables in the total energy mix to more than 30% by 2030.

The Kenyan private sector, particularly the energy industry, has received tremendous invigoration because the current government works closely with international financial institutions. Kenya has significant feasibility in implementing all three major renewable energy technologies, solar, hydro, and wind power, due to its geographical location and accessibility of respective prime areas. Renewable energy sources dominate Kenya's electricity sector regarding the amount of electricity generated and installed capacity.

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[4] Bamisile, Olusola, Dongsheng Cai, Humphrey Adun, Michael Taiwo, Jian Li, Yihua Hu, and Qi Huang. "Geothermal energy prospect for decarbonization, EWF nexus and energy poverty mitigation in East Africa; the role of hydrogen production." Energy Strategy Reviews 49 (2023): 101157. https://www.sciencedirect.com/science/article/pii/S2211467X23001074

[5] Barnes, Douglas F. "Effective solutions for rural electrification in developing countries: Lessons from successful programs." *Current Opinion in Environmental Sustainability* 3, no. 4 (2011): 260-264; Van Ruijven, Bas J., Jules Schers, and Detlef P. van Vuuren. "Model-based scenarios for rural electrification in developing countries." *Energy* 38, no. 1 (2012): 386-397.

[6] Abbas, Majed, Yaming Zhang, Yaya Hamadou Koura, Yanyuan Su, and Wasim Iqbal. "The dynamics of renewable energy diffusion considering adoption delay." *Sustainable Production and Consumption* 30 (2022): 387-395.

[7] Ibid

[8] M. Amir and S. Z. Khan, "Assessment of Renewable Energy: Status, Challenges, COVID-19 Impacts, Opportunities, and Sustainable Energy Solutions in Africa," Energy and Built Environment 3, no. 2 (2022): 186-200, https://doi.org/10.1016/j.enbenv.2021.10.002.

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[14] Spittler, Nathalie, Brynhildur Davidsdottir, Ehsan Shafiei, and Arnaud Diemer. "Implications of renewable resource dynamics for energy system planning: The case of geothermal and hydropower in Kenya." *Energy Policy* 150 (2021): 111985.

Currently, the generation mix consists of hydro, geothermal, wind, solar, and other energy sources, which contribute 46%, 31.6%, 9.5%, 19%, and 0.17%, respectively, of the total installed generation capacity of 2,711 MW as of the end of April 2020.[15] The generation volume varies across different renewable resources, with geothermal being the top producer as of the end of 2017. The installed capacity operating on renewable energy has seen an upward trend since 2017, registering a growth of 6.96% in 2019.[16] Wind, solar, and small hydro have been the most developed renewables with energy investments. The renewable energy projects are mostly grid-based and serve urban and peri-urban populations within Kenya. However, off-grid markets (solar energy for rural, un-electrified, and under-electrified households in remote country areas) are rapidly growing.[17] According to the International Renewable Energy Agency (IRENA) 's Annual Report, Kenya has deployed a significant share of Africa's mini-grids.[18] Thus, Kenya is notably the leading African country in deploying mini-grids.

a) Current Status and Trends

Kenya has seen a rapid increase in the number of renewable energy installations. In 2014, renewable energy accounted for 75% of the country's 1,832 MW of installed generation capacity.[19] Ten of the 30 largest power plants are hydro-powered, while one is the 70 MW Turkwell geothermal plant. The rest of the capacity originates from non-renewable resources, with an 891 MW share from oil and 302 MW from various thermal stations.[20] These include the coal-powered plant and the gas turbines, such as those in the 120 MW Iberafrica station, the 240 MW Syongesku, and the 242 MW Bagha stations.[21] Renewable resources can be further subdivided into those in the energy mix, leading to solar and wind accounting for 0.244% and 0.15% of the country's energy production and 0.12% and 0.58% of the installed capacity, respectively.[22]

Several success stories exemplify trends in technology deployment. Nairobi, for example, has a solar-powered business park that hosts 506 rooftop solar installations. This approach is not only a change but also a business-enhancing factor in Kenya, where the cost of power is extremely high.[23] A water project generates and feeds 453 kWh of electricity into the national grid. The project determines local community needs, provides solutions, and designs systems, and as a result, is adaptable to a variety of developments. What characterizes this case is a local community that is open to new technology.

