

**EXAMINING GOVERNMENT INTERVENTION IN RENEWABLE ENERGY ADOPTION IN
UGANDA**

OCTAVIA JAPIANS OLOKA

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DECLARATION

I, Oloka Octavia Japians, hereby declare that this dissertation is my work and has not been presented to any institution for any reward.

Signature..  Date 11/06/2024

APPROVAL.

The research report titled 'Examining government Intervention in renewable energy adoption in Uganda' is the work of Oloka Octavia Japians done under my supervision and is ready for submission.

Signed•  Date 11/06/2024

Mukisa Simon Peter

DEDICATION.

This research report is dedicated to my family and close friends. I also dedicate it to researchers and any other parties that would like to throw more light on the renewable energy sector in Uganda and the government's involvement.

ACKNOWLEDGEMENT.

This study would not have been a success without the help and encouragement of many people. First and foremost, I must thank God the Almighty for my life and the knowledge to generate this Special Project Report. I also would like to thank my parents for the unwavering support that has been offered throughout the making of this report.

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1.0 INTRODUCTION

Renewable energy has attracted widespread attention due to its ability to prevent/control climate change and provide long-term energy solutions. Uganda, a developing country in East Africa with enormous natural resources, is showing increasing interest in utilizing renewable energy resources to fulfill rising energy demand and reduce dependency on fossil fuels. The purpose of this study is to examine the potential practicality and future of renewable energy adoption in Uganda.

The following chapter will consist of the background of the study, statement of the problem, purpose of the study, general study objectives, the hypothesis, scope of the study, justification of the study, significance of the study, the conceptual framework, limitations, de-limitations and conclusion.

1.1 Background to the study

Uganda, like many developing countries, faces significant hurdles in meeting its rising energy consumption while maintaining environmental sustainability. The widespread use of traditional biomass fuels for cooking and heating, along with a heavy reliance on non-renewable energy sources for electricity generation, has had a negative impact on Uganda's environment, public health, and socioeconomic growth. Furthermore, Uganda's energy sector is vulnerable to supply disruptions and the volatility of fuel prices, threatening the country's overall energy security.

To address these multiple difficulties, Uganda must commit to diversifying its energy portfolio and embracing renewable energy sources. The country has an abundance of resources, including solar, wind, hydro, geothermal, and biomass, which have the potential to encourage sustainable development while providing clean and dependable energy solutions. Nonetheless, despite the inherent promise, broad adoption of renewable energy technology in Uganda is still in its early phases. To promote the widespread deployment of renewable energy alternatives, several impediments and constraints must be overcome.

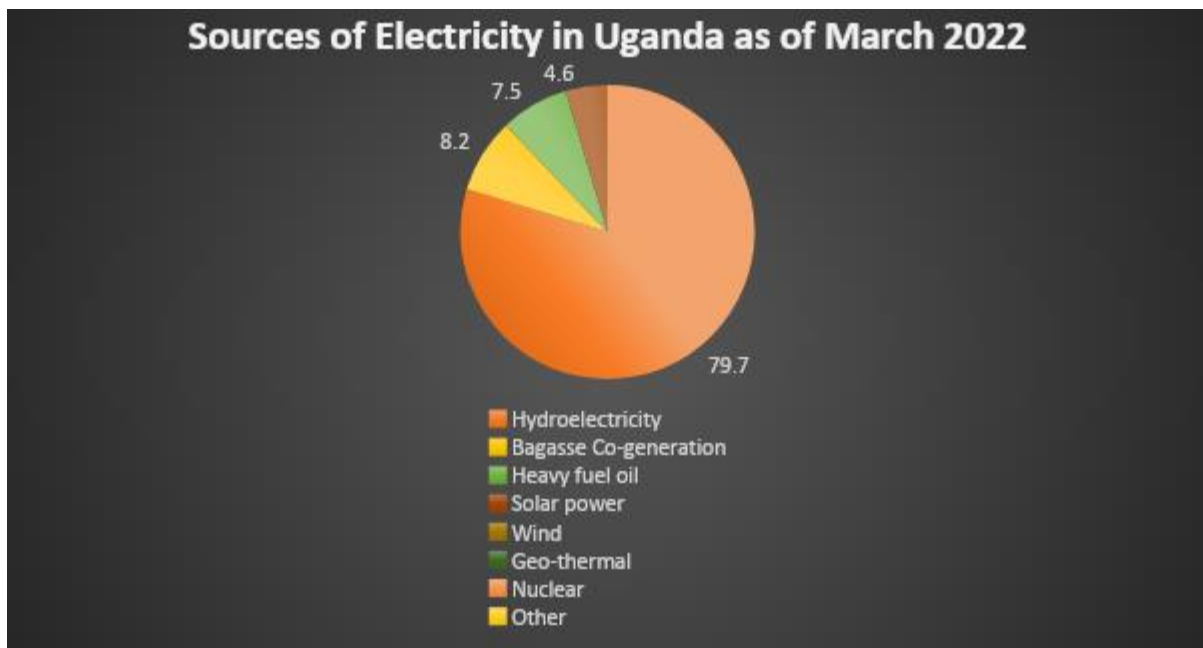
Uganda relied heavily on charcoal and fuelwood in the 1980s, providing for more than 95 percent of its energy needs. This dependence, however, was not without repercussions. Low Lake Victoria water levels, the country's principal source of power generating potential, caused significant generation shortages and an energy crisis in 2005 and 2006, resulting in frequent and protracted blackouts. According to the Uganda Bureau of Statistics, just approximately 20% of Ugandans had access to electricity at the time. Nonetheless, Uganda has made efforts in increasing its energy capacity since then.

In Uganda's rural and urban regions, wood fuels, particularly charcoal and fuelwood, were the predominant energy sources for cooking and heating. However, this has had serious consequences for the country's forests. Between 1990 and 2010, Uganda's wooded land shrank from 49,240 km² to 29,880 km², accounting for 39% of the country's total forest cover. This yearly deforestation rate of around 90,000 hectares causes a scarcity of fuelwood in rural areas as well as rising charcoal and fuelwood costs. Furthermore, inefficient charcoal manufacturing,

along with the extensive usage of traditional three-stone stoves, has increased energy prices and indoor air pollution levels, disproportionately harming women and children.

Uganda's economic development is hampered by a lack of access to electricity in both rural and urban regions. It stifles job growth, limits investment in rural infrastructure, and restricts access to information and communication technology. Because of the lack of power, rural public institutions such as health and educational facilities are also hampered in offering better services.

Renewable energy sources such as solar, wind, hydro, geothermal, and biomass provide an appealing answer to Uganda's energy difficulties. These sources are renewable, renewed naturally, and do not deplete finite resources. They provide several benefits, including reducing reliance on fossil fuels, lessening the effects of climate change, lowering pollution, creating jobs, boosting economic growth, and improving energy security. Furthermore, renewable energy helps in sustainability by emitting less greenhouse gases, making it critical in the worldwide battle to control climate change.



The above illustration is of the Uganda Electricity Installed Capacity as of March 16th 2022 by the Electricity Regulatory Authority in Kampala, Uganda.

Renewable energy has gained importance in recent years as governments strive to lessen their reliance on fossil fuels and mitigate the effects of climate change. Some countries have effectively raised the amount of renewable energy use in their energy mix thus paving the way for others to follow.

1.2.1 Statement of the problem

Uganda's ideal energy situation would include the use of a diverse mix of renewable energy sources, near-universal energy access, low carbon emissions, enhanced energy security, socioeconomic growth, increased employment levels, community empowerment, innovative financing, supportive policies, technological advancements, and regional leadership.

This goal would necessitate joint efforts and would result in environmental sustainability, economic success, and a higher quality of life for its residents but instead the reality is, that there is much use of conventional biomass fuels for cooking and non-renewable energy sources for power generation which has had a negative impact on the environment, health, and energy security.