Apart from innovations, there is also an increasing awareness of energy-efficient technologies. A program is on the way that provides incentives of 70% towards the installation of efficient converter kits. At the end of 1999, 1,151 kits were installed, and 528 lamps were totaled in the first three months of 2000.[24] More than 1,200 mainly diesel electricity suppliers have applied for the program, and there has been expressed demand for 3 MW. LED will likely be popular, as there are plans for a project that will focus on enabling the financial mechanisms for applying LED, a new yet expensive and, therefore, highly unpopular technology. Energy policy and trade discussions tell part of the story of the emerging role of renewable technology. Kenya is currently leading the development of renewable energy test centers on the Kenyan Coast and the Yala Swamp. These centers are designed to test, familiarize, train, and innovate new renewable energy ideas. Close to 20 local companies have promised to participate actively in a program demonstrating the technical and cost layers of renewable energy sources, particularly biomass and some aspects of wind, for local communities.[25]

Funding for the centers' construction has been pledged between €10 million and €12 million. This wet mill and the rice-processing town of the same name could do with a reduced electricity bill. Interestingly, the Kenyan government, which would have stifled the idea not too long ago, is also emerging as an essential partner in technology transfer. The opening of the energy policy discussion is demonstrated by lifting the ban on using kerosene in cooking schools, hotels, and urban establishments. At that time, it was declared that energy, especially renewable sources, is crucial in preparing the nation's future. A Policy White Paper later claimed that renewable sources should provide 80% of energy requirements by the end of the next decade.

b) Key Challenges

In developing nations, the adoption of renewable energy sources is affected by various challenges. ***Financial limitations*** are one of the main hindrances to implementing these projects. Governments in sub-Saharan Africa need more resources; thus, there is a massive reliance on funds and investments.[26] Kenya is similar to the other countries in the sub-Saharan region. The country suffers from an economic deficit and mainly relies on financial aid to advance the country's projects. Apart from the economic deficits related to the trade deficits, the government also faces corruption challenges, which hinder the efficient utilization of limited funds.[27]

[15] Takase, Mohammed, Rogers Kipkoech, and Paul Kwame Essandoh. 2021. "A comprehensive review of energy scenario and sustainable energy in Kenya." *Fuel Communications* 7: 100015.
[16] Ibid
[17] Samoita, D., Nzila, C., Østergaard, P. A., and Remmen, A. "Barriers and solutions for increasing the integration of solar photovoltaic in Kenya's electricity mix." Energies 13, no. 20 (2020): 5502. https://www.mdpi.com/1996-1073/13/20/5502/pdf.
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[22] Ministry of Energy and Petroleum. 2023. KENYA ENERGY TRANSITION & INVESTMENT PLAN 2023 – 2050. The Republic of Kenya
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[24] Ibid
[25] Ministry of Energy and Petroleum. 2023. KENYA ENERGY TRANSITION & INVESTMENT PLAN 2023 – 2050. The Republic of Kenya
[26] Takase, Mohammed, Rogers Kipkoech, and Paul Kwame Essandoh. 2021. "A comprehensive review of energy scenario and sustainable energy in Kenya." *Fuel Communications* 7: 100015.
[27] Ibid

Kenya's population and economy are expanding faster than the country's energy needs. The Kenyan government's Vision 2030 initiative aims to make Kenya's economy middle-income by 2030 by presenting bold plans for future economic growth.[28] Its main issues are the nation's dependency on hydroelectric power and the lack of investment in power production. Power interruptions cost Kenyan businesses an average of 6.3 million monthly shillings in lost revenue.[29] Every five hours or so is spent in downtime. The World Bank estimates these diversions cause a 7.1% drop in overall enterprise sales.[30] Kenya Power Company notifies users of impending shutdowns on its Power Alert website.

Another significant barrier to the uptake and success of renewable energy in developing nations is ***inadequate infrastructure***. This might relate to the physical infrastructure: for instance, the northern region of Kenya needs road access, making it challenging to transport gear, wind turbines, and other equipment to appropriate locations. It can also relate to the physical inputs into energy production, such as fuel and energy resource extraction. In developing nations, mismatched policies and regulatory frameworks impede the uptake and prosperity of renewable energy technology.

Furthermore, local necessity energies have frequently offered "kind solutions" without considering the most efficient energy use. In many sub-Saharan houses, adopting suitable renewable technology like solar PV systems could help save the environment and improve people's health, considering the prevalence of respiratory illnesses caused by poorly ventilated shacks and the usage of candles.[31] Energy conservation, power availability, and efficiency can be improved using appropriate and effective renewable technology. The lack of infrastructure in developing nations may significantly impact the adoption of renewable energy, as demand for fossil fuels and other environmentally unfriendly energy sources continues to outpace supply. These elements could exacerbate one another's effects on rural development.

While the government is committed to increasing the percentage of renewable energy sources in the electricity grid by 2030, its efforts have manifested extensive discussions of policy implications, while on the ground, energy access remains minimal in some areas.[32]. Another key challenge in Kenya's energy sector is the delay in approving Power Purchase Agreements and the Government of Kenya's reluctance to issue letters of support for project developers—a key component in achieving financial closure for projects.[33] ***Exceptionally affordable technologies, such as helpful micro-hydro systems, are primarily overlooked,*** mainly because of the commercial nature of the renewable industry, which focuses on one-off mega-projects and limited competition among renewable energy technology suppliers. The lack of infrastructure should not be considered an impediment in isolation, as decent infrastructure can lay the basis for later industrial development. Energy poverty is often cited as a reason for the slow uptake of renewable energies. However, the solution is complex and holistic, involving technical, social, and economic dimensions. Where renewable energy technology has been adopted, the decision-making methods and means of transferring technology have also been implicated as the most problematic. These require connections between the host communities, their representatives, and the stakeholders, including national policies and regional businesses.

c) Kenyan Policies Relating to Renewable Energy

The Kenyan government promotes using renewable energy and other alternative sources to fossil fuels. While Kenya has managed to change to the use of renewable energy in the primary electricity production grid, many people use fossil fuels in domestic activities such as cooking. In rural areas, for example, many people use firewood to cook food and warm any water needed within the domestic household. Many people use charcoal and liquid petroleum gas in small and medium-sized towns for cooking and heating water.[34] In larger cities, many people use liquid petroleum gas. This indicates that despite the sustainability of the electrical grid, certain areas still face energy access and efficiency gaps.[35] The Kenyan government encourages Kenyans to use alternative energy sources such as Biogas and solar energy for domestic activities. This would not only reduce the carbon footprint of domestic households but also reduce the demand on the electrical grid significantly.

The Ministry of Energy in Kenya has created different strategic partnerships. It has developed initiatives that enhance ***the use of biogas*** in many Kenyan homes, especially in rural areas. These partnerships have yielded many positive impacts. For example, 17000 biogas digesters have been built in rural areas across 36 counties in the past five years.[36] The Kenya Biogas Programme, which the Dutch Government supports, made this achievement possible. The government has also partnered with different institutions of higher learning to construct biodigesters meant to help train students on the various technologies that can be used in their

[28] Rotich, Ibrahim Kipngeno, Hilda Chepkirui, and Peter K. Musyimi. 2024. "Renewable energy status and uptake in Kenya." *Energy Strategy Reviews* 54: 101453.
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[31] Ayhan, S. H. and Jacob, T. "Competing energy visions in Kenya: The political economy of coal." The Political Economy of Coal (2022). https://library.oapen.org/bitstream/handle/20.500.12657/52615/9781000551556.pdf?sequence=1#page=196
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[36] Ibid

construction.[37] This initiative is intended to improve people's knowledge about the construction of biodigesters, thus making it successful.

The Kenyan government has also supported the development and use of solar energy. As of 2021, the Kenyan government generated approximately 170 MW of solar energy, and approximately 66% went into the primary power grid.[38] Apart from incorporating solar energy into the electrical sector, the government has played a significant role in ensuring that people in rural areas use solar-powered equipment. For example, there has been a proliferation of solar lamps and water pumps in rural areas.[39] Therefore, in homes where becoming a part of the electrical grid is too expensive, they can have lamps that they can charge under the sun during the day and then use as a light source at night. The Kenyan government's involvement in encouraging the shift has also encouraged private companies to develop region-specific solar-related solutions.[40] For example, some companies offer solar packages that can power a house for lighting only, while other domestic power uses are powered by other means.