Despite the country's tremendous renewable energy potential, adoption of these resources is restricted due to technological, economic, and legislative hurdles but Uganda has tried to take great measures to address this difficulty and encourage the use of renewable energy. Key initiatives include investment in hydropower projects such as the Isimba and Karuma dams, promotion of solar energy for off-grid and rural areas, exploration of geothermal potential, efforts to increase rural electricity access, and investments from domestic and international sources. Uganda also strengthened its legislative and regulatory framework, increased public knowledge of renewable energy, and has engaged in regional energy integration initiatives, but all these have led to a very slight improvement with still a great dependence on hydro electricity but more than 75%.

Addressing the energy challenges for renewable energy adoption requires a comprehensive strategy that would include diversifying energy sources through continued investment in renewables like solar, wind, hydro, geothermal, and biomass, while attracting public and private sector investments. Prioritizing energy access expansion but keeping in mind that energy efficiency is essential. Policy instruments, capacity building, and environmental conservation measures play key roles too, as does fostering cross-border cooperation, public awareness, and proper monitoring as Legislators must work to increase the legislature's research capabilities so as to fix shortcomings in Uganda's existing policy, legal, and institutional frameworks for natural resource management as well to use the research capacity of independent national and international policy research think tanks in the respective fields or knowledge such as the Uganda Wildlife Society, the Advocates Coalition for Development and Environment, GreenWatch, the International Union for Conservation of Nature, and the World Resources Institute.

Some other initiatives include public-private partnerships, long-term planning, and alignment with global climate commitments which are integral to achieving a sustainable, clean, and resilient energy future, necessitating collaboration among various stakeholders.

1.3.1 Purpose of the study

The purpose of the study will be to analyse the role of government in renewable energy adoption for the development of Uganda.

1.4.1 General study objectives

The objectives of this study will be to:

- i. Analyse the history of energy usage in Uganda.
- ii. Analyse the status of renewable energy in Uganda.
- iii. Analyse the role of government in the adoption of renewable energy in Uganda.

1.5.1 Research hypothesis

The research hypothesis of the study will be to:

H1: The status of the potential of renewable energy adoption positively affects the potential of renewable energy adoption in Uganda.

H2: The role of government positively affects the potential of renewable energy adoption in Uganda.

H3: Renewable energy adoption in the economic, social, and environmental sectors positively affects the potential of renewable energy adoption.

1.6.1 Scope of the study

The research will be concerned with the country of Uganda, which is located in East Africa. Uganda is the fundamental backdrop for assessing renewable energy potential, examining socio-economic and environmental implications, evaluating the legislative and regulatory framework, and finding hurdles to implementation thus causing it to be the geographical scope of the study.

A chronological frame of the time study scope will entail historical, present, and future perspectives. Here, by considering looking at the historical patterns and changes in Uganda's energy sector, renewable energy uptake, and associated problems, the historical backdrop shall aid in shedding light on Uganda's energy sector's history dating back to the 1980's and the elements that have led to its current position as of 2022.

Respectively, a large focus on the present situation of renewable energy adoption in Uganda, including recent advancements, policies, and efforts to which this contemporary perspective

will allow better assessment of the current potential and challenges of renewable energy sources in the country. With the consideration of the future view of renewable energy in Uganda as also an important detail, it will include addressing prospective trends, predictions, benefits and measures that Uganda could follow in the next years to further encourage renewable energy dependence.

1.7.1 Significance of the study

This study is significant because it has the potential to give useful insights and suggestions to the government, policymakers, investors, and stakeholders involved in Uganda's energy industry. The findings of this study can help with the following:

Sustainable Development: By examining the potential of renewable energy sources, this study can help Uganda achieve long-term development goals such as access to clean and inexpensive energy, poverty reduction, and environmental conservation. Energy security may be improved by diversifying Uganda's energy mix with renewable sources, lowering reliance on imported fossil fuels and limiting the risks associated with supply interruptions and variable costs.

Environmental Sustainability: Using renewable energy may dramatically reduce greenhouse gas emissions while mitigating the negative environmental consequences of traditional biomass fuels and nonrenewable energy sources. This research might provide light on the possible environmental advantages of renewable energy development.

Job Creation and Economic Growth: The broad adoption of renewable energy technology has the potential to create jobs, particularly in rural regions where resources such as biomass and solar are plentiful. This research can discover prospective socioeconomic advantages and help with informed decision-making for job development and economic growth.

Policy suggestions: By identifying the hurdles and constraints to renewable energy adoption, this research may offer policymakers with evidence-based suggestions and ways to solve these issues. It can help Uganda adopt appropriate laws, legislation, and incentives to boost renewable energy deployment.

In conclusion, this study on the potential of renewable energy in Ugandan development is significant and justified in addressing the country's energy challenges, promoting sustainable development, enhancing energy security, mitigating environmental impacts, fostering economic growth, and providing valuable policy recommendations.

1.8.1 Justification of the study

The reasons for doing this research on the possibilities of renewable energy in Uganda's growth are based on the following factors:

Concerns about the environment: Uganda, like other nations, is confronting environmental difficulties because of the usage of traditional biomass fuels and non-renewable energy sources.

Deforestation, indoor air pollution, and greenhouse gas emissions are all caused by these energy choices. This research intends to identify sustainable solutions that can minimize these environmental problems and create a cleaner and greener energy system by examining the possibilities of renewable energy.

Energy Security: Uganda's energy industry is sensitive to supply interruptions and shifting fuel costs due to its reliance on imported fossil fuels and hydroelectric electricity. Diversifying the energy mix with renewable sources can improve energy security by lowering reliance on fossil fuels, imported fuels and mitigating the risks associated with fluctuating global energy markets.

Socio-economic development: Access to dependable and inexpensive energy is critical for socioeconomic growth. This research attempts to find chances for employment development by examining the potential of renewable energy, particularly in rural regions where renewable resources are abundant. Furthermore, renewable energy may enhance energy availability, particularly in distant and disadvantaged places, helping to reduce poverty and boost overall economic growth.

Policy Advice: The outcomes of this study can give evidence-based insights and recommendations to policymakers for developing supporting laws and regulations. It may lead the establishment of incentives and procedures to encourage the deployment of renewable energy, such as feed-in tariffs, tax breaks, and capacity-building initiatives.

Global Commitments: Uganda, just as other nations, has pledged to contribute to global climate change mitigation efforts and to achieve sustainable development goals. This research connects with these pledges and helps Uganda's attempts to transition to a low-carbon and sustainable energy system by estimating the potential of renewable energy.

In summary, the rationale for this study is to address environmental problems, improve energy security, promote socioeconomic growth, provide policy direction, and line with global commitments. This research intends to contribute to a sustainable and resilient energy future for Uganda by examining the possibilities of renewable energy in the nation.

1.9.1 Conceptual framework

DEPENDANT VARIABLE

Government policy and regulation

Government investment

Advancement and Innovation

INDEPENDENT VARIABLE

Renewable energy usage

1.10.1 Limitations and de-limitations

While this study tries to investigate and give insights on the possibilities for renewable energy adoption in Uganda, it is critical to recognize the scope and boundaries of this research. The limitations and delimitations play an important role in setting the context and application of the study.

Limitations include features of the research that may have an impact on the study's results thus affecting the generalizability and accuracy of results. Some of these limitations are as follows;

Data Availability: The availability and quality of data linked to renewable energy potential, energy consumption patterns, and socioeconomic variables in Uganda may impact the study's conclusions.

Resource Variability: Due to geographical and climatic factors, the practicality and dependability of renewable energy sources such as solar and wind may vary, influencing their general adoption in different parts of Uganda.

Technical Restrictions: Technical limits in renewable energy technologies, such as intermittent energy generation, limited energy storage capacity, and infrastructural obstacles, may have an impact on the practical implementation and dependability of these sources.

Financial and economic issues: Such as the initial investment costs and long-term operations expenditures involved with renewable energy projects, may influence the pace of acceptance and scalability of such efforts.

Policy and Regulatory Challenges: The effectiveness of policies, regulations, and incentives to promote renewable energy deployment may be constrained by administrative challenges, lack of enforcement, and changes in political priorities.