5. Conclusion and Policy Considerations

This study has examined the multifaceted barriers to renewable energy adoption in Kenya, encompassing financial, infrastructural, technological, and policy-related challenges that represent broader constraints facing developing nations across sub-Saharan Africa. The discussion reveals various obstacles and constraints that limit the deployment and commercialization of clean energy technologies in developing countries. Kenya's experience serves as an illustrative case within the broader African context. While Kenya demonstrates considerable progress in renewable capacity expansion, generating 90% of its electricity from renewable sources, persistent issues such as limited funding, infrastructural gaps, slow regulatory processes, and capacity building deficits impede optimal growth and development.

The constrained opportunities and challenges identified in this paper are not distinct or exclusive to Kenya but represent clear patterns that hamper regional developmental aspirations. However, the analysis reveals pathways for addressing these systemic barriers through coordinated policy interventions and strategic partnerships. This study concludes that Kenya's renewable energy transition requires a multi-faceted approach to simultaneously address financial, infrastructural, and policy barriers. Key recommendations include: (1) establishing dedicated renewable energy financing mechanisms with robust international donor support, (2) accelerating infrastructure development in rural areas to support renewable energy deployment and grid integration, (3) streamlining Power Purchase Agreement approval processes to reduce project development timelines, and (4) expanding comprehensive skills development programs to create local technical capacity for renewable energy technologies.

Success in achieving sustainable energy transformation will depend on sustained political commitment, strategic international partnerships, and meaningful community-level engagement to ensure renewable energy solutions meet local needs while contributing to national development goals. Collaborative efforts between government institutions, private sector actors, international donors, and local communities will be essential to ensure that renewable energy becomes a central driver of sustainable economic development in Kenya and across developing nations seeking energy security and environmental sustainability. The findings suggest that while significant challenges persist, appropriate policy frameworks, adequate financing, and technical capacity building can enable developing countries to harness their renewable energy potential for transformative economic and social development.

a) Policy Considerations

Numerous financial instruments support renewable energy in Africa, which the government must help to impact the renewable energy landscape. Policies for regulatory measures for renewable energy in the power sector and grid access are essential, and the government must provide grants and other subsidies.

Employment is the cornerstone of productive economic development. As the world embraces renewable technologies and more sustainable practices, job opportunities in the electrical industry will multiply for skilled electricians. Data from the US Bureau of Labor Statistics shows that the demand for electricians will grow by 80%. Skill development is critical for local job creation to meet future needs and economic growth.41. Studies show that Kenya had about 700 FTE jobs in the bioethanol sector in 2019, while the biogas sector employed 800 people, and the electric cooking sector employed 20042. Given the importance of job creation opportunities in renewable technologies, the government must urgently attract fresh talent by investing in comprehensive training programs.

Kenya appears well-positioned to attain a substantial increase in renewable energy, essential to achieving universal energy access (SDG 7) and contributing to achieving SDG 8 for job creation. The timing of the government commitment to deploy and increase renewable energy sources in the electricity grid by 2030 is crucial to comply with Kenya's projections in this paper. The commitment aligns with the United Nations Sustainable Development Goals (SDGs). The SDGs provide a benchmark and blueprint for peace and

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[41] Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook*, Electricians, at https://www.bls.gov/ooh/construction-and-extraction/electricians.htm
[42] Lee, Chih-Jung, Rebekah Shirley, Maureen Otieno, and Hope Nyambura. "Powering jobs: the employment footprint of clean cooking solutions in Kenya." *Energy, Sustainability and Society* 11 (2021): 1-22.

prosperity for people and the planet to assess a country's current living conditions now and into the future.

The government should focus on the SDGs, directly addressing energy and climate change.

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[6] Bamisile, Olusola, Dongsheng Cai, Humphrey Adun, Michael Taiwo, Jian Li, Yihua Hu, and Qi Huang. "Geothermal Energy Prospect for Decarbonization, EWF Nexus and Energy Poverty Mitigation in East Africa; The Role of Hydrogen Production." *Energy Strategy Reviews* 49 (2023): 101157. https://www.sciencedirect.com/science/article/pii/S2211467X23001074.

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