Delimitations, on the other hand, specify the study's parameters and emphasis and define which components of the research are included/omitted, assisting in the definition of the study's boundaries and scope and so help to clarify what the research attempts to address and what falls outside of its scope. These may include;

Geographical Focus: The research will largely focus on Uganda's renewable energy potential and adoption barriers, rather than detailed comparisons with other nations' energy landscapes.

Study focus Components: The research will focus on solar, wind, hydro, geothermal, and biomass as the key renewable energy sources, without digging thoroughly into other developing technologies.

Study Variables Focus: While acknowledging socioeconomic advantages, the research will largely investigate the technical, economic, and environmental elements of renewable energy, with less focus on social dynamics and community interaction.

1.11.1 Conclusion

Uganda's resolve to improve grid stability, extend energy access, and adopt energy efficiency measures shows the country's goal to improve the lives of its population while driving economic progress. Furthermore, the development of novel financing structures, supporting regulations, and cross-border collaboration demonstrates the government's commitment to meeting its renewable energy targets. This will however not be without difficulties, which vary from technological obstacles to policy implementation and environmental concerns. It necessitates a coordinated effort on the part of government agencies, the commercial sector, civil society, and foreign partners.

Henceforth, the findings and recommendations will be an instrument of guidance and information to the policy makers and stakeholders on the socio-economic and environmental benefits, technological advancements and regulatory considerations necessary for the adoption and promotion of renewable energy in Uganda thus ultimately accelerating the transition towards a cleaner and more sustainable energy future.

2.0 LITERATURE REVIEW

2.1 History of Energy sector

In 1975, Danish physicist Bent Sørensen proposed 100% renewable energy, leading to the term "soft energy path" by energy policy analyst Amory Lovins in 1976, where energy efficiency and renewable sources replace fossil and nuclear fuels. Later in 1998, a detailed analysis of renewable energy scenarios was published, followed by 100% scenarios. In 2006, Czisch demonstrated that energy supply could match demand in Europe and North Africa in a 100% renewable scenario. Danish Energy Professor Henrik Lund published a paper on the optimal combination of renewables, leading to increased publications on 100% scenarios worldwide.

The concept of 100% renewable electricity has significantly evolved in the 21st century, with solar photovoltaic modules dropping by 75% and on-shore wind power becoming economically competitive with fossil and nuclear power. Concentrated solar thermal power with thermal storage is now in the limited commercial stage, with potential for further cost reductions of roughly 50%.

Iceland was the first country to propose 100% renewable energy in 1998. Countries like Japan, Australia, Albania, Iceland, and Paraguay primarily use renewable sources for electricity. Norway also primarily uses hydropower. Iceland proposed hydrogen for transportation and fishing, while Australia proposed biofuel for non-electric transportation. The United States, Denmark, and Europe set a 2050 timeline for converting to 100% renewable energy, later reduced to 2040 in 2011. Zero Carbon Britain 2030 aims to eliminate carbon emissions by 2030. Hawaii enacted a law in 2015 to achieve 100% renewable energy by 2045.

2.2 History of Energy sector in Uganda

Before independence: Uganda's energy industry was largely concerned with supplying home requirements using traditional biomass sources such as firewood and charcoal. During this time, the sector's progress was hampered by a lack of infrastructure and technology.

Post-Independence: Following its independence, Uganda focused on increasing its energy infrastructure to promote economic growth and development. In the early 1950s, the government launched initiatives to capture hydroelectric resources, which culminated in the construction of the Owen Falls Dam (now known as the Nalubaale Dam).

1970s and 1980s: The energy industry encountered issues because of political instability in this time frame, disrupting energy production and delivery. The industry saw a decrease in investment and maintenance, resulting in power shortages and irregular supplies.

In the 1990s: Uganda implemented energy sector reforms to encourage private investment. The government implemented initiatives to encourage renewable energy and increase energy efficiency.

From the 2000s until present: Uganda has invested in renewable energy sources including hydropower, solar, and wind to diversify its energy mix. The nation has also taken steps to improve access to power in rural regions and encourage energy efficiency.

The historical timeline of events in regards to the energy sector of the economy as indicated above proves the several advancements and reforms undertaken with the aim of enhancing access to dependable and sustainable energy sources. Uganda has achieved great progress in the energy industry over the years, moving away from a reliance on conventional biomass and toward a more diverse energy mix that includes renewable sources driven by the need to improve energy access, promote economic development, and mitigate the impacts of climate change.

2.3 Global Energy sector projection

In the United States, the independent National Research Council has noted that "sufficient domestic renewable resources exist to allow renewable electricity to play a significant role in future electricity generation and thus help confront issues related to climate change, energy security, and the escalation of energy costs ... Renewable energy is an attractive option because renewable resources available in the United States, taken collectively, can supply significantly greater amounts of electricity than the total current or projected domestic demand."

The world is projected to spend an additional \$8 trillion over the next 25 years on non-renewable resources, a cost that could be eliminated by transitioning to 100% renewable energy. Research suggests that converting the world to renewable energy by 2050 is feasible and affordable, but requires political support. This would involve building more wind turbines and solar power systems, reducing bioenergy use, and promoting electric cars and enhanced transmission grids and storage. By 2018, no G20 country had committed to a 100% renewable target.

In 2018, 181 peer-reviewed studies on 100% renewable energy were published. The Special Report on Global Warming of 1.5 °C cited 100% renewable energy as a potential approach to

expand to 1.5 °C pathways if the findings are confirmed. Although, wind and solar energy share was steadily increasing globally as of the year 2021 which was accounting for only 5% of total primary energy consumption, but despite being more usable.

A report by J.P. Morgan Asset Management (the biggest lender to fossil fuels in the world) analyzed renewable energy forecasts made by eight scientists and research bodies (including Bent Sorensen, Mark Z. Jacobson, Amory Lovins) between 1970 and 2020 and claimed that all of them were unrealistically optimistic as they ignored "energy density, intermittency and the complex realities of incumbent energy systems"

2.4 Uganda Energy sector projection and statistics

Highlighting the challenges and opportunities in meeting the country's growing energy demand, with five major sectors being household, commercial, industrial, agriculture, and transportation despite abundant energy resources, over 79.6% of the population lacks electricity access, with household electricity being the lowest. The demand for energy is driven by population growth and economic development, with a projected increase from 39.03 million in 2015 to 61.93 million by 2030. This growth necessitates increased investments in renewable energy projects. Though with abundant energy resources, a significant portion of the population still lacks electricity access, hindering socio-economic development. There is importance of expanding energy infrastructure and promoting renewable energy solutions to improve energy access. This increasing energy demand presents opportunities for renewable energy deployment, particularly in rural areas.

Several statistics as of 2018 related to energy consumption, access, and projections in Uganda have been published with the following data:

- **Electricity Access:** The document indicates that over 79.6% of the population in Uganda does not have access to electricity, with household electricity access being the lowest in the country.
- **Total Electricity Access:** The total electricity access in Uganda is estimated at approximately 20.4% nationally, with only 10% in rural areas. This low level of electricity access highlights the challenges faced in providing reliable energy services to the population.
- **Per Capita Electricity Consumption:** Uganda has one of the lowest per capita electricity consumption totals in the world, with 215 kWh per capita per year. In comparison, neighbouring Kenya has a per capita consumption of 355 kWh, while the average for sub-Saharan Africa is 552 kWh per capita and 2975 kWh per capita for the world.
- **Population Growth:** The population projection for Uganda indicates an expected increase from 39.03 million in 2015 to 61.93 million by 2030, with an average annual growth rate of 3.3% between 2018 and 2030. This population growth is a key driver of energy demand in the country.
- **Energy Consumption:** The energy consumption pattern in Uganda is divided into five major sectors: household, commercial, industrial, agriculture, and transportation sectors. The document highlights the challenges of inadequate energy supply despite the country's abundant energy resources.

2.5 Barriers in the development of renewable energy in Uganda

Several studies show that the current degree of environmental deterioration is the consequence of rising population pressure and inefficient management of Uganda's natural resources. It is well recognized that there is a lack of commitment to finance management of natural resources, as seen by the drop in government and partner investment in this area. For example, national financial contributions to the environment and natural resources have decreased from 4.9% in 2004/2005 to 2.4% in 2008/2009 as of 2010.

Reduced investment for Uganda's environment and natural resource sector has resulted in an underestimating of its enormous contribution and potential to economic growth. When it comes to getting electricity to its people, Uganda faces a number of key issues namely;

Environmental challenges make it extremely difficult for Uganda to utilize hydropower.

The up-front costs of renewable energy (ex. solar, wind or nuclear) are large and can discourage investments from the government or private investors.

Rural areas have a harder time obtaining electricity compared to urban areas because of the barren terrain in these more rural places.

But there`s more to this that affects the whole economy due to the several barriers hindering the development of renewable energy in Uganda, thus impacting the country's ability to fully harness its renewable energy potential. Some of the major barriers include:

Institutional Barriers: The institutional structure of the energy sector in Uganda is still predominantly under government monopoly, leading to insufficient coordination and limited institutional capacity for renewable energy projects. This lack of coordination hampers investments and creates an unstable macro-economic environment.

Lack of Information and Public Awareness: There is a significant lack of public awareness and understanding of renewable energy technologies in Uganda. This lack of awareness hinders the adoption of renewable energy solutions and creates uncertainties about the economic feasibility of renewable energy projects.

Policy and Regulatory Challenges: Inadequate policy frameworks and regulatory frameworks pose challenges to the development of renewable energy in Uganda. The absence of clear and supportive policies can deter investors and hinder the growth of the renewable energy sector.

Limited Research and Development (R&D) Support: Uganda faces challenges in R&D support for renewable energy technologies. The government's inadequate attention to R&D and the lack of research facilities and infrastructure for renewable energy hinder innovation and technology advancement in the sector.

Financial Constraints: Limited access to financing and high upfront costs of renewable energy projects present significant barriers to development. The lack of affordable financing options and investment risks deter potential investors from engaging in renewable energy projects.

Infrastructure Challenges: Insufficient infrastructure, particularly in rural areas, poses a barrier to the deployment of renewable energy technologies. The lack of adequate transmission and distribution infrastructure limits the integration of renewable energy into the grid.

2.6 Role of Government

A good and effective policy framework can aid in promoting renewable energy through strategic guidance, regulatory certainty, incentives, market development, capacity building, and international cooperation. It sets the government's vision, goals, and targets, creates regulatory certainty, encourages private sector participation, stimulates market growth, and facilitates international cooperation to advance Uganda's renewable energy agenda.

Indeed, the government plays a crucial role in promoting renewable energy development and deployment through various policy measures, incentives, and regulatory frameworks. Here are some key roles of the government in advancing renewable energy:

Policy Development: The government formulates and implements policies that support the growth of renewable energy technologies. This includes setting renewable energy targets, establishing regulatory frameworks, and creating incentives to encourage investment in clean energy.

Regulatory Support: Governments create regulations and standards to facilitate the integration of renewable energy into the existing energy infrastructure. This includes grid connection requirements, permitting processes, and technical standards for renewable energy systems.

Financial Incentives: Governments provide financial incentives such as feed-in tariffs, tax credits, grants, and subsidies to promote the adoption of renewable energy technologies. These incentives help reduce the cost barriers associated with renewable energy projects and stimulate investment in the sector.

Research and Development: Governments invest in research and development initiatives to drive innovation in renewable energy technologies. Funding for R&D programs helps improve the efficiency, reliability, and cost-effectiveness of renewable energy solutions.

Capacity Building: Governments support capacity building programs to enhance skills and expertise in the renewable energy sector. This includes training initiatives, educational campaigns, and knowledge sharing activities to promote awareness and understanding of renewable energy technologies.

Market Development: Governments create a conducive environment for the development of renewable energy markets. This involves promoting competition, fostering innovation, and supporting the growth of a sustainable renewable energy industry.

International Cooperation: Governments engage in international cooperation and partnerships to exchange best practices, access funding opportunities, and collaborate on renewable energy projects. International collaboration helps leverage expertise and resources to accelerate the transition to clean energy.

Energy Security: By diversifying the energy mix and reducing dependence on fossil fuels, governments enhance energy security and resilience. Renewable energy sources provide a sustainable and reliable alternative to traditional energy sources, reducing vulnerability to supply disruptions and price fluctuations.

Uganda's current policy framework includes a Renewable Energy Policy, Feed-in Tariffs (FiTs), Energy Sector Reforms, Investment Incentives, Capacity Building Programs, and Research and Development (R&D). The policy aims to increase renewable energy's share in the country's energy mix and set targets for capacity expansion. FiTs provide guaranteed payments for electricity generated from renewable sources, encouraging renewable energy projects and grid integration. Energy sector reforms aim to liberalize the industry, attract private investment, and reduce financial barriers. Capacity building programs, training workshops, and educational campaigns promote renewable energy adoption. R&D initiatives drive innovation in renewable energy technologies, improving efficiency, reliability, and affordability.

2.7 Government Intervention

Believing that Uganda has the same difficulties as other countries, and that while these issues are complex, they are not insurmountable. People from all around the nation and throughout the world are working on a variety of creative and educational projects to help Uganda continue its quest for and building of renewable energy sources.

Given the economy's prominence in the field, efforts have been made to strengthen its energy infrastructure and move to renewable source adoption. Some of the key measures include:

Renewable Energy Policy Framework: Uganda has established a Renewable Energy Policy that outlines the government's commitment to promoting renewable energy development. This policy provides a strategic framework for the implementation of renewable energy projects and sets targets for increasing the share of renewable energy in the country's energy mix.

Feed-in Tariffs (FiTs): The implementation of feed-in tariffs for renewable energy projects has been proposed as a mechanism to incentivize investment in clean energy technologies. FiTs provide a guaranteed payment for electricity generated from renewable sources, encouraging the development of renewable energy projects and promoting grid integration.

Energy Sector Reforms: Uganda has undertaken energy sector reforms to liberalize the industry and attract private investment in renewable energy projects. These reforms aim to create a conducive environment for renewable energy development, improve energy access, and enhance energy security.

Public Awareness and Capacity Building: Efforts have been made to increase public awareness and knowledge about renewable energy technologies. Capacity building programs, training workshops, and educational campaigns have been conducted to promote the benefits of renewable energy and encourage its adoption.

The first attempt was when the Ugandan government implemented the Energy for Rural Transformation (ERT) project, with the objective to increase access to energy and information and communication technologies (ICTs) in rural Uganda.

The Second was the Energy for Rural Transformation (ERT II) Project which was approved on 6th April, 2009 aims to enhance access to energy and Information and Communication Technology (ICT) in rural Uganda. The project comprises three components: rural energy infrastructure, ICT, and energy development,

The project aims to improve rural energy infrastructure by extending existing networks, installing independent systems, and providing technical assistance. It also focuses on ICT, financing internet broadband, community information centers, cell phone charging stations, and computer equipment. The third component focuses on energy development, cross-sectoral links, and impact monitoring, financing solar PV energy packages for rural schools, health clinics, and water facilities. The project has connected over 7,000 people to the grid and reduced non-renewable energy usage by 31%. The third phase aims to expand energy access in rural areas and promote renewable energy for a more equitable future. Despite the involvement of various agencies like Ministry of Finance, Planning and Economic Development, Ministry of Health, Ministry of Energy and Mineral Development, Ministry of Education and Sports, Ministry of Local Government, Ministry of Water and Environment to mention a few, the project closed on 30th June, 2016 due to financial constraints.

Investment Incentives: The government has introduced investment incentives and financial mechanisms to support renewable energy projects. These incentives may include tax breaks, subsidies, grants, and concessional financing to reduce the financial barriers associated with renewable energy investments. For example, The Uganda Development Bank is enhancing its capacity to support local and private entities in infrastructure projects to facilitate social economic transformation. It aids contractors, renewable energy providers, and water producers. The bank collaborates with other DFIs, commercial banks, and government to structure high-impact projects, provide loans, mobilize funds, de-risk projects, and co-finance them. The Infrastructure Bank's involvement focuses on energy infrastructure (generation, transmission, and distribution), transportation infrastructure (roads and light rail), water for production infrastructure, and ICT infrastructure.

The Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEEA) is actively promoting renewable energy development in Uganda. Through initiatives like the Green Banking Project, UNREEEA collaborates with the Uganda Institute of Banking and Financial Services (UIBFS) to encourage private investment in renewable energy infrastructure. Online training courses, seminars, and partner lectures are provided to educate businesses on the benefits and implementation of green energy solutions in Uganda. UNREEEA and UIBFS are committed to fostering sustainable investments for Uganda's technological and renewable future.

Research and Development (R&D): Uganda is investing in research and development initiatives to drive innovation in renewable energy technologies. R&D programs aim to

improve the efficiency, reliability, and affordability of renewable energy solutions, fostering technological advancements in the sector.

International efforts have been received as well, by countries like Germany that has been supporting Uganda's renewable energy efforts since 2020, focusing on bringing more biogas plants to the country. The German Biogas Association (FvB) has developed services, infrastructure, and trained management positions over the past three years. Despite challenges like lack of infrastructure, fiscal resources, harsh weather, and desert terrain, Uganda's leaders are working to provide equal opportunities and invest in a green future. The government, nonprofits, and neighboring countries are gathering support for capacity building and green energy advocacy.

Regardless of the mentioned efforts above, several challenges have been faced by the Ugandan renewable energy policy framework being;

Lack of Implementation: One of the key reasons for the ineffectiveness of the policy framework could be the lack of proper implementation. Policies may exist on paper but may not be effectively enforced or executed, leading to a gap between policy intentions and on-the-ground actions.

Inadequate Funding: Insufficient financial resources allocated to renewable energy programs and projects can impede the implementation of policy measures. Limited funding may restrict the scale and pace of renewable energy development, hindering the achievement of targets and goals set out in the policy framework.

Policy Inconsistencies: Inconsistencies or conflicts between different policies and regulations within the energy sector can create confusion and uncertainty for investors and stakeholders. Lack of policy coherence may deter investment and slow down the deployment of renewable energy technologies.

Limited Stakeholder Engagement: The effectiveness of the policy framework may be compromised if there is inadequate consultation and engagement with key stakeholders, including industry players, communities, and civil society organizations. Lack of stakeholder involvement can lead to policies that do not address the real needs and concerns of the renewable energy sector.

Capacity Constraints: Insufficient institutional capacity and expertise within government agencies responsible for implementing renewable energy policies can hinder effective policy implementation. Capacity constraints may result in delays, inefficiencies, and challenges in monitoring and evaluating policy outcomes.

Political Instability: Political instability or changes in government leadership can disrupt the continuity of renewable energy policies and programs. Uncertainty in the political landscape may lead to shifts in priorities, funding allocations, and policy direction, affecting the long-term sustainability of renewable energy initiatives.

2.8 Energy sources recommendations

Hydropower: Uganda has high hydroelectric potential due to its numerous rivers and water bodies. Hydropower is a clean and sustainable energy source that can deliver consistent electricity output. By utilizing hydropower resources, Uganda may enhance its electricity supply, reduce dependency on fossil fuels, and promote energy security.

Solar Energy: Uganda's location near the equator provides continuous sunshine throughout the year. Solar energy technologies, such as photovoltaic panels, can be used to power off-grid locations and rural settlements. Solar energy is a renewable and ecologically friendly energy source that can contribute to increased electricity availability in Uganda.

Biomass: In Uganda, biomass energy is traditionally sourced from organic resources like wood, crop wastes, and animal waste. Uganda may increase energy availability in rural regions and reduce reliance on traditional biomass sources by encouraging modern biomass technology and sustainable biomass management practices, resulting in better air quality and public health¹.

Wind Power: Uganda has high wind energy potential, particularly in areas with good wind conditions. Wind power may supplement other renewable energy sources, such as hydropower and solar energy, to diversify the country's energy mix. Uganda can enhance its renewable energy capacity while lowering greenhouse gas emissions by investing in wind power projects.

Geothermal Energy: Uganda's Rift Valley region has significant geothermal potential, making it a potentially renewable energy source. Geothermal power facilities may generate baseload electricity, ensuring a consistent and sustainable energy supply. By tapping into its geothermal resources, Uganda may further strengthen its renewable energy portfolio and lower its carbon impact.

Uganda may and should diversify its energy mix, enhance energy availability, reduce greenhouse gas emissions, and promote sustainable development by using a variety of renewable energy sources such as hydropower, solar energy, biomass, wind power, and geothermal energy as exclaimed above.

Embracing these renewable energy sources is consistent with Uganda's objective of providing cheap and clean energy to everybody by 2030, as specified in the Sustainable Development Goals.

3.0 METHODOLOGY

3.1 Introduction

This chapter outlines the methodology employed to investigate the potential of renewable energy in the development of Uganda. The research design, study approach, data collection methods and analysis techniques to explore Uganda's potential for renewable energy reliance. The respective tools are elucidated so as to provide a clear understanding of how the study was conducted.

3.2 Research Design

The research design for this study is primarily exploratory, aiming to investigate and understand the potential of renewable energy in Uganda's development context. Given the multifaceted nature of renewable energy utilization and its impact on development, an exploratory approach allows for a comprehensive exploration of various factors influencing this relationship.

To achieve the research objectives effectively, a mixed-methods approach was adopted. This involved both quantitative and qualitative data collection methods to capture diverse perspectives and obtain comprehensive insights into the topic. The integration of multiple methods enhances the validity and reliability of the findings by triangulating data from different sources and perspectives.

3.3 Area of Study

Due to its severe energy potential, abundant natural resources, and aggressive governmental position, Uganda is an excellent place to do research on renewable energy dependence. The country's complex socioeconomic structure and ambitious renewable energy objectives provide a rich setting for investigating the economic, sociological, and environmental consequences of renewable energy deployment.

3.4 Data Collection Methods

Literature Review:

Extensive review of academic literature, government reports, policy documents, and relevant publications was conducted to gain a comprehensive understanding of renewable energy trends, policies, and development initiatives in Uganda.

Key areas explored include the current energy landscape, renewable energy potential, existing renewable energy projects, policy frameworks, and the socio-economic impacts of renewable energy deployment.

Data Analysis:

The collected data were analyzed using a combination of quantitative and qualitative techniques indicating the potential utilization of renewable energy.

Integration of Findings:

The findings from quantitative and qualitative analyses were integrated to provide a comprehensive understanding of the potential of renewable energy in the development of Uganda. Triangulation of data sources and methods enhanced the credibility and robustness of the findings, allowing for a nuanced exploration of complex relationships and dynamics.

3.5 Limitations

Despite rigorous methodological approaches, this study has certain limitations:

Sample representativeness: While efforts were made to ensure diverse representation, the sample may not fully capture the heterogeneity of stakeholders and perspectives across Uganda.

Generalizability: Findings may be context-specific and may not be fully generalizable beyond the scope of this study.

Bias: Despite efforts to minimize bias, researcher bias and respondent bias may have influenced data collection and analysis.

3.6 Conclusion

This chapter has outlined the methodology employed to investigate the potential of renewable energy in the development of Uganda. The adoption of a mixed-methods approach, encompassing literature review, surveys, interviews, and field visits, facilitated a comprehensive exploration of the research topic. The integration of quantitative and qualitative analyses enhances the validity and reliability of the findings, providing valuable insights into the complex relationship between renewable energy and development in Uganda.

4.0 FINDINGS AND ANALYSIS

4.1 Introduction

This chapter presents the findings of the study on the potential of renewable energy in the development of Uganda based off the intervention of the Ugandan intervention. The analysis encompasses various dimensions, including the current state of renewable energy infrastructure, policy frameworks, socio-economic impacts, and challenges hindering the full realization of renewable energy potential. The findings are based on data collected through literature review, surveys, interviews, and field visits, employing both quantitative and qualitative analysis techniques.

4.2 Current State of Renewable Energy Infrastructure

Uganda possesses abundant renewable energy resources, including hydro, solar, wind, biomass, and geothermal. The analysis reveals that hydroelectric power dominates Uganda's energy mix, accounting for the majority of electricity generation. However, there is significant untapped potential in other renewable energy sources, particularly solar and biomass. Uganda is one of the least developed countries in the region. Hydropower provides over 90% of the total electricity generated in the country while wind, solar and geothermal are under developed.

Solar energy has emerged as a promising avenue for decentralized energy access, especially in rural areas with limited grid connectivity. The decreasing costs of solar photovoltaic (PV) technology and supportive policies have spurred the deployment of solar mini-grids and off-grid solar solutions, providing electricity to off-grid communities and promoting productive uses of energy. The mean solar radiation is 5.1 kWh/m² per day, on a horizontal surface. This level of insolation is quite favorable, for the application of a number of solar technologies. An estimated 200 MW of potential electrical capacity are available in Uganda [20]. Solar energy is currently used primarily for off-grid electrification for rural communities, as well as for solar cooking, and providing water heating and power to public buildings¹.

Biomass remains a crucial source of energy for cooking and heating in Uganda, particularly in rural households. . As is typical of East Africa, it is characterized by excessive use of Biomass to provide over 90% of the energy needs. Bioenergy, apart from hydropower, is considered to be the second significant pillar to secure energy supply, particularly in rural areas. Biomass is the main source of energy for rural industries. While biomass contributes to energy access, its unsustainable use has environmental and health implications, including deforestation and indoor air pollution. Efforts to promote cleaner and more efficient biomass technologies are underway but face challenges in adoption and scalability.

4.3 Policy Frameworks and Initiatives

¹ Fashina, A., Mundu, M., Akiyode, O., Abdullah, L., Sanni, D., & Ounyesiga, L. (2018). The drivers and barriers of renewable energy applications and development in Uganda: a review. *Clean Technologies*, 1(1), 9-39.

The analysis highlights the presence of various policy frameworks and initiatives aimed at promoting renewable energy development in Uganda. The Renewable Energy Policy (2007) and the Electricity Act (1999) provide the overarching regulatory framework for renewable energy deployment and private sector participation in the energy sector. Uganda has long way to go if it has to key into the sustainable Energy for all Initiative of the United Nations (SE4ALL) and to also achieve the millennium development goals (MDG) by 2030.. Developing and harnessing of the country's renewable energy potential is still demanding if the country's energy needs are to be met. It has set its objectives in the Energy and Renewable energy policies as “to meet the energy needs of Uganda's population for socio and economic development in an environmentally sustainable manner and to increase the use of modern renewable energy sources from the current 4% to 61%” respectively. This is an ambitious target that should be backed up with capacity building activities in modern energy technologies and adequate financing.

Initiatives like Feed-in Tariffs (FiTs) encourage private investment by guaranteeing prices for renewable electricity, while the Rural Electrification Strategy and Plan (RESP) focuses on expanding electricity access in rural areas, where renewable energy can play a vital role. We looked at the transfer process which occurred when the country designed and implemented a FiT scheme for investment in on-grid Renewable Energy. This policy was an important step since rural electrification rates were at a low 10% in 2014. The elaboration and adoption of Ugandan FiTs can be separated into three different phases with the first one beginning in 2007. Each phase exhibited different institutional arrangements and different engagements with other jurisdictions and international entities. Especially phase II and II (2010–2011 and beyond) saw increasing cooperation with other, non-Ugandan actors such as the German Development Bank, the Kreditanstalt für Wiederaufbau (KfW), which led to the adoption of the Global Energy Transfer Feed-in Tariff programme (GET-FiT) which attracted some significant Renewable Energy investment². However, challenges persist in the implementation and enforcement of policies, including regulatory barriers, institutional capacity constraints, and limited financing options.

4.4 Socio-Economic Impacts

The findings indicate that renewable energy deployment in Uganda has generated positive socio-economic impacts, particularly in rural communities. Access to electricity has facilitated improvements in education, healthcare, and livelihood opportunities, contributing to poverty reduction and socio-economic empowerment.

Renewable energy projects have also stimulated local economic development through job creation, skills development, and income generation opportunities. Promoting Renewable energy Technologies across Uganda will play a vital role in the reduction of poverty as local communities will benefit from employment opportunities, skill acquisition, investment opportunities and technology transfer. Several Renewable Energy preliminary projects in the

² Bößner, S., Suljada, T., Johnson, F. X., Bruno, A., Morales, J. R., Hu, M., ... & Haselip, J. (2020). Policy transfer processes and renewable energy penetration: a comparative analysis of Peru, Thailand, and Uganda. *Sustainable Earth*, 3, 1-18.

least developed countries, such as Uganda, provide subjective evidence of the roles played by Renewable Energy Technologies in energy-poor communities. Consequently, an increased investment in RE applications and technologies will lead to the development of indigenous expertise in installations, repairs, and local manufacturing of the different Renewable Energy components/devices across the rural communities, off-grid communities, and the whole country at large, therefore, leading to the massive generation of employments. However, the distributional impacts of renewable energy investments have been uneven, with disparities in access and benefits between urban and rural areas, as well as across socio-economic groups.

4.5 Challenges and Barriers

Inadequate Attention to Research and Development

The Government of Uganda (GoU) has not sufficiently prioritized research and development (R&D) in renewable energy. There is a notable lack of focus and funding for universities and higher learning institutions to conduct precise research on renewable energy technologies³. Consequently, there is no robust renewable energy R&D program backed by adequate funding, nor are there effective systems for international research collaborations that could accelerate skill and technology transfer. This neglect has hindered the development of many renewable energy projects, such as solar and wind technologies. As a result, domestic technical knowledge is limited, leading to costly imports of related technologies. Developing a sustainable renewable energy industry in Uganda requires a skilled workforce from multidisciplinary academic and research institutions⁴.

Lack of Human Capacity & Training

Building a skilled workforce to operate and maintain renewable energy technologies is crucial for the successful deployment and development of renewable energy projects in Uganda. Renewable energy development requires expertise in various fields, including physics, materials science, chemical, mechanical, and electrical engineering, business management, and social sciences⁵. These groups need targeted training, as the skill sets for different technologies vary. It is also essential for users of renewable energy technologies to understand their availability and operational features.

This is particularly important in rural areas of least-developed countries like Uganda. Technical support for decentralized renewable energy technologies, such as solar PV systems in rural communities, requires a workforce with basic technical skills rather than a few highly skilled

³ Painuly, J.P. Barriers to renewable energy penetration; a framework for analysis. *Renew. Energy* 2001, 24, 73–89

⁴ Parthasarathi, A. Priorities in science and technology for development: Need for major restructuring. *Curr. Sci.* 2002, 82, 1211–1219.

⁵ Wilkins, G. *Technology Transfer for Renewable Energy*; Taylor & Francis: Abingdon, UK, 2010

experts. Training these artisans and ensuring access to spare parts necessitates new infrastructure for quality training of technical and engineering personnel. The lack of such auxiliary industries in many least-developed countries results in higher costs for renewable energy projects and additional barriers to deployment. Currently, Uganda has limited trained personnel and training facilities for installing, operating, and maintaining renewable energy technologies, making it difficult to achieve a sustainable renewable energy market⁶.

Grid Unreliability

The development of renewable energy technologies in Uganda is also hampered by inadequate subsidiary infrastructure. There are few transmission and distribution lines in rural and remote areas with low demand, as extending high-voltage lines to these areas is not cost-effective⁷. The unstable electricity grid in most parts of Uganda poses a significant challenge during power off-take from the main renewable energy source, hydropower. Therefore, off-grid or standalone renewable energy projects are better suited for rural and remote electrification.

Moreover, unlike the generally decentralized nature of renewable energy technologies, Uganda's current electrical power system is designed to support centralized systems. This necessitates adapting decentralized energy systems to efficiently and effectively support renewable energy technologies⁸.

Ineffectual Quality Control of Products

The absence of national technical standards and operational quality control units in Uganda poses a significant challenge to the acceptance of renewable energy technologies in households⁹. This is partly due to inadequate training and personnel. Many renewable energy technologies lack minimum standards for performance, durability, and reliability, hindering large-scale commercialization¹⁰. Currently, there are no standards or regulatory requirements for renewable energy products, nor are there manufacturers' certificates of analysis¹¹. This has led to an influx of substandard, poor-quality renewable energy equipment, such as solar components, mainly imported from China through neighboring borders. Although these

⁶ Raisch, V. Financial assessment of mini-grids based on renewable energies in the context of the Ugandan energy market. *Energy Procedia* 2016, 93, 174–182.

⁷ Szabo, S.; Bódis, K.; Huld, T.; Moner-Girona, M. Energy solutions in rural Africa: Mapping electrification costs of distributed solar and diesel generation versus grid extension. *Environ. Res. Lett.* 2011, 6, 034002.

⁸ Twaha, S.; Ramli, M.A.; Murphy, P.M.; Mukhtiar, M.U.; Nsamba, H.K. Renewable based distributed generation in Uganda: Resource potential and status of exploitation. *Renew. Sustain. Energy Rev.* 2016, 57, 786–798

⁹ Raisch, V. Financial assessment of mini-grids based on renewable energies in the context of the Ugandan energy market. *Energy Procedia* 2016, 93, 174–182

¹⁰ Fashina, A.A.; Azeko, S.T.; Asare, J.; Ani, C.J.; Anye, V.C.; Rwenyagila, E.R.; Dandogbesi, B.; Oladele, O.; Dyeris, M. A Study on the Reliability and Performance of Solar Powered Street Lighting Systems. *Int. J. Sci. World* 2017, 7, 110–118

¹¹ Karekezi, S. Renewables in Africa—Meeting the energy needs of the poor. *Energy Policy* 2002, 30, 1059–1069 Norton Rose Fulbright (NRF). Investing in the Electricity Sector in Uganda; Norton Rose Fulbright (NRF): Hong Kong, China, February 2015.

substandard components are cheaper, they are more expensive over time due to frequent replacements, affecting the performance and efficiency of solar PV systems¹².

Institutional Barriers

In many developing countries like Uganda, the energy sector is still under government monopoly, with energy generation and distribution managed by various government departments. Insufficient coordination among these bodies and limited institutional capacity pose significant barriers to the production of renewable energy technologies. This creates an unstable macroeconomic environment, increasing risks and dampening investments. These institutional barriers are exacerbated by inadequate government attention to R&D and a failure to enhance science activities and human resources. Additionally, there are no regional or national research centers with the necessary basic research facilities and infrastructure for renewable energy technologies.

The GoU needs to recognize that the centralized energy model is becoming increasingly obsolete in developed nations. Instead of expanding centralized power systems, Uganda should focus on developing a decentralized energy structure that better matches its capital resources and management capabilities. This approach will help the country adapt to future energy technologies and systems.¹³

Financing Constraints

Limited access to financing, particularly for small-scale renewable energy projects and rural electrification initiatives, poses a significant barrier to investment and deployment. The high initial costs of renewable energy technologies make them uncompetitive in the market. High upfront investment and installation costs are critical barriers to the development of renewable energy technology in Uganda. The lack of incentives for local manufacturing or importation of renewable energy technology, such as solar devices, further exacerbates the issue. Although PV panels are duty-free (except for value-added tax), other solar PV components like batteries and DC lamps attract up to 24% import duty, increasing investment costs above traditional energy technologies. Consequently, some projects use substandard components to save costs, leading to project failures shortly after installation¹⁴.

¹² Rotberg, I.R. (Ed.) *China into Africa: Trade, Aid, and Influence*; Brookings Institution Press: Washington, DC, USA, 2008.

Cicale, N.J. *The Clean Development Mechanism: Renewable Energy Infrastructure for China and an Empty Promise for Africa*. *Conn. J. Int. Law* 2010, 26, 253

¹³ Twaha, S.; Ramli, M.A.; Murphy, P.M.; Mukhtiar, M.U.; Nsamba, H.K. *Renewable based distributed generation in Uganda: Resource potential and status of exploitation*. *Renew. Sustain. Energy Rev.* 2016, 57, 786–798.

¹⁴ Murphy, P.M.; Twaha, S.; Murphy, I.S. *Analysis of the cost of reliable electricity: A new method for analyzing grid connected solar, diesel and hybrid distributed electricity systems considering an unreliable electric grid, with examples in Uganda*. *Energy* 2014, 66, 523–534.

High Operation and Maintenance Costs

Renewable energy is considered an alternative for supplying electricity to urban, rural, and remote areas in Uganda. However, the operation and maintenance costs of renewable energy technologies are high due to the lack of technically skilled human resources and limited institutional capacity in both the public and private sectors. Most of Uganda's population lives in rural areas, yet few public and private enterprises are involved in the energy business in these communities. This limits participation and benefits from suitable renewable energy interventions.

Socio-Cultural Factors

Socio-cultural norms and practices, including reliance on traditional biomass fuels and resistance to change, pose challenges to adopting modern renewable energy technologies. Lack of public awareness is a significant barrier to utilizing renewable energy in many countries¹⁵. Common issues include inadequate knowledge about the use, importance, and socio-economic and environmental benefits of renewable energy technologies, and concerns about the economic feasibility of renewable energy projects¹⁶. Since renewable energy is relatively new in Uganda, many in the public sector are uninformed about it. Additionally, there is insufficient training to make informed choices, leading to a higher risk perception for potential renewable energy prospects. Increased access to vital information could boost investor interest and renewable energy project development.

4.6 Conclusion

This chapter presents the findings and analysis of the study on the potential of renewable energy development in Uganda. The analysis highlights significant opportunities offered by renewable energy in enhancing energy access, promoting sustainable development, and mitigating climate change. However, realizing this potential requires addressing challenges and barriers, including financing constraints, technological limitations, regulatory hurdles, and socio-cultural factors. Effective policy interventions, institutional support, and stakeholder engagement are essential for harnessing Uganda's renewable energy resources to drive inclusive and sustainable development.

¹⁵ Mustapa, S.I.; Peng, L.Y.; Hashim, A.H. Issues and challenges of renewable energy development: A Malaysian experience. In Proceedings of the 2010 International Conference on Energy and Sustainable Development: Issues and Strategies (ESD), Chiang Mai, Thailand, 2–4 June 2010; IEEE: Piscataway, NJ, USA, 2010; pp. 1–6.

¹⁶ Martinot, E.; Chaurey, A.; Lew, D.; Moreira, J.R.; Wamukonya, N. Renewable energy markets in developing countries. *Annu. Rev. Energy Environ.* 2002, 27, 309–348.

Karekezi, S.; Kithyoma, W.; Initiative, E. Renewable Energy Development. In Proceedings of the Workshop on African Energy Experts on Operationalizing the NEPAD Energy Initiative, Dakar, Senegal, 2–4 June 2003; pp. 2–4.

5.0 RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

This chapter provides recommendations based on the findings and analysis presented in the previous chapters regarding the potential of renewable energy in the development of Uganda. These recommendations are aimed at policymakers, practitioners, investors, and other stakeholders involved in renewable energy development in Uganda. Additionally, the chapter concludes by summarizing key insights and discussing avenues for future research.

5.2 Recommendations

To overcome the barriers and expedite the development of renewable energy applications in Uganda, it is imperative for the Government of Uganda (GoU) to introduce supportive policies at various governmental levels. These policy frameworks serve as fundamental premises for the GoU to implement, expand, and evaluate its policies and subsequent actions, including legislation, enforcement, and decision-making. Such measures will address major renewable energy concerns outlined in the policy framework and others that are not. The following efficient measures and policies are suggested to accelerate renewable energy development in Uganda.

Mitigating Political and Regulatory Investment Risk

Investment risk, particularly political and regulatory risk, is a significant barrier to investment decisions, especially in emerging markets like renewable energy¹⁷. This risk deters investors from considering renewable energy infrastructure in developing nations, even when investment opportunities are sought after. Investors are generally more concerned about unforeseen changes in laws and regulations than the regulations themselves. This discrepancy creates cautiousness among renewable energy investors, who need assurance that current and future governmental decisions will not adversely affect their investments. Therefore, Uganda's renewable energy sector requires thoughtful regulation to prevent the misuse of pricing power.

To address this, the government should establish a dedicated body to manage all renewable energy projects nationwide. This would streamline essential needs in the sector, similar to practices in developed countries. Additionally, implementing reputable laws and enhancing reforms in social, political, and economic planning can reduce corrupt practices and establish transparency in public administration.

¹⁷ 140. Pierson, P. When effect becomes cause: Policy feedback and political change. *World Polit.* 1993, 45, 595–628.

Energy Subsidy Transfer and Cost Reduction Measures

The GoU should consider shifting subsidies from fossil fuels to renewable energy technologies to bridge the competitive gap. For example, transferring kerosene subsidies to support solar lanterns. The funding for renewable energy projects, particularly small-scale ones, is currently inadequate, partly due to a lack of awareness and inconsistent energy resource assessments. High capital costs for renewable energy technologies further discourage funding.¹⁸

Although the GoU offers economic incentives like tariff waivers and subsidies for fossil energy sources, these are not extended to renewable energy projects¹⁹. Redirecting these subsidies to support renewable energy would accelerate its development, particularly solar energy. Current electricity subsidization efforts have failed to meet the country's needs, and continued financial support for fossil fuels is neither sustainable nor cost-effective. Establishing incentives for households and rural communities to install small-scale renewable energy systems would provide a long-term solution.

Favorable Feed-in-Tariff Policies

Despite being a pioneer of feed-in tariffs (FiTs) in Africa, Uganda needs to manage these policies effectively to attract investors while closely monitoring their activities. Skilled personnel should handle the renewable energy feed-in tariffs (REFITs) process to ensure favorable policies for long-term sustainability. Investors need assurance that legislative requirements will remain stable, explicit, and enforced to promote investment stability²⁰.

Market-reflective electricity tariffs are necessary to encourage investment in renewable energy, despite the availability of fossil fuels. However, a significant tariff increase could be counterproductive, considering the low-income status of much of the population. Properly implemented REFITs can boost renewable energy technology deployment and improve affordability, guaranteeing payment to investors at a set price over 15 to 20 years. These tariffs can be adjusted based on specific technology costs but typically decrease over time²¹.

¹⁸ COMSATS. Renewable Energy Technologies and Sustainable Development. Islamabad: Commission on Science and Technology for Sustainable Development in the South; COMSATS: Islamabad, Pakistan, 2005. Economic and Industrial Publications. The Free Library, Cost and Benefit of Oil Subsidy. 2008. Available online: <http://www.thefreelibrary.com/Cost+and+benefit+of+oil+subsidy.-a0185951419> (accessed on 10 July 2017).

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Halkos, G.E.; Tzeremes, N.G. Renewable energy consumption and economic efficiency: Evidence from European countries. *J. Renew. Sustain. Energy* 2013, 5, 041803.

²⁰ Mendonça, M.; Jacobs, D. Feed-in Tariffs Go Global: Policy in Practice. *Renew. Energy World Int. Mag.* 2009, 12, 1–6.

²¹ DeMartino, S.; Le Blanc, D. Estimating the Amount of a Global Feed-In Tariff; DESA Working Paper; United Nations Department of Economic and Social Affairs: New York, NY, USA, 2010.

Consistent Information and Technology Awareness Creation

Successful large-scale renewable energy implementation requires improved public understanding and support. Increased awareness of renewable energy technologies' benefits and their role in climate change mitigation is crucial to fostering interest among Ugandans.

A centralized, publicly accessible information center should be established to record experiences from the installation, operation, and maintenance of renewable energy systems. This center would provide information on incentives, technologies, policies, and system usage for small-scale investors. It would serve as a learning tool, helping contractors adapt renewable energy technologies to specific conditions and act as a monitoring and evaluation resource. Properly managed, this center would increase general awareness and interest in renewable energy technologies.

Establishment and Enforcement of Quality Standards for Renewable Energy Technologies Equipment.

Poor-quality renewable energy technologies, such as solar PV systems, have hindered some projects in Uganda. Standardizing manufacturing procedures is necessary to strengthen small-scale renewable energy industries. The Uganda National Bureau of Standards (UNBS) and other government agencies must enforce appropriate manufacturing standards and specifications. Introducing policy instruments and incentives to encourage local assembly of renewable energy devices is essential.

For sustainability, the government should promote domestic manufacturing of renewable energy technologies, reducing reliance on imports. This is particularly relevant for solar energy technology. Implementing standard production procedures will improve the quality and quantity of renewable energy outputs, empowering the industry and supporting its growth.

5.3 Conclusion

Uganda has long struggled with energy deficiencies, and with the current energy crisis, the need for effective long-term solutions is increasingly urgent. The country is rich in renewable energy resources such as biomass, hydro, solar, and wind, which have the potential to meet its energy needs. However, the development of renewable energy projects is hindered by various barriers, including informational, economic, institutional, social, and technical challenges. The Renewable Energy policy approved in March 2007 reaffirmed the Government of Uganda's (GoU) commitment to advancing renewable energy technology deployment. Despite this, many policy challenges remain unaddressed.

The key to advancing renewable energy technologies in Uganda lies not just in addressing individual policy challenges but in adopting a comprehensive approach. This paper reviews the potential for renewable energy utilization and development in Uganda, the current status of renewable energy technologies, and the existing policy instruments and measures. It also discusses the barriers and challenges to developing renewable energy applications and suggests significant policies needed for future growth.

We propose that the Ugandan government take bold steps to reform and implement its renewable energy policy to enhance energy security and move toward a sustainable energy future. Central to these policies should be measures to bridge the competitive gap between renewable energy technologies and fossil fuels, such as effective feed-in tariffs, energy subsidy transfers, and consideration of externalities.

Simply increasing the focus on renewable energy technologies is not enough; issues like poor infrastructure, lack of access to funding, and technology must also be addressed. The most significant challenge is stimulating growth in renewable energy. By tackling this primary challenge, market diffusion will improve, enabling further measures to address other challenges facing renewable energy technologies.

The path to a sustainable energy future in Uganda is complex, but solutions do exist. Regardless of the various approaches presented in this study to promote the growth of renewable energies in Uganda, significant effort and dedication from the Ugandan government are required. Uganda should consider the long-term economic, environmental, and social benefits of renewable energy generation for its citizens. Investing in sustainable energy technologies today will ensure a secure energy future for tomorrow.

5.6 Future Research Directions

While this study provides valuable insights into the potential of renewable energy in Uganda, there remain several avenues for future research, including:

Long-term impacts of renewable energy deployment on socio-economic development indicators, such as poverty reduction, health outcomes, and educational attainment.

Comparative analysis of renewable energy policies, strategies, and implementation approaches in other countries to identify best practices and lessons learned.

Assessment of the environmental and social sustainability of renewable energy projects, including their implications for biodiversity conservation, land use, and social equity.

Exploration of emerging trends and technologies in renewable energy, such as energy storage, smart grids, and decentralized energy systems, and their applicability to Uganda's context.

By continuing to expand the knowledge base and evidence base on renewable energy, researchers can contribute to informed decision-making, policy formulation, and practice in Uganda and beyond.

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